Department of Energy
Savannah River Operations Office
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OCT 27 2016

Tom Foster, President & Project Manager
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Building 766-H, Room 2407
Aiken, SC 29808

Dear Mr. Foster:

SUBJECT: Approval of Emergency Planning Hazards Assessment (EPHA) for the Defense Waste Processing Facility (DWPF), S-EHA-S-00001, Revision 13, July 2016

REFERENCES: Letter, Schifer to Bartholomew, July 27, 2016, Approval of Emergency Planning Hazards Assessment for Defense Waste Processing Facility (DWPF), S-EHA-S-00001, Revision 13, July 2016

The Department of Energy-Savannah River Operations Office (DOE-SR), Office of Safeguards, Security and Emergency Services has reviewed the subject document, Emergency Planning Hazards Assessment for DWPF, S-EHA-S-00001, Revision 13. Based on the evaluation completed by DOE-SR, there were comments found that required resolution. These comments included a change in EPHA methodology, which was addressed in a meeting held September 20, 2016. The minutes are enclosed along with the comment resolution document.

All comments were addressed and resolved.

If you have any questions, please call me or have your staff contact Howard Burgess, of my staff at 2-5538.

Sincerely,

for Jack R. Craig
Savannah River Site Manager

OSSES-17-001

3 Attachments:
(1) EPHA Issues Meeting Minutes
(2) Comment Resolution
(3) EPHA

OCT 27 2016

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S-EHA-S-00001
Revision 13

EMERGENCY PLANNING HAZARDS ASSESSMENT FOR THE DEFENSE WASTE PROCESSING FACILITY (U)

July 2016

Savannah River Remediation

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13	W.C. Swygert	Wendy Swygert July 26, 2016	D. Armstrong	DR Armstrong July 26, 2016

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LIST OF ACRONYMS

AEGL	Acute Exposure Guideline Levels
ALOHA	Area Location of Hazardous Atmospheres
ARF	Airborne Release Fraction
ARP	Actinide Removal Process
CDC	Canister Decontamination Chamber
CDMC	Contact Decontamination and Maintenance Cell
CDCSTS	CDC Smear Test Station
CPC	Chemical Process Cell
CSSX	Caustic Side Solvent Extraction
CSTF	Concentration, Storage, and Transfer Facility
CTF	Central Training Facility
DBA	Design Basis Accident
DCF	Dose Conversion Factor
DF	Decontamination Factor
DOE	Department of Energy
DR	Damage Ratio
DSS	Decontaminated Salt Solution
DWPF	Defense Waste Processing Facility
DWTT	Decontamination Waste Treatment Tank
EAL	Emergency Action Level
EMPP	Emergency Management Program Procedure
EPA	U.S. Environmental Protection Agency
EPHA	Emergency Planning Hazards Assessment
EPIP	Emergency Plan Implementing Procedure
EPZ	Emergency Planning Zone
ERPG	Emergency Response Planning Guideline
FB	Facility Boundary
FESV	Failed Equipment Storage Vault
FGR	Federal Guidance Report
FSAR	Final Safety Analysis Report
GE	General Emergency
GWSB	Glass Waste Storage Building
HEPA	High Efficiency Particulate Air

LIST OF ACRONYMS (Cont.)

HLW	High-Level Waste
HS	Hazards Survey
ICRP	International Commission on Radiological Protection
LEL	Lower Explosive Limit
LFL	Lower Flammability Limit
LPF	Leak Path Factor
LPPP	Low Point Pump Pit
LWHT	Late Wash Hold Tank
LWPT	Late Wash Precipitate Tank
MAR	Material At Risk
MC	Melt Cell
MCU	Modular Caustic Side Solvent Extraction Unit
MFT	Melter Feed Tank
MST	Mono-Sodium Titanate
NPH	Natural Phenomena Hazards
OE	Operational Emergency
PAC	Protective Action Criteria
PPT	Precipitate Pump Tank
PRFT	Precipitate Reactor Feed Tank
PVVS	Process Vessel Ventilation System
RCT	Recycle Collection Tank
RD	Release Designations
REDC	Remote Equipment Decontamination Cell
RF	Respirable Fraction
RPC	Remote Process Cell
RPT	Recycle Pump Tank
SAE	Site Area Emergency
SB	Site Boundary
SCT	Shielded Canister Transporter
SE	Strip Effluent
SEFT	Strip Effluent Feed Tank
SME	Slurry Mix Evaporator
SMECT	Slurry Mix Evaporator Condensate Tank
SPC	Salt Process Cell
SPT	Sludge Pump Tank
SRAT	Sludge Receipt and Adjustment Tank
SRF	Source Release Fraction
SRR	Savannah River Remediation, LLC
SRS	Savannah River Site

LIST OF ACRONYMS (Cont.)

ST	Source Term
TED	Total Effective Dose
TEEL	Temporary Emergency Exposure Limit
TEL	Threshold for Early Lethality
TSR	Technical Safety Requirement
URS PS	URS Professional Solutions, LLC
WMA	Wildlife Management Area
WTC	Weld Test Cell

ABBREVIATIONS

°C	degrees Celsius (temperature)
Ci	Curie
°F	degrees Fahrenheit (temperature)
ft.	foot
g	gram
g/min	grams per minute
gal	gallon
gpm	gallons per minute
hr.	hour
kg	kilograms
kg/L	kilograms per liter
kg-mol	kilogram-mole
km	kilometer
lb.	pound
m	meter or milli (10^{-3})
M	molar
mg/L	milligrams per liter
mg/m^3	milligram per cubic meter
mg/s	milligrams per second
min	minute
m/s	meter per second
$Pu\text{-}238_{eq}$	Plutonium-238 equivalent
ppm	parts per million (by volume)
rem	roentgen equivalent man
vol%	volume percent (concentration)
wt%	weight percent (concentration)
µ	micro (10^{-6})

1.0 INTRODUCTION

1.1 PURPOSE

This report documents the facility Emergency Planning Hazards Assessment (EPHA) for the Defense Waste Processing Facility (DWPF) located on the Department of Energy (DOE) Savannah River Site (SRS) (Appendix A, Figure 1). This hazards assessment identifies and analyzes hazards significant enough to warrant consideration in the DWPF operational emergency management program. The EPHA was conducted in accordance with the Emergency Management Program Procedure (EMPP) 6Q-001, (Ref. 1). The EPHA provides the technical basis for facility emergency planning efforts.

1.2 SCOPE

The scope of this EPHA is for DWPF operational facilities evaluated in the Final Safety Analysis Report (FSAR) (Ref. 2). Principal buildings and systems associated with the vitrification process include:

- Interarea transfer system, including Actinide Removal Process (ARP) and Low Point Pump Pit (LPPP)
- Vitrification Building
- Glass Waste Storage Buildings (GWSB)
- Ventilation system, including Sand Filter, Fan House, and Stack

These, and major support systems and facilities within the S-Area Property Protection Area fence, are included in this assessment.

1.3 BACKGROUND

This EPHA is intended to provide an emergency planning basis compliant with the requirements of DOE Order 151.1C (Ref. 3) and EMPP 6Q-001 (Ref. 1). The consequence analysis methodology specified in EMPP 6Q-001 utilizes the concept of a barrier approach as opposed to risk/probability analysis for hazardous material releases. The development of a compliant EPHA involves the compilation and screening of the facilities' radiological, biological, and chemical inventories. For materials that exceed screening thresholds, hazard characterization and barrier identification are performed. For an EPHA, operational event scenarios for potential releases of the materials can be taken from approved documents supporting the FSAR, the approved facility FSAR (if available), the approved Technical Safety Requirements (TSRs) (if available), facility operating procedures, input by facility Subject Matter Experts, and the results of facility walkdowns. The event scenarios range from minor to beyond design basis events. From the identified scenarios, a consequence assessment is performed to determine downwind dose and/or concentrations at defined receptor locations.

Safety Basis documents provide analyses and consequences for the worst credible and/or Design Basis Accidents (DBAs). The analyses are used to determine design and performance specifications of safety features. DBAs and their associated assumptions can be used as a starting

point for emergency response planning: however, their use may be limited because they may contain a number of conservative assumptions that may not be appropriate. Unlike many Safety Basis documents, an EPHA is not required to use a "bounding" analysis, rather the analysis within the EPHA is intended to meet the standard of "conservative" and may be based on facility operations as opposed to bounding cases. For example, a maximum tank inventory may be based on operating history rather than on physical capacity.

The FSAR sets a safety envelope that essentially covers accidents over the design basis spectrum. The result is to have a linkage between individual hazards identified and a final control set that addresses each hazard and defines the operating requirements within which the risk to workers and the public have been shown to be acceptable. The EPHA quantitatively documents consequences for a full spectrum of events based on a barrier challenge/failure analysis (deterministic analysis). The result is to identify the level of response necessary to mitigate an event that may affect co-located workers or the public.

In an FSAR, an unmitigated release might be postulated to determine if Evaluation Guidelines (EGs) could be exceeded. The accident analysis would then credit mitigation, which would be justified and protected (e.g., via TSRs) to reduce risk (not dose) to an acceptable level. EPHA accident analysis considers mitigation as part of the process and can use both passive and active mitigation. It may credit operator intervention using a criterion of "reasonable" response. This is why an EPHA typically assumes a spill response time of 10 minutes versus 30 minutes or longer. The EPHA may eliminate accidents from consideration if the initiator is of sufficient time duration that operator intervention might reasonably occur. For example, the EPHA might assume that workers would terminate a transfer before waste tanks fill and begin to overflow since it takes many hours for this accident to develop.

Finally, the EPHA identifies Emergency Action Levels (EALs) and the facility Emergency Planning Zone (EPZ) from accident analysis results. Events capable of exceeding defined Protective Action Criteria (PAC) at the receptor locations are assigned an emergency classification. Malevolent acts are not used for EPZ determination. Based on consequence assessment, a facility Emergency Plan Implementing Procedure (EPIP) will be developed or revised for use by facility personnel to classify events in a timely manner.

1.3.1 Natural Phenomena Hazards

The EPHA considers a range of initiating events and failure mechanisms including traditionally defined accidents, as well as events arising from external causes such as Natural Phenomena Hazards (NPH) events. In most cases, NPH events will produce releases similar to those that could be caused by other initiators. For example, catastrophic failure of a chemical storage tank might be postulated due to a seismic event. However, if approximately the same level of damage might also be caused by an operational accident, such as running a truck into the tank, the NPH event would simply be considered another initiator for the failure of the storage tank. If events are identified where the only initiator to a release is an NPH event, it is explicitly stated in the EPHA.

As described in DOE G 151.1-2, paragraph 2.5.1 (Ref. 4), catastrophic events may be excluded from emergency planning on the grounds that consequences of the initiating event will

overwhelm the planned initial response to any resulting release of hazardous materials. In such circumstances, the initiating event itself and its immediate safety implications become the overriding priority of initial response activities. For such events, mitigation of which is expected to be beyond any site's response capabilities, the principal function of site emergency management is to recognize the occurrence and initiate notification of DOE Headquarters and others. Notifications may best be initiated by declaring a General Emergency (GE); however, it is neither necessary nor useful to attempt quantitative analysis of the consequences of such catastrophic events in the EPHA as a basis for emergency classification. Criteria for classification of catastrophic events are included in the site-level EAL procedure, Manual 6Q15.1, EPIP 114, "Emergency Categorization and Classification" (Ref. 5). Classification of catastrophic events is based on a qualitative assessment of the type and magnitude of events and expected consequences.

1.3.2 Malevolent Acts

The EPHA is required to address malevolent acts. Malevolent acts (e.g., sabotage) are potential initiators of hazardous material releases within the scope of emergency planning. In many cases, malevolent acts will produce consequences similar to those caused by other initiators. Identifying a malevolent act as a potential initiator does not necessarily mean that a separate analysis of that scenario is needed. The DOE Emergency Management Guide defines two types of malevolent acts: moderate and extreme (Ref. 4, Section 2.5.1). Moderate events are those that could be initiated by a single individual using materials or tools readily available in the facility or small quantities of flammables. Extreme events are those events that require the actions of multiple people to execute and/or the materials necessary are not readily found in the area to cause extensive damage to the facility (e.g., materials must be brought in from outside the facility). Selection and analysis of malevolent acts is bound by capabilities within the current Design Basis Threat for the facility.

1.4 REVISION SUMMARY

1.4.1 Significant changes from Revision 12

The following significant items were reflected in this revision.

- Changed the facility boundary to 100 m.
- Addressed the new bounding recycle stream and double stacking of canisters.
- Added the Decontamination Waste Treatment Tank stream.
- Removed mono-sodium titanate (MST) from 512-S.
- Removed specific stream number designations and replaced with updated stream name designations where applicable.
- Updated FSAR sections numbers in the text and verified references.
- Renumbered subsections for ventilation in Section 3.2.
- Added Interarea Transfer Lines as Segment 9.0.
- Changed 3-RD-4 and 4-RD-1 to filter inoperational.

- Updated results tables in Section 6.0.
- Updated Section 7.0 EALs.
- Updated distances in Section 8.0.
- Added list of radionuclides to the results in Calculation 1.
- Updated references and ALOHA runs in Calculation 2.
- Simplified Calculation 3, including Eckert-Drake spreadsheets.
- Updated values in Attachment A tables of Calculation 4.
- Updated table in Source Term (ST) section to include 100 m and updated table in Dimethyl Mercury Limited ST to include SAE in Calculation 5. Updated Results table along with Eckert-Drake, Aloha and Hotspot runs as necessary.
- Updated Appendix D to reflect changes in main body of document and in calculations.

1.4.2 Significant Changes from Revision 11

- Removed LPPP explosion scenarios and associated EAL (Site Area Emergency [SAE] 1.1).
- Removed ARP explosion scenarios and associated EAL (SAE 1.2).
- Added Crossflow Filter Detonation Scenario (4-Release Designation [RD]-5).
- Added Backpulse Tank Detonation Scenario (4-RD-6).
- Updated chemical inventory to include dimethyl mercury.
- Added LPPP dimethyl mercury release scenario (3-RD-1).
- Updated PAC for formic acid.
- Updated the Material at Risk (MAR) for spill involving sludge-contaminated SeaLand container (5-RD-1).
- Added the following scenarios:
  - Fire involving SeaLand Container Containing Sludge-Contaminated Equipment (5-RD-2),
  - Fire involving B-25 Waste Container (5-RD-3),
  - Impact accident ruptures B-25 Waste Container (5-RD-4),
  - Explosion in B-25 Waste Container (5-RD-5), and
  - Glass-Contaminated SeaLand Container Spill (5-RD-6).
- Provided justification for elimination of explosion and/or fire events involving glass in a SeaLand container.

1.4.3 Significant changes from Revision 10

- Deleted nitric acid as a chemical of concern due to low dispersibility.
- Added information on the ventilation system associated with the building and operations in DWPF.

- Revised the conversion of radionuclides to an equivalent isotope using the Dose Conversion Factors (DCFs) from Federal Guidance Report (FGR) 13 (Ref. 6).
- Revised consequence assessment, EALs, and EPZ to reflect changes associated with the conversion of the MAR to Pu-238eq using FGR 13 DCFs.
- Eliminated unfiltered ground level release scenarios for 511-S and 512-S for non-energetic releases (system interlocks shut down the ventilation system).
- Revised the formic acid release scenarios to take into account the reduced air flow over the surface of liquid in the diked areas and thus reducing the rate of release from spilled formic acid.
- Included formic acid release scenarios for 980-S.
- Revised scenarios to only consider the maximum container or release from an area within a structure (e.g., Chemical Process Cell (CPC), Salt Process Cell (SPC) or the maximum container in building (e.g., 511-S, 512-S).
- Included the volatile component from melter accidents in the ST.
- Used Hotspot mixture files in modeling radiological events involving volatile components and potential gamma emitter contributions to the dose from ground shine.
- Updated Isopar concentration from 105 ppm to 600 ppm for Modular Caustic Side Solvent Extraction (CSSX) Unit (MCU) strip effluent transfers to DWPF.

1.4.4 Significant changes from Revision 9

The following significant items were reflected in this revision:

- Changes in the characterization of formic acid spills within DWPF by utilizing Eckert-Drake Evaporative Model to obtain direct release STs for use in the Areal Location of Hazardous Atmospheres (ALOHA) Modeling Program to accommodate 90 wt% solution versus 100 wt%.

1.4.5 Significant changes from Revision 8

The following significant items were reflected in this revision:

- Changes in feed stream isotopic concentrations to incorporate MCU feed streams.
- Removal of Late Wash Precipitate Tank (LWPT) dilute concentrations from consideration.
- The Mono-Sodium Titanate (MST)/Solid Stream from 512-S is now pumped to the Precipitate Reactor Feed Tank in 221-S and no longer the Actinide Solids Receipt Tank.
- The Actinide Solids Receipt Tank has been renamed the Strip Effluent Feed Tank (SEFT) which now receives strip effluent from MCU.

1.4.6 Significant Changes from Revision 7

The following significant items were reflected in this revision:

- This revision analyzes formic acid. This is in response to a 2004 OA-40 finding regarding the screening of chemical hazards.
- Section 5 Barrier Identification was removed per the EMPP 6Q-001.
- The Accident Analysis Section was revised to match current practices to improve the ability of the EPHA to support accident assessment. The calculation of accident STs is in the accident analysis section to consolidate key data and facilitate the development of the Technical Support Room Data Appendix.
- The Accident Analysis Section was updated to consider explosions at the LPPP and Actinide Removal Processing (ARP) (512-S).
- Hazards Screening section was updated per EMPP 6Q-001.
- A Technical Support Room Data Appendix is now required per EMPP 6Q-001.

1.4.7 Significant changes from Revision 6

Added information on GWSB 2 in Section 3 Facility Description.

1.4.8 Significant changes from Revision 5

This is a limited scope revision that addresses the following:

- The format of the document was revised to be in compliance with Style Guide (font size, numbering, etc.). The format only changes are not marked with revision bars as every page would have a revision bar defeating the purpose of using the marking.
- Deleted all information regarding Precautionary PAC distance per direction of the Washington Savannah River Company Emergency Preparedness Group.
- Added distances to the Threshold for Early Lethality (TEL) in accordance with EMPP-001 to the consequence assessment tables.
- Added a section to accident analysis documenting the basis for EALs involving security events.
- Added information on Contaminated Equipment Storage in Section 3, Facility Description, and addressed the radioactive material inventory in Section 4, Identification, Screening, and Characterization of Hazards.
- Section 6.3 was revised to correctly identify that unfiltered releases from the CPC and Melt Cell (MC) can only occur as the result of a catastrophic event. The accident analysis relating to unfiltered releases for individual vessel failures was removed.
- Corrected the release height for releases from the LPPP and the 512-S ARP. The Stacks for the 511-S and 512-S are not significantly taller than the adjacent buildings. The buildings create a downdraft that pulls all releases to the ground. Calculations 5, 6, and 8 were revised to correct this error. Section 7 of the EPHA was updated with new consequence assessment results that resulted in additional emergencies. Section 8 was revised to add the new EALs and revise others affected by this change.

- Correction of Table 5 of Calculation 6 with regards to classifiable events. The EALs for unfiltered individual vessel failures in the CPC were removed but not the conflicting analysis that indicates an EAL should have been developed.
- Section 6.3 had the wrong STs for Slurry Mix Evaporator Condensate Tank (SMECT) releases identified. Calculation had a ST that is based on assumption that solids were carried over to SMECT from the Slurry Mix Evaporator (SME). This was identified as being overly conservative by the facility and the EALs were withdrawn based on analysis conducted previously. The incorrect STs were deleted and replaced with new analysis based on the correct STs. The results in Section 7 that identified the SMECT (3-RD-10, 3-RD-11) as having the potential for a Site Area Emergency (SAE) were replaced with a new accident analysis.
- 8.1.3 Alert EALs for transfer spill of tens of gallons but less than hundreds of gallons of waste into the LWPT cell with unfiltered releases from 512-S had the wrong ST but the correct ST is in EPIP. The ST in 8.1.3 was corrected.
- Calculation does not list in the assumptions/inputs section that the hydrogen levels in the Actinide Solids Receipt Tank are lower than the other vessels in the CPC and that a detonation is not a probable scenario to analyze. The basis for this was added to the calculation.
- Calculation was inconsistent in identifying the various initiators that can breach a tank or vessel. The STs are correct but the inconsistencies make correlation with the Safety Analysis difficult. The inconsistencies were corrected.
- Table 7 in Calculation contained a number of typographical errors that incorrectly identified, in several cases, if an accident scenario requires additional analysis. These typographical errors were corrected.

1.4.9 Significant changes from Revision 4

- Included scope identified in ARP Consolidated Hazard Analysis.
- Deletion of LPPP tank explosions (because of time required to reach the Lower Flammability Limit).
- Deletion of analysis of permitted NOx release.
- Deletion of analysis of underground transfers of waste.
- Deletion of EAL for Zone 1 Exhaust Duct Radiation Monitor.

1.4.10 Significant changes from Revision 3

- Revised calculations to include release pathways from Calculation No. 33 of the previous revision. The Release Designations (RDs) in revised calculations are now consistent with RDs in EPHA Section 6.
- Incorporated Design Changes G-DCF-S-00223 and G-DCF-S-00254.

- Revised format and content in accordance with revised EPHA, Procedure EMPP 6Q-001, and EAL, Procedure EMPP 6Q-002 (both effective December 2000), including, but not limited to, the following:
  - Reviewed chemical inventories and revised as necessary; screened out many chemicals previously analyzed (under old EMPP 6Q-001).
  - Deletion of Notification of Unusual Event classification. Addition of Operational Emergency and Courtesy Notification Event.
  - Addition of Precautionary PAC (i.e., distance to 100 millirem [mrem] and Emergency Response Planning Guideline [ERPG] 1).
  - Revision of the EPZ technical basis.

NOTE: Changes were not tracked previous to Revision 3.

2.0 SUMMARY

An EPHA was conducted for the DWPF in accordance with EMPP 6Q-001 (Ref. 1). The analysis included the following:

- Compilation and characterization of hazardous material
- Scenario development for potential releases of identified hazardous materials
- Conversion to equivalent isotope for radiological material
- Consequence assessment of the identified scenarios
- Emergency classification development
- Determination of the facility EPZ

Based on this EPHA, the DWPF requires an emergency plan and implementation procedures. Materials present within the DWPF that require full consequence assessment are as follows:

• Chemicals:	formic acid; dimethyl mercury
• Radionuclides:	Co-60, Sr-90, Ru-106, Cs-134, Cs-137, Ce-144, Pm-147, Eu-154, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-244

For materials identified above, accident scenarios were identified that may exceed the specified PAC at downwind receptor locations of interest. For each identified scenario, a consequence assessment and corresponding EAL determination was completed. Results show the potential for the following classifiable operational emergencies:

	Chemical	Radiological	Biological	Other
• General Emergency	0	0	0	0
• SAE	0	0	0	0
• Alert	2	0	0	1

The EPZ for DWPF, as determined in Section 8, corresponds to the general Site Boundary.

3.0 FACILITY DESCRIPTION

The DWPF is designed to vitrify stored high-level waste (HLW). Three separate aqueous slurries of HLW are sent to 221-S for treatment: (1) sludge slurry generated from the Concentration, Storage, and Transfer (CST) Facility; (2) MST/Sludge Solids slurry from the Actinide Removal Process; and (3) Strip Effluent (SE) slurry from CST Facility. The 221-S feeds are chemically treated, and soluble and insoluble solids melted with glass frit into a durable borosilicate glass. The glass is poured into stainless steel canisters and stored in the GWSB until transferred to a federal repository for final disposal (Ref. 2, Section 6.0.2).

3.1 EPHA SEGMENTATION

Independent segments were established for initial inventory and screening purposes, as shown in Table 3.1. Segments 1 through 9 are described in detail in sections 3.1.1 through 3.1.9, respectively. The ventilation systems are described in Section 3.2.

Table 3.1 Defense Waste Processing Facility Preliminary Segmentation

Segment Number	Building/Process
1	Vitrification Building (221-S)
2	Cold Chemical Storage (422-S)
3	GWSB #1 & #2 (250-S and 251-S)
4	Low Point Pump Pit (511-S)
5	ARP (512-S, 512-6S, 512-7S)
6	Decontaminated Equipment & Waste Staging
7	Water Treatment and Storage Facilities (980-S)
8	Failed Equipment Storage Vault (FESV) (260-S)
9	Interarea Transfer Lines

3.1.1 Vitrification Building

According to Section 5.2 of the FSAR (Ref. 2), the Vitrification Building (221-S) is a multilevel reinforced concrete structure designed as a Category I Facility. It houses radiological process operations in shielded confinement cells. The balance of the building is standard construction and includes a manipulator repair shop, a radiological machine shop, a railroad airlock, a Shielded Canister Transporter (SCT) maintenance and decontamination area, and a filter room. Main process include the following:

- SPC — The cell adjacent to the CPC that receives material from LPPP- Precipitate Pump Tank (PPT) (511-S) for subsequent transfer to the CPC (Ref. 2, Section 5.2.3.1).
- CPC — The process feed preparation cell that provides equipment to supply slurry to the glass melter (Ref. 2, Section 5.2.3.2).
- Glass Melt Cell (MC) — The part of the process that houses the glass melter. The melt process is accomplished in a slurry-fed, joule-heated melter designed to incorporate high level waste into a solid, borosilicate glass matrix (Ref. 2, Section 5.2.3.3).

- Melter Off-gas Treatment Facilities and Backup Off-gas Cell (BuOGC) – The primary function of the melter off-gas treatment system is to reduce the amount of radioactive particles and mercury in the vapors that evolve from the melter before their release to the Zone 1 ventilation exhaust system (Ref. 2, Section 5.2.3.4).
- Canister Decontamination Cell (CDC) — The cell which houses the equipment required to clean and decontaminate the external surfaces of the canister (Ref. 2, Section 5.2.3.8).
- Weld Test Cell (WTC) — A separate cell with its own air supply which houses the welding equipment used to make the final canister closure. The weld test cell contains equipment used to press the previously installed inner canister closure plug down into the neck of the canister, place and weld the final seal plug into the canister, and smear and inspect the sealed canister (Ref. 2, Section 5.2.3.8).
- Remote Equipment Decontamination Cell (REDC) and Contact Decontamination and Maintenance Cell (CDMC) — These facilities located at the south end of the building are for the cleaning, routine maintenance, repair, modification, testing, and inspection of contaminated process equipment from DWPF and from other facilities. In these facilities, equipment from the vitrification process and supporting cells can be decontaminated in a controlled fashion, using both remote and contact techniques. Usually, decontamination is first remotely performed in the REDC until a sufficiently low contamination level is reached. After that, final contact decontamination and/or maintenance can be performed in the CDMC (Ref. 2, Section 5.2.3.9).

These cells, except for the WTC, are located in the Remote Process Cell (RPC) and are serviced by the main process cell crane. New equipment to be installed in the RPC, or failed equipment to be removed from the RPC, is normally moved in, or out of, the Vitrification Building by way of the railroad well at the south end of the building (Ref. 2, Section 5.2.2.1).

Confinement of hazardous material in the vitrification building is generally accomplished using the confinement barriers and ventilation systems installed to confine radioactive materials within the process cell and to limit exposures to personnel in the operating areas of the building (Ref. 2, Section 5.1.3.3).

Shield windows are provided in the following main process cells (REDC, CDMC, MC, CDC and WTC) as well as in the following areas (CDC Smear Test Station [CDCSTS], Mercury Cells, Analytical Cells, Sample Cells, and the Crane Maintenance Area [CMA]) for observing operations (Ref. 2, Section 5.2.2.1).

Airlock separation is provided between the RPC and the exterior of the Vitrification Building. This airlock can accommodate a full size rail flatcar carrying the largest piece of process equipment. Rails are recessed in the airlock floor so that trucks or tractor/trailer rigs can also be used to deliver or remove equipment or components from the building. Airlock doors for the main process cells are administratively controlled. There are no interlocks or controls to prevent both doors from being open at the same time. (Ref. 2, Section 5.2.2.1).

Each of the individual main process cells (excluding the Backup Off-Gas [BuOG]), the railroad well, and each transfer tunnel (excluding the MC/CDC tunnel) are equipped with a sump and

sloped floors to facilitate drainage into the sump. Decontamination wash down solutions used in the cell and any spilled materials are collected in the sumps. Materials from sumps are pumped to the Decontamination Waste Treatment Tank (DWTT) or to the Recycle Collection Tank (RCT), neutralized, and transferred to the tank farm via the RCT. Drains from the crane maintenance floor sump are routed to the DWTT via the hot decontamination waste header (Ref. 2, Section 5.2.2.1).

3.1.2 Cold Chemical Storage (Building 422-S)

The cold chemical system provides the necessary chemicals for process requirements, decontamination, and neutralization operations. Bulk liquid chemicals and dry chemicals are received and stored in designated locations throughout the facility. After preparation, the cold chemicals are transferred to feed tanks in radiological areas on the first and third levels, on the mezzanine of the Vitrification Building, and to the Chemical and Industrial Waste Treatment Facility. Spills, overflows, and drains in Building 422-S outside facilities are collected in diked areas that drain to the caustic, nitric acid, or organic acid sumps. Catalyst solutions drain to a catalyst sump that discharges back to the catalyst tanks (Ref. 2, Section 5.4.13.1).

Nitrogen Supply System: Nitrogen gas systems supply users for purging, blanketing, pressurizing, measuring, sampling, and analyzing. The storage tank and vaporizers are located outdoors near the Cold Feed Storage Area (422-S). Outside overhead piping delivers gaseous nitrogen to the Pump Pit. Piping within the Cold Feed Storage Area (422-S), the Service Building (210-S), and the Vitrification Building (221-S) delivers gaseous nitrogen to other users (Ref. 2, Section 5.4.14.1).

3.1.3 Glass Waste Storage Buildings

GWSB #1 and GWSB #2 provide space for the safe handling and temporary storage of filled glass waste canisters while they are awaiting transfer to a permanent storage location. The GWSBs are located northwest of the Vitrification Building.

The connecting roads between the GWSBs and the Vitrification Building are designed for use by the SCT. Traffic sharing of the roads is administratively controlled (Ref. 2, Section 5.3.2.4).

Radiation shielding protection for personnel is provided by concrete walls, earth embedment, and a concrete deck that forms the floor of the operating area. The stored canisters are protected against external damage and are cooled by natural circulation to prevent internal heat buildup (Ref. 2, Section 5.3.2.4).

3.1.4 Low Point Pump Pit

The LPPP is equipped with three pump tanks (10 ft. 2 in. tall and 12 ft. in diameter; Ref. 2, Section 5.3.2.8): the Sludge Pump Tank (SPT), the Precipitate Pump Tank (PPT), and the Recycle Pump Tank (RPT). The pump tanks are housed separately in contiguous concrete cells. The pump cells are below grade with the walls extending upward above the building floor. These cells are separated by shield walls and atmospherically connected through ventilation openings in the side walls of the center (recycle waste) cell. Each cell has seven removable concrete shield covers that form a barrier over the cell to protect and maintain the structural integrity of the cell

and its contents. Access to the cells is achieved through the removal of the top concrete shielding covers. Closed circuit television cameras are provided to monitor in-cell maintenance operations.

The cell floors have a slope for drainage purposes and a shallow trench at the low side for direct flow to the sump. Each sump is equipped with a level indicator. Cells are lined with a minimum thickness of 3/8-inch stainless steel on the floor and partially up the walls. The remainder of the walls has 1/4-inch-thick liners. The pump cells are equipped with individual underliner systems for draining and detecting leaks in the stainless steel floor liners. A system of drainage slots in the concrete under the liner conducts leaks into an underliner sump. Collected leakage flows out the bottom drain to the underliner sump that is equipped with a conductivity probe and pump out capability (Ref. 2, Section 5.3.2.8).

3.1.5 Actinide Removal Process (Building 512-S, 512-6S, 512-7S)

The 512-S ARP is located in Building 512-S and designed to remove the actinides from the salt solution by filtration.

The 512-S ARP is comprised of the following buildings and support structures (Ref. 2, Section 5.3.2.9):

- 512-S, Process Building
- 512-1S, High Efficiency Particulate Air (HEPA) Filter Building
- 512-2S, Instrument Shelter Room
- 512-4S, Nitrogen Storage Pad
- 512-6S, Laboratory
- 512-7S, Cold Chemical Storage Area

The Process Building (512-S) is divided into a High Bay Process Area and a Low Bay Service Area. The Process Area consists of a below grade structural concrete pit internally divided into three cells lined with stainless steel. The cells are capped with segmented reinforced concrete covers that can be removed and replaced remotely, using the bridge crane located in the High Bay. The individual cells house equipment necessary for the chemical and filtration processes. Each of the three cells is equipped with a sump to collect leakage and spillage. A Backpulse Tank Vault is located at grade. The Service Area contains an Electrical Room, Battery Room, Change Room, offices, Crane Control Room, Vacuum Blower Room, and Instrument Control Valve Gallery.

Attached to the south end of Building 512-S is the Instrument Shelter (512-2S). The HEPA Filter Building (512-1S), which houses the Process Vessel Vent and Process Ventilation HEPA filter banks, is adjacent to 512-2S. A small laboratory (512-6S) is located to the East of the Process Building.

Located to the North of the Process building is the Nitrogen Storage Pad. The Cold Chemical Storage Area (512-7S), adjacent to the Nitrogen Storage Pad, provides a centralized location for the delivery, storage, and supply of cold feed chemicals to Building 512-S.

To support the process, the Filter Flush Water System provides for transfer of filter cleaning fluids in the amounts required for filter wet lay-up or chemical filter cleaning operations. The Process Vessel Vent System supplies fresh filtered air to the cells. Two air intake HEPA filters, one in service and the other in standby, mitigate the potential release of radioactive particulates in the event of a flow reversal from the cells to the environment.

The LWPT is used as a multipurpose reactor and filtration feed tank. Normally, MST treated Salt Solution is transferred from the Tank Farm to the LWPT. The ability to add MST to the Salt Solution is maintained in 512-S as an off-normal evolution. The MST/Salt Solution is then circulated through a cross-flow filtration unit to remove salt solution and concentrate the solids. Numerous batches of MST/Salt Solution are processed until the accumulated MST/Sludge Solids reach a slurry concentration suitable for transfer to DWPF. The MST/Sludge Solids are then washed with water to reduce the sodium remaining in the concentrated slurry. After washing is complete, the slurry is transferred. If necessary, the filter is chemically cleaned after the washing operation is complete, and spent cleaning solutions are also transferred to the LPPP-PPT. These spent chemical solutions also function as a flush of the transfer line. (Ref. 2, Section 5.3.2.9).

The filtrate produced during these operations will be collected in the Late Wash Hold Tank (LWHT) and later transferred to H Area. In MCU, the filtrate is treated as necessary to remove Cs-137 and then it is sent to the Saltstone Facility for incorporation into grout.

3.1.6 Decontaminated Equipment and Waste Staging

Decontaminated equipment, glass-contaminated equipment, and staged waste are stored in an outside location (Ref. 2, Section 5.4.15). Decontaminated equipment from DWPF intended for reuse may be stored in engineered containers (SeaLand or equivalent; up to five containers including two double-height containers). Equipment stored in these containers may consist of transfer pumps, jumpers, and other miscellaneous equipment and may contain only residual amounts of radioactive material. Additionally, up to two SeaLand containers may be used for storage of 55-gallon drums containing glass-contaminated equipment.

Staged waste may also be stored in approved containers (B-25s or SeaLand containers) and may contain transuranic or low level waste (Ref. 2, Section 5.4.15). From operating experience, no more than 30 B-25s are typically staged in this area.

3.1.7 Water Treatment and Storage Facilities (980-S)

The Water Treatment And Storage Facilities consist of a degasifier system, a pH adjustment system and a neutralized/fire water storage tank. This treated water supplies neutralized water to the neutralized/fire water storage tank. A combination neutralized well water/fire water storage tank with a capacity of 300,000 gallons is located outside the fire pump rooms on the south side of the water treatment building. The bottom 240,000 gallons of the tank are reserved for fire protection and cannot be accessed by the neutralized well water distribution system.

Neutralized (non-chlorinated) water is supplied to selected users where the chloride ion constitutes a chemical contaminant or a potential cause of stress corrosion cracking in stainless steel equipment or piping (Ref. 2, Section 5.4.5.2).

3.1.8 Failed Equipment Storage Vault

The Failed Equipment Storage Vault structure consists of reinforced concrete vaults, buried below grade. The FESV structure was designed as a Category I Facility. Each FESV is provided with a shield cover constructed of reinforced concrete, and a weather cover is placed over the area where the two shield covers meet to keep rain water from entering the vaults. The weather cover is constructed of galvanized steel with gasket material attached to the underside. The FESV structure has a crane for removal of covers and for movement of the unusable radioactive equipment to be stored in the FESV (Ref. 2, Section 5.3.2.10).

3.1.9 Interarea Transfer Lines

The Interarea Transfer Lines consist of buried pipelines connecting the Vitrification Building and H-Area facilities, with the ARP mostly in 512-S and the LPPP at intermediate locations (Ref. 2, Section 5.3.2.7). The soil cover above the transfer line jacket limits the dose rate at the ground surface to less than 1.0 mrem/hr. A soil thickness of 4 feet above the transfer line jacket is sufficient to achieve this (Ref. 2, Figure 5.3-2). The Interarea Transfer Lines system transfers:

- MST/Salt Solution from H-Area to the LWPT in the 512-S Building
- MST/Sludge Solids from the LWPT in the 512-S Building to the Precipitate Reactor Feed Tank (PRFT) in Vitrification Building via the LPPP-PPT
- Filtrate from the LWHT in 512-S to the Modular Caustic Side Solvent Extraction (CSSX) Unit (MCU)
- Sludge from Tank 40H to the Vitrification Building via the LPPP-SPT
- SE from MCU to the SEFT via the LPPP-SPT Cell
- Recycle from the Vitrification Building to the HDB-8 via the LPPP-RPT
- Decontaminated Salt Solution (DSS) from MCU to H-Area

Interarea Transfer Lines consist of lines with two 3-inch stainless steel core transfer lines surrounded by a 10-inch carbon steel jacket. Interarea Transfer Lines [i.e., Sludge, MST/Salt Solution, MST/Sludge Solids, Strip Effluent, Decontaminated Salt Solution (DSS) and 512-S Filtrate lines] are constructed to contain their contents, including following detonation in the core pipe or jacket (Ref. 2, Section 4.4.39.1). Because there is no mechanism for airborne release, these lines are not considered further in the EPHA.

3.2 VENTILATION SYSTEM

The ventilation systems are evaluated as part of the segment in which system is located.

3.2.1 Vitrification Building Ventilation

The process areas of the Vitrification Building are divided into three zones for purposes of ventilation and contamination control. Zone 1 contains the areas with the highest potential for contamination and Zone 3 includes the areas with the lowest potential for contamination.

Therefore, the air pressure is maintained highly negative for Zone 1 and slightly negative for Zone 3 (Ref. 2, Section 5.4.1.1). The areas contained in each zone are as follows:

Zone 1: The Zone 1 exhaust system collects off-gas from the Vitrification Building process areas, process vessels and enclosures, and the melter as well as ventilation air from these potentially contaminated areas. Each source is treated to reduce particulates before being fed to a common plenum. In this plenum, the various off-gas sources merge to a common air exhaust stream. This stream is treated by a sand filter to remove radioactive particulates. After filtration through the sand filter, the air is discharged to the atmosphere through a stack (Ref. 2, Section 7.2.1.1). The height of the stack from the top to the concrete foundation is 147 ft. (45 m) to provide elevated release and preclude released radioactive materials from being drawn back into the Vitrification Building air inlets (Ref. 2, Section 5.3.2.3).

Three normally operating fans and one standby fan are provided to continuously exhaust air from the Zone 1 areas. Fans are located in the Building 292-S fan house. Ventilation air from Zone 1 is drawn through the sand filter and then discharged to the atmosphere via the Zone 1 exhaust stack. The exhaust fans are equipped with variable inlet vanes, a flow measuring device, discharge dampers, and isolation dampers. Controls for the Zone 1 exhaust fans will start the standby fan when operational problems lead to a low flow condition or when the negative pressure in the exhaust rises above a set pressure.

All fans shut down if normal power fails. The two 480 V load centers in the Fan House which serve the Zone 1 exhaust fans are connected to the two standby diesel generators. One out of four Zone 1 exhaust fans is required to operate to maintain the negative pressure needed. The fans are automatically switched to diesel power in the event of normal power failure (Ref. 2, Section 5.4.1.1).

In case of stack blockage, a port on the duct segment leading from the fan house to the stack can be opened to allow the already filtered exhaust air to be discharged to the atmosphere near grade level (Ref. 2, Section 5.1.3.4).

Zone 2 and Zone 3: Exhaust air from Zone 3 of the 221-S Vitrification Building cascades to the Zone 2 areas (operating corridors). Air exhaust from Zone 2 areas, the weld test cell, and radiologically controlled shops is potentially contaminated with radioactivity. Exhaust air from each area is discharged into a single exhaust stream. This stream is processed through a common HEPA filtration unit to remove radioactive particulates before it is discharged to the atmosphere through a stack located on the Vitrification Building (Building 221-S) roof. Zone 2 exhaust system equipment is located upstream of the common HEPA filtration unit (Ref. 2, Section 7.2.1.2).

3.2.2 Cold Feed Preparation Ventilation Systems

For Building 221-S, separate vent paths are used to segregate organic acid vapor and other chemical vapors in the cold feed tanks. Formic acid vapor collected from the 90% formic acid feed tank is vented to the 221-S roof. The gases in the cold feed vent header are filtered and discharged to the Zone 2 exhaust stack (Ref. 2, Section 7.3.1.1).

For 422-S, two tank ventilation systems are provided for the outside facilities to direct discharge of chemical vapors and particulates to the environment through high efficiency filters. The high efficiency filter removes most particles, and the HEPA filter removes the submicron particles from the off-gas. The chemical vapors from the formic acid dilution tank, dilute formic acid feed tank, frit slurry makeup tank, and oxalic acid make up tank are vented through an organic acid vent system (Ref. 2, Section 7.3.1.1).

3.2.3 512-S and Low Point Pump Pit Ventilation Systems

For the process tanks and cells during normal operations at the 511-S (LPPP) and the 512-S buildings, contaminated or potentially contaminated gaseous effluents are collected in the Pump Pit Ventilation System Process Vessel Ventilation System (PVVS) and filtered through sets of HEPA filters. The Pump Pit Ventilation System exhausts through a heater and HEPA filters before release through the Pump Pit Stack (Ref. 2, Section 5.4.1.1). The maintenance and service areas and open cells in the maintenance mode are directed through HEPA filters in the Maintenance and Service Area Exhaust systems (Ref. 2, Section 7.2.1.3). The stacks for the 511-S and 512-S are not significantly taller (i.e., 2.5 times taller) than the adjacent buildings.

3.2.4 Glass Waste Storage Building Ventilation Systems

The ventilation systems for the Glass Waste Storage Building Vaults are designed for removal of the canisters decay heat (Ref. 2, Section 5.4.1). For GWSB #1, the office area and electrical equipment room are provided with heating and cooling units. An exhaust fan discharges air from selected portions of the office area through an 18-ft. (5.48-m) stack (Ref. 2, Section 5.4.1.1).

3.2.5 Chemical Waste Neutralization Facility (980-S) Vent

The chemical waste neutralization facility provides for the neutralization and permitted disposal of nonradioactive chemical and industrial liquid wastes from the DWPF. The chemical waste neutralization system tanks vent to the atmosphere. The organic neutralization tanks are provided with flame arrestors in their vent lines (Ref. 2, Section 7.3.1.2).

3.3 FACILITY BOUNDARY DESCRIPTIONS

3.3.1 Site Boundary

The site boundary (SB) is defined as the perimeter of the DOE-owned and controlled land at SRS. The distance to the closest site boundary from DWPF is 10,940 meters (Ref. 1).

3.3.2 Facility Boundary

Rather than calculate the distance from the release to the nearest facility boundary for each scenario, a common distance to the facility boundary (FB) is determined (Ref. 1). For DWPF a default distance of 100 m is used (Ref. 1). Building 512-S, although remote to S Area, will be analyzed using the same facility boundary distance (100 m).

3.3.3 Other Onsite Receptors of Interests

In addition to receptor locations used for emergency classifications (30 meters, Facility Boundary, and Site Boundary), consequences to other adjacent facilities with public access or significant personnel occupancy are also considered. The Crackerneck Wildlife Management Area (WMA) is 9400 meters from S-Area and the Central Training Facility (CTF) is approximately 570 meters distant (Ref. 1).

4.0 HAZARD CHARACTERIZATION

The objective of this section is to identify hazards that are significant enough to warrant consideration in a facility's operational emergency hazardous material program. Note that "hazard," as used in this section, refers to both non-radioactive hazardous materials and radioactive material.

It eliminates from further analysis those materials that do not present an airborne, toxic hazard.

DOE G 151.1-2 states that materials that are monolithic solids under normal conditions, and thus, do not present an airborne hazard may be eliminated from consideration in the hazards assessment (Ref. 4, Section A.2.1). In accordance with this guidance, solid vitrified waste is generally eliminated from further consideration. However, if a plausible scenario is postulated that can reduce solid glass to a respirable aerosol, then it will be considered.

4.1 NON-RADIOACTIVE MATERIALS

4.1.1 Chemical Screening

According to the *Hazards Survey for S-Area* (Ref. 7), the chemical screening for DWPF identified formic acid and dimethyl mercury as needing further evaluation in the EPHA.

A more detailed discussion of chemical screening, including all inventory data, can be found in Reference 7. Chemicals in the canyon (221-S) were included in the Hazards Survey (HS), but excluded in the EPHA because there is no pathway for a release.

For stored chemicals, dikes provide containment for contents of the largest tank within the diked area, as well as segregation of incompatible liquids. As these passive mitigative devices will prevent mixing of incompatible chemicals, no reactive releases are postulated for stored chemicals.

4.1.2 Hazardous Biological Agents and Toxins

There are no federally listed "biological select agents or toxins" being shipped to, cultured, stored, or associated with work being performed at SRR facilities (Ref. 8).

4.2 RADIOACTIVE MATERIALS

All segments containing radioactive material previously listed are categorized as either a Hazard Category 2 or 3 Facility (Ref. 2). According to the *Hazards Survey for S-Area* (Ref. 7), radioactive materials previously listed are required to be evaluated in the EPHA.

4.3 HAZARDOUS MATERIAL REMAINING FOR ANALYSIS

The above-described methodologies were applied to DWPF chemical and radionuclide (Calc 1) inventories. Hazards identified as requiring further analysis are (Ref. 2 and 7):

Chemicals	Radionuclides
formic acid; dimethyl mercury	Co-60, Sr-90, Ru-106, Cs-134, Cs-137, Ce-144, Pm-147, Eu-154, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-244

4.4 PROTECTIVE ACTION CRITERIA (PAC) FOR REMAINING HAZARDS

4.4.1 Radiological Protective Action Criteria

Two radiological PAC are used in emergency planning. The first is 1 rem Total Effective Dose (TED). This is the threshold, at specific receptors, used to classify a potential operational emergency. The second PAC is 100 rem, the TEL, and is used in development of a facility EPZ (Ref. 1).

Radiological Protective Action Criteria

PAC Name	Value (rem)
Operational Emergency	1
Threshold for Early Lethality	100

4.4.2 Chemical Protective Action Criteria

Chemical PAC used in emergency planning listed in order of preferences are: Acute Exposure Guideline Levels (AEGLs) promulgated by the U.S. Environmental Protection Agency (EPA); Emergency Response Planning Guide (ERPGs) published by the American Industrial Hygiene Association; and the Temporary Emergency Exposure Limits (TEELs) developed by DOE. For these criteria, the exposure level to be used represents no irreversible health effects (i.e. AEGL-2, ERPG-2, or TEEL-2) commonly referred to as PAC-2 (Ref. 32).

The PAC-3 (i.e., AEGL-3, ERPG-3, or TEEL-3) is considered the TEL. Criteria used for chemicals of concern in the EPHA are (Ref. 32):

Chemical Protective Action Criteria

Chemical	PAC-2	PAC-3	Units
formic acid	25	250	ppm
dimethyl mercury	0.046	2.3	mg/m^3

5.0 ACCIDENT ANALYSIS

The method used to transform inventories of hazardous materials into STs is as follows:

- Determine barrier failure modes by identifying initiating events.
- For each failure mode, determine mechanisms for release.
- Based on release mechanisms, develop a quantitative estimate of the MAR.
- Consider the nature of the material (physical state, vapor pressure, etc.) and the postulated mode of failure.
- Calculate the ST by applying the damage ratio (DR), airborne release fraction (ARF), respirable fraction (RF), and the leak path fraction (LPF) for each event to the MAR.

5.1 SOURCE TERM DEVELOPMENT

5.1.1 Radiological Source Terms

The radiological ST is calculated as follows (Ref. 1):

$$ST = (MAR)(DR)(ARF)(RF)(LPF) \qquad \text{[Eq. 5-1]}$$

where:

ST =	Source Term
MAR =	Material at Risk
DR =	Damage Ratio (fraction)
ARF =	Airborne Release Fraction
RF =	Respirable Fraction
LPF =	Leak Path Factor (fraction)

Since the purpose of this EPHA is to establish the emergency-planning basis in regards to the initial phases of an event (identification, classification, and initial protective actions), the resuspension ST will not be calculated or utilized. The use of the maximum ST and the worst-case dispersal conditions in the consequence assessment of accident scenario is extremely conservative and compensates for this assumption.

According to DOE-HDBK-3010-94, by the time a maximum MAR has been assumed and:

- DR has been maximized as 1;
- bounding ARFs and RFs have been applied;
- no leakpath reduction is accounted for; and
- 95% or greater meteorology has been used for dispersion;

the answer obtained is extremely conservative (Ref. 10, Section 7.3.6.2). For the EPHA, the maximum MAR for the facility or container type is used in determining the ST and conservative meteorology is used in consequence assessment. In order to reduce conservatism or an overestimation of the consequences, median ARF and RF values are used when available. Note: If median ARF/RF values are unavailable, bounding ARF/RF values are assumed.

The duration of releases considered in EPHA are: explosion 3 min, spill 10 min (Ref. 1, Section 5.1.4.7), and fire 20 min (Ref. 25, Section 4.0). Chemical releases are evaluated at 15 min (Ref. 1, Section 3.0).

5.1.2 Equivalent Isotope Calculation of Source terms

To aid in the accident scenario/consequence assessment analysis, the MAR for each segment are converted into a dose equivalent isotope to facilitate dispersion modeling calculations. The STs are converted into a Pu-238eq on the basis of dose. Because the listings for radionuclides in the FSAR do not provide specific information on the absorption, FGR 13 (Ref. 6) is used to convert materials to Pu-238eq with a default M absorption type and for consequence assessment modeling. If criticalities are considered, an radioisotope mixture is used based on the FSAR documents or as shown in DOE-Handbook-3010-94 (Ref. 10) for material that contributes to ground shine. The conversion of multiple isotopes to Pu-238eq simplifies the comparison of various scenarios and allows for a more rapid consequence assessment under actual meteorological conditions during an incident. Dose calculations in safety basis documents generally convert multiple isotopes to Pu-239 equivalent curies whereas an EPHA uses Pu-238eq Ci.

$$Pu-238eq = \frac{1}{DCF_{Pu-238}} \sum_i (A_i)(DCF_i) \qquad \text{[Eq. 5-2]}$$

where:

Pu-238eq =	Pu-238 equivalent (curies). Other isotopes may be used; however, Pu-238(M) is the historical choice for all but noble gases and iodine.
DCF_{Pu-238} =	Exposure-to-Dose Conversion Factors for Inhalation per Unit Intake for Pu-238(M) as taken from Federal Guidance Report No. 13 (Ref. 6).
A_i =	The number of Curies of the *i*th isotope.
DCF_i =	Exposure-to-Dose Conversion Factor for Inhalation for *i*th isotope.

Note: Most safety basis documents use International Commission on Radiological Protection Publications (ICRP) 68 (Ref. 9) and ICRP 72 (Ref. 11) as the basis for the DCFs for workers and the public, respectively. The EPHA uses FGR 13 (Ref. 6) DCFs (based on ICRP 72) for all receptors – workers and the public. Because of this, there may be a slight difference between the DCFs used for Safety Basis documents and those used for EPHAs.

5.1.2.1 Radiological Inventory for DWPF

For most releases from DWPF waste streams, the groundshine contribution to the TED is negligible. Exceptions include aerosol release from the strip effluent stream and releases of Cs-137 and Sb-125. For these exceptions, the inhalation pathway is still the dominant pathway resulting in approximately 80% of the TED (Ref. 12, Sheet 18). Pu-238eq values from the

characterization of the MAR are determined in Appendix B, Calculation 1 (except for SEFT), and summarized in the below table:

Table 5.1 Summary of MAR Values

Description	Location: Tank(s)	MAR
Sludge Stream	*LPPP:* SPT	1.45E+00 Ci/gal Pu-238eq
Strip Effluent Stream	*CPC:* SEFT	1.65E+01 Ci/gal Cs-137 (Ref. 2, Table 9.4-1a)
Sludge Receipt and Adjustment Tank (SRAT) Stream	*CPC:* SME, SMECT, Melter Feed Tank (MFT), SRAT	2.65E+00 Ci/gal Pu-238eq
Melter Off-gas Stream	Melter Off Gas	4.97E-05 Ci/ft^3 Pu-238eq
Melter Stream 24 (includes volatile component)	Melter, Canister	9.38E-01 Ci/lb. Pu-238eq
Recycle Stream	*CPC:* RCT; *LPPP:* RPT	8.90E-01 Ci/gal Pu-238eq
512-S Feed Stream	Feed Stream	1.74E-02 Ci/gal Pu-238eq
MST/Sludge Solids Stream (at LWPT Vessel Heel)	*SPC:* PRFT; *LPPP:* PPT; *512-S:* LWPT	7.32E-01 Ci/gal Pu-238eq
DWTT	*CPC: DWTT Tank*	5.30E-01 Ci/gal Pu-238eq
Filtrate Stream	*512-S:* LWHT	2.18E-02 Ci/gal Pu-238eq
SeaLand Container – Sludge	Waste Staging	2.11E-01 Ci Pu-238eq
2 SeaLand Containers – Glass	Waste Staging	4.43E+03 Ci Pu-238eq
B-25 Container	Waste Staging	1.40E-01 Ci Pu-238eq

5.1.3 Chemical Source Terms

The approach embodied in the ST equations presented above for radioactive materials can also be applied to non-volatile chemicals. However, no compendium of values for ARF and RF currently exists for chemicals. Usually these parameters are derived from the material properties using basic physical and chemical principles. Alternatively, given the MAR and release scenario, the ALOHA (Ref. 13) computer code can be used to determine chemical STs and model their transport and dispersion. Key factors in developing chemical STs are often spill area, duration of release, and the presence of an energy source. Chemical STs for reaction product formation (e.g., two chemicals spilling and mixing) are normally determined by manual calculation using conservative assumptions.

5.1.3.1 Chemical Inventory for DWPF

The maximum concentration of dimethyl mercury in DWPF is 3 mg/L. This is a bounding value for transfers from CSTF. It is representative of the bounding 3H Overheads condensate, which is the highest potential source of dimethyl mercury in the CSTF (Ref. 14). This value will be used to represent the composition of transfers from CSTF to DWPF.

The formic acid inventory as identified in the HS (Ref. 7) is as follows:

Location	Quantity
221-S	1205 gal
	615 gal
422-S	6500 gal
	6500 gal
980-S	3147 gal
	3147 gal

5.1.4 Threshold Source Term Determination

Operational emergency thresholds were determined for each postulated type of event by determining the ST required to reach PAC at 30 meters. The ST required to reach the PAC is compared to the ST obtained from each scenario. If the scenario ST did not equal or exceed the PAC ST the scenario was eliminated from further analysis.

Calculation 5 in Appendix B documents threshold quantities necessary for events to exceed PAC at receptor locations of interest (i.e., classifiable Operational Emergencies [OEs]). These threshold quantities are used to determine if further analysis is required for a specific event. The threshold quantities are also provided in the EALs to provide the MAR and ST for classification purposes. If the ST for a specific event does not meet or exceed the threshold quantity then the event will not exceed the PAC and therefore does not result in a classifiable emergency. Events that meet or exceed the threshold quantity are carried forward for consequence analysis.

5.2 221-S VITRIFICATION BUILDING

5.2.1 Chemical Releases

Formic acid tanks are found within Building 221-S, but, as stated in Appendix B, Calculation 3, there are no consequences from releases from a formic acid release because any overflow or spill is captured by the Organic Acid Drain Catch Tank (Ref. 2, Section 5.4.13.3). This tank has a 1205 gallon capacity well over the 615 gallon capacity of the Formic Acid Feed Tank in 221-S (Ref. 2, Table 9.4-11). This effectively eliminates any release to the environment.

All other chemicals within 221-S were screened out (Ref. 7). Chemical releases from 221-S do not need further consideration in the EPHA.

5.2.2 Radiological Releases

Scenarios analyzed address single tank events and will not disable ventilation systems.

5.2.2.1 221-S Tank Spill/Breach

Failure of Primary Barrier — Tank is ruptured due to cell cover/equipment drop, etc., and the contents are spilled to the cell floor. The supporting documents for the FSAR considered spills within the process cells resulting from the following sources:

- Leak in the lines from Hanford Connectors, corrosion, explosion, etc.
- Tank overflows.
- Vessel failure due to corrosion, explosions, etc.
- Seismic event.

Other Barriers/Mitigative Features — Releases from the cell are mitigated by the sand filter and released through the 45 m stack.

Range of Possible Releases — The median ARF/RF is 2E-05/0.7 for a 3 m free-fall spill of slurry and 4E-05/0.7 for an aqueous solution (Ref. 10, Section 3.1). All of the non-melter waste streams except MCU SE are assumed to be slurries with at least 1-wt% sludge solids. The MCU SE has less than 1-wt% solids and is treated as an aqueous solution for selecting ARF/RF values (Ref. 15, Section 4.0 Input Number 1). A DR of 1 is used to reflect the entire contents of the tank spilling to the floor. The sand filter Decontamination Factor (DF) is 200 (Ref. 2, Table 9.4-7). The LPF (5E-03) is the inverse of the DF. This is evaluated as filtered elevated releases (45 meters) with release duration of 10 minutes.

5.2.2.1.1 SPC Tank Spill/Breach

The PRFT contains the MST/Sludge Concentrated Solids Stream. The maximum overflow/spill volume is 8310 gal for the PRFT (Ref. 2, Table 9.4-2). The MST/Sludge Solids Stream is used for this inventory. Although there may be some leakage of a 3-way valve between the PRFT and the SEFT the amount of strip effluent from SEFT is assumed to be extremely small in comparison to the volume of MST/Sludge Solids in PRFT.

Release Designation 1-RD-1

MAR (Pu-238eq Ci/gal)	Spill Volume (gal)	MAR (Ci Pu-238eq)	DR	ARF	RF	LPF	ST (Ci Pu-238eq)
7.32E-01	8310	6.08E+03	1	2E-05	0.7	5E-03	**4.26E-04**

This event does not exceed the declaration threshold ST of 3.95E-01 Ci Pu-238eq for a 10 minute filtered elevated release (Appendix B, Calculation 5). It is therefore removed from further consideration.

5.2.2.1.2 CPC Tank Spill/Breach

The CPC contains the RCT, the SRAT, the SMECT, the Slurry Mix Evaporator (SME), MFT, SEFT, and the DWTT. Of these tanks the SME and DWTT have the maximum overflow volumes of 11,298 gal (Ref. 2, Table 9.4-2). The SME (along with the SMECT, SRAT and MFT) contains SRAT stream with 2.65 Ci/gal Pu-238eq. The DWTT contains 5.30E-01 Ci/gal Pu-238eq. Therefore, the SME MAR bounds the DWTT MAR. The SEFT has an overflow volume of 10,657 gal and the main constituent in this tank is strip effluent which contains primarily Cs-137 (Ref. 2, Tables 9.4-2 and 9.4-1a). Although there may be some leakage of a 3-way valve between the PRFT and the SEFT the amount of MST/sludge solids from the PRFT waste stream is assumed to be extremely small in comparison to the volume of strip effluent in SEFT. The RCT has an overflow volume of 10,479 gal and contains the Recycle Stream with 8.90E-01 Ci/gal. This RCT is bounded by the SME tank. The SME tank and the SEFT volume

and contents will be used to determine the ST for this scenario. SRAT Stream from Calculation 1 is used for the inventory for the SME.

Release Designation 1-RD-2

Tank	MAR (Ci/gal)	Spill Volume (gal)	MAR (Ci)	DR	ARF	RF	LPF	ST (Ci)
SME	2.65E+00 Pu-238eq	11,298	2.99E+04	1	2E-05	0.7	5E-03	**2.09E-03 Pu-238eq**
SEFT	1.65E+01 Cs-137	10,657	1.76E+05	1	2E-05	0.7	5E-03	**1.23E-02 Cs-137**

This event does not exceed the declaration threshold ST of 3.95E-01 Ci Pu-238eq or 6.80E+03 Ci Cs-137 for a 10 minute filtered elevated release (Appendix B, Calculation 5).

5.2.2.1.3 Off-Gas Condensate Tank or Backup Off-Gas Condensate Tank Spill/Breach

The OGCT and the BuOGCT have a maximum volume of 12,000 gal (no overflow volume provided). The Melter Off-gas Stream from Appendix B, Calculation 1 is used for the inventory.

Release Designation 1-RD-3

MAR (Pu-238eq Ci/ft^3)	Spill Volume(gal)	MAR (Ci Pu-238eq)	DR	ARF	RF	LPF	ST (Ci Pu-238eq)
4.97E-05	1604	7.97E-02	1	2E-05	0.7	5E-03	**5.58E-09**

MAR (Ci Pu-238eq) = MAR (Pu-238eq Ci/ft^3) *(Spill Volume gal / 7.48 gal/ft^3)

This event does not exceed the declaration threshold ST of 3.95E-01 Ci Pu-238eq for a 10 minute filtered elevated release (Appendix B, Calculation 5). It is therefore removed from further consideration.

5.2.2.1.4 Melter Spill/Breach

This postulated event involves a spill of the entire molten glass inventory (888 gal overflow volume) in the melter (Ref. 2, Table 9.4-2). The event involves a splash portion resulting from the initial spill and an off-gas portion as the volatiles escape from the cooling glass (Ref. 16, Section 6.2.1).

At highly elevated temperatures, some semi-volatile isotopes can become volatile and be released as respirable particles. In DWPF, temperatures high enough to support this phenomenon are only present in the molten glass contained in the melter. Of the semi-volatile isotopes modeled in the DWPF curie balance, only Cs-137 and Ru-106 were found to have the potential to be volatilized at the temperatures present in the molten glass. Analyses have demonstrated, however, that these two semi-volatile isotopes alone are not sufficient to model all significant radiological consequences due to molten glass releases. For these types of events, two additional isotopes must be modeled: Sb-125 and its daughter Te-125m (these isotopes have insignificant impact on other events which do not involve molten glass). Therefore, for accidents involving molten glass, volatile isotopes are assumed to have release fractions of 1, and the nonvolatile isotopes and the remaining semi-volatile isotopes are assumed to have release fractions of zero (Ref. 2, Section 9.4.1.2. p 9.4-9).

The volatile elements in the melter off-gas are cesium, ruthenium, tellurium and antimony (strontium would normally be volatile, but the strontium in the molten glass is not volatile due to

its form). The time duration to release 90% of the volatiles is less than 10 minutes (Ref. 16, Section 6.2.2). For modeling, a 10 minute release duration for the spill and the volatile release is assumed. Both streams interact in the sand filter and are exhausted from the 45 m stack.

The Melter Stream is used for the spill component as a viscous solution and the Melter Off-gas Stream is used for the volatilization component. The inventory of the Melter Off-gas Stream is 35.3 ft^3 and the volume of the melter is assumed to be at the overflow volume of 888 gal (22,256 lbs.) (Ref. 16, Sheet 46). The median ARF/RF for a spill of a viscous solution is 3E-06/0.8 (Ref. 10, Section 3.1).

Note: Because the volatile components are dominated by gamma emitters, a mixture file is used to model this release. The DF of 200 for the sand filter equates to an efficiency of 99.5% (LPF = 5E-03) for use in the mixture file.

Release Designation 1-RD-4

Volatile Component (Melter Off-gas Stream)

Isotope	MAR (Ci/ft^3)	Spill Volume(ft^3)	MAR (Ci)	DR	ARF	RF	LPF	ST (Ci)
Ru-106	1.34E-04	35.5	4.76E-03	1	1	1	5E-03	2.38E-05
Cs-137	6.86E-03	35.5	2.44E-01	1	1	1	5E-03	1.22E-03
Sb-125	2.47E-05	35.5	8.77E-04	1	1	1	5E-03	4.39E-06
Te-125m	5.15E-05	35.5	1.83E-03	1	1	1	5E-03	9.15E-06

Spill Component (Melter Stream)

Isotope	MAR (Ci/lb.)	Spill Volume(lbs)	MAR (Ci)	DR	ARF	RF	LPF	ST (Ci)
Co-60	9.62E-02	22,256	2.14E+03	1	3E-06	0.8	5E-03	2.57E-05
Sr-90	2.63E+01	22,256	5.85E+05	1	3E-06	0.8	5E-03	7.02E-03
Ru-106	1.28E+00	22,256	2.85E+04	1	3E-06	0.8	5E-03	3.42E-04
Cs-134	8.22E-02	22,256	1.83E+03	1	3E-06	0.8	5E-03	2.20E-05
Cs-137	1.10E+01	22,256	2.45E+05	1	3E-06	0.8	5E-03	2.94E-03
Ce-144	5.62E+00	22,256	1.25E+05	1	3E-06	0.8	5E-03	1.50E-03
Pm-147	1.37E+01	22,256	3.05E+05	1	3E-06	0.8	5E-03	3.66E-03
Eu-154	3.52E-01	22,256	7.83E+03	1	3E-06	0.8	5E-03	9.40E-05
Pu-238	8.38E-01	22,256	1.87E+04	1	3E-06	0.8	5E-03	2.24E-04
Pu-239	7.28E-03	22,256	1.62E+02	1	3E-06	0.8	5E-03	1.94E-06
Pu-240	4.87E-03	22,256	1.08E+02	1	3E-06	0.8	5E-03	1.30E-06
Pu-241	9.42E-01	22,256	2.10E+04	1	3E-06	0.8	5E-03	2.52E-04
Am-241	6.10E-03	22,256	1.36E+02	1	3E-06	0.8	5E-03	1.63E-06
Cm-244	6.04E-02	22,256	1.34E+03	1	3E-06	0.8	5E-03	1.61E-05

See Appendix B, Calculation 2 for consequence assessment output.

5.2.2.2 221-S Transfer Spills

Failure of Primary Barrier — Transfer line, feed line, or vent line is broken/mis-installed, etc. and transfer is spilled to the floor.

Other Barriers/Mitigative Features — Releases from the cell are mitigated via the Heating, Ventilation, and Air Conditioning (HVAC) system.

Range of Possible Releases — The median ARF/RF is 2E-05/0.7 for a 3 m free-fall spill of slurry and 4E-05/0.7 for an aqueous solution (Ref. 10, Section 3.1). All of the non-melter waste

streams except SE are assumed to be slurries with at least 1-wt% sludge solids. The SE has less than 1-wt% solids and is treated as an aqueous solution for selecting the bounding ARF/RF of 2E-04/0.5 (Ref. 15, Section 4.0 Input Number 1). A DR of 1 is used. The sand filter DF is 200. The LPF (5E-03) is the inverse of the DF making the filter efficiency 99.5%. Transfers are assumed to flow for 10 minutes prior to discovery and shutoff. Spills due to overflowing tanks are also assumed to flow for 10 minutes prior to discovery and shutoff. This is a filtered elevated release (45 meters) with release duration of 10 minutes.

5.2.2.2.1 Transfer Spill Involving the SPC

This transfer involves a transfer from the LPPP PPT to the PRFT. The spill rate is assumed to be 250 gpm (Ref. 15, Table 6-1) over 10 minutes for a total spill volume of 2500 gal. MST/Sludge Solids Stream is used for the inventory.

Release Designation 1-RD-5

MAR (Pu-238eq Ci/gal)	Transfer Rate (gal/min)	Spill time (min)	Spill Volume (gal)	MAR (Ci Pu-238eq)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
7.32E-01	250	10	2500	1.83E+03	1	2E-04	0.5	5E-03	**9.15E-04**

This event does not exceed the declaration threshold ST of 3.95E-01 Ci Pu-238eq for a 10 minute filtered elevated release (Appendix B, Calculation 5). It is therefore removed from further consideration.

5.2.2.2.2 Transfer Spill Involving the CPC

There are several potential transfer spills for process in DWPF. The table below lists the highest volume spill for streams in DWPF (Ref. 15, Table 6-1).

Stream	Description	Spill Rate (gal/min)	Volume in 10 minutes	Pu-238eq*	Pu-238eq Ci
Sludge Stream	Transfer from LPPP or within DWPF process area	250	2500 gal	1.45E+00 Ci/gal	3.63E+03
MST / Sludge Solids Stream	Transfer from LPPP or within DWPF process area (if transferring from PRFT)	250	2500 gal	7.32E-01 Ci/gal	1.83E+03
Recycle Stream	Transfer within DWPF process or to LPPP	250	2500 gal	8.90E-01 Ci/gal	2.23E+03
SRAT Stream	Transfer within DWPF process area	250	2500 gal	2.65E+00 Ci/gal	6.63E+03
Melter Stream	Transfer within DWPF process area	1.67	419 lbs.**	9.38E-01 Ci/lb.	3.93E+02
Strip Effluent**	Transfer from SEFT to SRAT (62.5% SE and 37.5% LWPT Vessel Heel)	250	2500 gal	See mixture file	***
DWTT	Transfer within DWPF process area	250	2500 gal	5.30E-01 Ci/gal	1.33E+03

*From Calc 1
**(1.67 gal/min / 7.48 gal/ft^3) * 187.5 lbs./ft^3*10 min (Ref. 16, Sheet 46)
***This waste stream will have a high gamma component; therefore it will be evaluated separately. The percentages are reflected as the DR for the respective stream.

Transfers involving the SRAT Stream bounds all other transfer spills in the CPC (excluding the MCU Strip Effluent). Both the SRAT Stream and the MCU SE will be evaluated and the waste

stream that produces the further distance to the PAC will be used to develop an EAL for this scenario, if warranted.

Release Designation 1-RD-6a

SRAT Stream

MAR (Pu-238eq Ci/gal)	Transfer Rate (gal/min)	Spill time (min)	Spill Volume (gal)	MAR (Ci Pu-238eq)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
2.65E+00	250	10	2500	6.63E+03	1	2E-05	0.7	5E-03	**4.64E-04**

This waste stream does not exceed the declaration threshold ST of 3.95E-01 Ci Pu-238eq for a 10 minute filtered elevated release (Appendix B, Calculation 5). It is therefore removed from further consideration.

Release Designation 1-RD-6b

SE Stream (62.5% SE and 37.5% LWPT Vessel Heel) (Ref. 15, Input 3)

Isotope	MAR (Ci/gal)	Spill Volume (gal)	% of Stream	MAR (Ci)	DR	ARF	RF	LPF	ST (Ci)
Strip Effluent	Aqueous								
Cs-137	1.65E+01	2500	0.625	2.58E+04	1	4E-05	0.7	5E-03	3.61E-03
MST/Sludge Solids	Slurry								
Co-60	7.49E-02	2500	0.375	7.02E+01	1	2E-05	0.7	5E-03	4.91E-06
Sr-90	2.02E+01	2500	0.375	1.89E+04	1	2E-05	0.7	5E-03	1.33E-03
Ru-106	9.98E-01	2500	0.375	9.36E+02	1	2E-05	0.7	5E-03	6.55E-05
Cs-134	7.04E-02	2500	0.375	6.60E+01	1	2E-05	0.7	5E-03	4.62E-06
Cs-137	1.77E+00	2500	0.375	1.66E+03	1	2E-05	0.7	5E-03	1.16E-04
Ce-144	4.36E+00	2500	0.375	4.09E+03	1	2E-05	0.7	5E-03	2.86E-04
Pm-147	1.07E+01	2500	0.375	1.00E+04	1	2E-05	0.7	5E-03	7.04E-04
Eu-154	2.74E-01	2500	0.375	2.57E+02	1	2E-05	0.7	5E-03	1.80E-05
Pu-238	6.49E-01	2500	0.375	6.08E+02	1	2E-05	0.7	5E-03	4.26E-05
Pu-239	5.70E-03	2500	0.375	5.34E+00	1	2E-05	0.7	5E-03	3.74E-07
Pu-240	3.80E-03	2500	0.375	3.56E+00	1	2E-05	0.7	5E-03	2.49E-07
Pu-241	7.29E-01	2500	0.375	6.83E+02	1	2E-05	0.7	5E-03	4.78E-05
Am-241	1.17E-02	2500	0.375	1.10E+01	1	2E-05	0.7	5E-03	7.68E-07
Cm-244	4.69E-02	2500	0.375	4.40E+01	1	2E-05	0.7	5E-03	3.07E-06

See Appendix B, Calculation 2 for consequence assessment output.

5.2.2.3 221-S Explosions

Failure of Primary Barrier —A deflagration results when the concentration of hydrogen is between the Lower Flammability Limit (LFL) and the Upper Flammability Limit (UFL). If a concentration of hydrogen is between the lower explosive limit to stoichiometric concentrations, the resulting explosion is a detonation (Ref. 17, Assumptions). Because the hydrogen concentrations in DWPF are maintained below the LFL for hydrogen through TSR controls (Ref. 18), the resulting explosion in vessels are assumed to be deflagrations. The tanks have two routes for pressure release allowing the expanding gas to escape to the atmosphere. There would be no large breach in the tank leading to a spill.

Other Barriers/Mitigative Features — Releases from the cell are mitigated via the ventilation system and exhausted from the facility through a sand filter and 45 m exhaust stack.

Range of Possible Releases — The bounding ARF/RF value is 5E-05/0.8 (Ref. 10, Section 3.2.2.3.2) for low pressure venting of liquids (i.e., tank failure). The DR = 1. The sand filter has a DF of 200 making the LPF to be 5E-03. The volume used in the following scenarios was determined in Reference 17.

The worst-case ST for pool fires is derived assuming a bounding spill in the CPC and is used for internal vessel pool fires. The ST for the bounding pool fire is added to that for an internal vessel explosion and assumes enough Isopar L is present to produce a pool fire with very little liquid waste present. Pool fire consequences are only evaluated for the vessels potentially containing Isopar L, i.e., the SEFT, PRFT, SRAT and SMECT. The SME, MFT, melter and RCT are hydrogen only and do not contain consequences contributed by organic pool fire (Ref. 2, Section 9.4.1.2). Converting Reference 17 (Sheet 21) to account for an increase in Isopar concentration from 105 ppm to 600 ppm, the bounding spill of the SEFT (12,000 gal) will release:

12,000 gallons X 3.785 L/gallon X 1.002 kg/L X 600 ppm by wt = 27.3 kg Isopar or 27.3 kg/163 kg/kg-mol = **0.1675 kg-mol Isopar**.

The total heat released by combustion is: Heat – 0.1675 kg-mol X 7,683,820 kJ/kg-mol = **1.29E+06 kJ**

From the heat of vaporization of the sludge, taken as that of water, assuming 50% energy deposition, the sludge vaporized is: Sludge = 0.5 X 1.29E+06 kJ/2261 kJ/kg = **285.3 kg**.

With the density assumed to be 1.26 g/cc this equates to 2.26E+05 cc or **59.7** gal of sludge. This is the bounding amount of material involved in a pool fire inside the tanks.

The radiological content is assumed to be equivalent to SRAT Stream (Ref. 17). The median ARF/RF for quiescent burning of a small solvent layer over large aqueous layer burning to self-extinguishment is 6E-03/1 (Ref. 10, Section 3.1). The median ARF/RF for a vigorously burning organic fire or the burning of a solvent over an aqueous phase that burns to complete dryness is 1E-02/1 (Ref. 10, Section 3.1).

These events are elevated releases with a 3 minute duration.

5.2.2.3.1 221-S Multiple Tank Explosion

A hydrogen explosion occurs in the tank. This explosion causes the loss of vessel purge flow, which causes other vessels to explode and create pool fires within the tanks or spillage of the tank contents to the floor (Ref. 2). The vessels share multiple purge supplies with the other CPC vessels providing a route for propagation of the explosion and creating pool fires in tanks with an organic layer (Isopar L). Because a deflagration is less energetic than a detonation the RCT is not affected. The deflagration is assumed to not cause severe damage to the Vitrification Building. The SMECT is assumed to contain radioactive material due to SRAT carryover and the SEFT and PRFT are assumed to contain a mixture of strip effluent and MST/sludge solids due to leakage through a three-way valve. The amount of material vaporized by the deflagration is determined to be 1.09 gal (see Calc 4) for all tanks except PRFT. The amount of material vaporized from the PRFT is 0.66 gal (Appendix B, Calculation 4). For this determination the tanks were assumed to be empty to provide the maximum amount of vapor space for the deflagration. For the overpressurization release, it is assumed that the minimum volumes in the tanks are present to provide the ST (Ref. 2, Table 9.4-2). The worst-case ST for pool fires is derived assuming a bounding spill in the CPC and is used for internal vessel pool fires. The ST

for the bounding pool fire is added to that for an internal vessel explosion and assumes enough Isopar L is present to produce a pool fire with very little liquid waste present.

Release Designation 1-RD-7

Location	MAR (Pu-238eq Ci/gal)	Spill Volume (gal)	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
SME Deflagration	2.65E+00	1.09	2.89E+00	1	1E-02	1	5E-03	1.44E-04
MFT Deflagration	2.65E+00	1.09	2.89E+00	1	1E-02	1	5E-03	1.44E-04
SEFT Deflagration	1.65E+01	1.09	1.80E+01	1	1E-02	1 5	E-03	3.05E-02
SEFT Pool Fire	1.65E+01	59.7	9.85E+02	1	6E-03	1	5E-03	
SRAT Deflagration	2.65E+00	1.09	2.89E+00	1	1E-02	1 5	E-03	4.89E-03
SRAT Pool Fire	2.65E+00	59.7	1.58E+02	1	6E-03	1	5E-03	
SMECT Deflagration	2.65E+00	1.09	2.89E+00	1	1E-02	1 5	E-03	4.89E-03
SMECT Pool Fire	2.65E+00	59.7	1.58E+02	1	6E-03	1	5E-03	
PRFT Deflagration	7.32E-01	0.66	4.83E-01	1	1E-02	1	5E-03	1.34E-03
PRFT Pool Fire	7.32E-01	59.7	4.37E+01	1	6E-03	1	5E-03	
							Total	**4.19E-02**

This event does not exceed the declaration threshold ST of 3.10E-01Ci Pu-238eq for a 3 minute filtered elevated release (Appendix B, Calculation 5).

The maximum single tank explosion involves the SRAT or the SMECT deflagration and pool fire. These have a total ST of 4.89E-03 Ci Pu-238eq. This does not exceed the declaration threshold of 3.10E-01 Ci Pu-238eq for a three minute, filtered, elevated release (Appendix B, Calculation 5); and therefore, is not considered further in the EPHA.

5.2.3 Hazardous Materials Requiring No Further Analysis

- **Process Vessel Fire** – Process vessel fires are considered as part of the multiple tank explosion scenario, 1-RD-7. The maximum ST based on the SRAT or the SMECT for a tank pool fire is 4.75E-03 Ci Pu-238eq. This event does not exceed the declaration threshold ST of 4.52E-01 Ci Pu-238eq threshold for a 20 minute, filtered, elevated release (Appendix B, Calculation 5). The dose contribution from the pool fire in the CPC and SPC from receiving SE is negligible. Fire from remaining process materials cannot occur because of the lack of available fuel (Ref. 2, Section 9.4.2). This event is therefore not considered further in the EPHA.
- **Leaks in 221-S** – The rate of leakage projected in scenarios for 221-S are bounded by the transfer rates between vessels. These types of scenarios are not considered further in the EPHA.
- **Criticality** - Due to the radionuclide inventory and neutron poisons present, conditions for a criticality are not credible (Ref. 2, Section 9.4.2.12.1). Therefore, criticality is not considered further in this EPHA.
- **Interarea Transfer Line Releases -** Interarea Transfer Lines (i.e., Sludge, MST/Salt Solution, MST/Sludge Solids, SE, DSS and 512-S Filtrate lines) are constructed to contain their contents, including following a detonation in the core pipe or jacket (Ref. 2, Section 4.4.39.1). Releases from these lines are not considered further in the EPHA.

5.3 COLD CHEMICAL STORAGE (422-S)

5.3.1 Chemical Releases

5.3.1.1 422-S Formic Acid Storage Tank Spill

This is the bounding postulated incident for a formic acid spill in Building 422-S. The unconfined spills outside of the diked areas are postulated to be from leaking pipes and would not approach the volume or surface area of the diked area. Rupture of a tanker carrying the acid would be covered under the transportation EPHA (Ref. 19).

Failure of Primary Barrier — The primary barrier is the tank. Tank rupture will allow the liquid contents to fill the diked area.

Other Barriers/Mitigative Features — The formic acid tanks are enclosed by a berm, thus limiting the available evaporative spill area. A sump is provided in the dike to remove spills/leaks.

Range of Possible Releases — This release scenario is a catastrophic failure of a Formic Acid Storage Tank in 422-S, spilling its entire contents of 6500 gallons of 90 wt% formic acid as an instantaneous spill but confined to the diked area. The effective surface area of this spill is 110 m^2 (Appendix B, Calculation 3). To model this percentage of solution, the Eckert-Drake Evaporative Model (Appendix B, Calculation 3) is utilized to determine a direct release ST. This is used in the ALOHA model (Ref. 13) as a 15 minute, direct release from ground level.

Release Designation 2-RD-1

Rate of Release

Building	Release Rate Adverse Meteorology (g/min)	Release Rate Average Meteorology (g/min)
422-S	**294**	**408**

5.3.2 Radiological Releases

None identified.

5.3.3 Hazardous Materials Requiring No Further Analysis

- **Formic Acid Dilution Tank and Dilute Formic Acid Feed Tanks** – The Formic Acid Dilution Tank and Dilute Formic Acid Feed Tank were screened out from further analysis due to low dispersibility (Ref. 7, Table B-2).
- **Formic and Nitric Acid Mixing** – The formic acid and nitric acid tanks are separated by dikes (Ref. 2, Section 5.4.13.3). No scenarios were identified that would cause mixing of the two tanks allowing production of NO_x.
- **Cell Explosions** – Based on the amount of time required for the cell to reach the LFL due to flammable gas buildup, explosions in the Vitrification Building, LPPP, or 512-S process cells will not occur due to leaks or spills into the cells (Ref. 2, Section 9.4.1.2, p. 9.4-12).

5.4 GLASS WASTE STORAGE BUILDINGS (250-S AND 251-S)

GWSB #1 and GWSB #2 provide space for the safe handling and temporary storage of filled glass waste canisters while they are awaiting transfer to a permanent storage location. As such, the canisters are considered monolithic solids, whether single or double stacked (Ref. 20), and are removed from further consideration.

5.5 LOW POINT PUMP PIT (511-S)

5.5.1 Chemical Releases

5.5.1.1 LPPP (511-S) Tank Spill/Breach

Failure of Primary Barrier — The tank is ruptured from cell cover/equipment drop, etc., and contents are spilled to the floor releasing dimethyl mercury.

Other Barriers/Mitigative Features — Releases from the cell are mitigated via the LPPP Ventilation System, which provides ground level release. The 53.5 ft. (16.3 m) stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building (Ref. 21, 33).

Range of Possible Releases — The maximum MAR is taken from the bounding tank in the LPPP, which is the PPT. The PPT fails, spilling its contents to the PPT cell. The PPT is conservatively assumed to contain MST/Sludge Solids from the LWPT. The ST is calculated in Appendix B, Calculation 6.

Release Designation 3-RD-1

Material	Quantity (gal)	Surface Area (m^2)
MST/Sludge Solids	6466	30.1

As shown in Appendix B, Calculation 6, this event will not result in a classifiable operational emergency (OE) and no EAL is required.

5.5.2 Radiological Releases

5.5.2.1 LPPP (511-S) Tank Spill/Breach

Failure of Primary Barrier — The tank is ruptured from cell cover/equipment drop, etc., and contents are spilled to the floor.

Other Barriers/Mitigative Features — Releases from the cell are mitigated via the LPPP Ventilation System, which provides HEPA filtration and ground level release. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release from the facility. The 53.5 ft. (16.3 m) stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — The maximum MAR is taken from three tanks in the LPPP:

Vessel	Volume (gal)*	Concentration (Ci Pu-238eq/gal)**	MAR (Ci Pu-238eq)
SPT	6217	1.45E+00	**9.01E+03**
PPT	6466	7.32E-01	4.73E+03
RPT	6179	8.90E-01	5.50E+03

*Ref. 2, Table 9.4-2
**Appendix B, Calculation 1

The median ARF/RF is 2E-05/0.7 for a 3 m free-fall spill of slurry (Ref. 10, Section 3.1). A DR of 1 is selected to reflect the entire contents of the tank spilling to the floor. The ventilation system for the LPPP has HEPA filtration. The normal efficiency for HEPA filtration is 99.97% for an LPF of 3E-04. However, for conservatism a LPF of 1E-03 is used. The release duration is 10 minutes (Ref. 1, Section 4.g.1).

Release Designation 3-RD-2

Release Designation	Release Type	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
3-RD-2	Filtered	9.01E+03	1	2E-05	0.7	1E-03	**1.26E-04**

This event does not exceed the declaration threshold ST of 1.43E-03 Ci Pu-238eq for a 10 minute filtered, ground level release (Appendix B, Calculation 5).

5.5.2.2 LPPP (511-S) Transfer Spill

Failure of Primary Barrier — During the operating mode, the tank can overflow or leak due to operator transfer errors, equipment malfunction, or plugging.

Other Barriers/Mitigative Features — Releases from the cell are mitigated via the LPPP Ventilation System, which provides HEPA filtration and a ground level release. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release from the facility. The 53.5 ft. (16.3 m) stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — The maximum spill rate for a transfer into LPPP is 250 gal/min (Ref. 15, Table 6-1). The MAR using this spill rate for a 10 minute spill is 2500 gal. In addition to the spillage from the transfer, it is assumed the maximum of material in the line is also spilled (see Attachment A). This is reflected in the below table:

Vessel	Volume (gal)	Line Volume (gal)	Total Volume Spilled (gal)	Concentration (Ci Pu-238eq/gal)*	MAR (Ci Pu-238eq)
SPT	2500	1400	3900	1.45E+00	**5.66E+03**
PPT	2500	900	3400	7.32E-01	2.49E+03
RPT	2500	1900	4400	8.90E-01	3.92E+03

*Appendix B, Calculation 1

The median ARF/RF is 2E-05/0.7 for a 3 m free-fall spill of slurry (Ref. 10, Section 3.1). A DR of 1 is selected to reflect the entire contents of the tank spilling to the floor. The ventilation system for the LPPP has HEPA filtration. The normal efficiency for HEPA filtration is 99.97%

for an LPF of 3E-04. However, for conservatism a LPF of 1E-03 is used. The release duration is 10 minutes (Ref. 1, Section 5.1.4).

Release Designation 3-RD-3

Release Designation	Release Type	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
3-RD-3	Filtered	5.66E+03	1	2E-05	0.7	1E-03	**7.92E-05**

This event does not exceed the declaration threshold ST of 1.43E-03 Ci Pu-238eq for a 10 minute filtered ground level release (Appendix B, Calculation 5).

5.5.2.3 LPPP (511-S) HEPA Filter Fire

Failure of Primary Barrier — A fire in the exhaust HEPA filter was postulated to occur based upon an outside initiator (e.g., maintenance). This event would result in a release of radioactive material based upon an initial loading in the filter.

Other Barriers/Mitigative Features — Releases can be mitigated via the ventilation system, which normally provides filtration and exhaust through a 53.5 ft. (16.3 m) stack. This stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The turbulence from the building will pull the release down to ground level (Ref. 21). This scenario assumes the filtration system is inoperable.

Range of Possible Releases — For a fire in a HEPA filter, the MAR is conservatively assumed to be one curie of Cs-137 (Ref. 22, Section 5.2.3.1). Based on this, the amount of material impacted is determined by taking a ratio of the Cs-137 loading projected on the HEPA to the Cs-137 concentration in the waste stream. This is shown in the below table:

Tank	Waste Stream	Max Cs-137 Content (Ci/gal)	Amount for 1 Ci Cs-137 (gal)*	Pu-238eq (Ci/gal)	MAR (Ci Pu-238eq)
SPT	Sludge Stream	1.34E+00	0.75	1.45E+00	**1.09E+00**
PPT	MST/Sludge Solids	1.77E+00	0.56	7.32E-01	4.10E-01
RPT	Recycle Stream	1.21E+01	0.08	8.90E-01	7.13E-02

*This is a ratio of how many gallons is required to have only 1 Ci of Cs-137.

For each HEPA filter involved in the fire the maximum MAR is 1.09E+00 Ci Pu-238eq. The two inlet filters are assumed to be clean. The bounding scenario for this event was determined to be four outlet filters fully loaded and impacted by the fire before mitigative actions can be initiated. The maximum MAR available to be acted upon by the event is 4.36E+00 Ci Pu-238eq of Sludge Stream 1. The bounding ARF/RF value of 1E-04/1 is used for a fire involving HEPA filters. The DR is 1. The filtration is not operable This is an unfiltered ground level release with duration of 20 minutes.

Release Designation 3-RD-4

MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
4.36E+00	1	1E-04	1	1	**4.36E-04**

This event does not exceed the declaration threshold ST of 1.73E-03 Ci Pu-238eq for a 20 minute, unfiltered ground level release (Appendix B, Calculation 5).

5.5.3 HAZARDOUS MATERIALS REQUIRING NO FURTHER ANALYSIS

- **Energetic events in the RPT** – Based upon controls within the Safety Basis, the RPT is maintained below LFL with a nitrogen purge (Ref. 2, Table 9.3-10).
- **Cell Explosions** – Based on the amount of time required for the cell to reach the LFL due to flammable gas buildup, explosions in the Vitrification Building, LPPP, or 512-S process cells will not occur due to leaks or spills into the cells (Ref. 2, Section 9.4.1.2, p. 9.4-11).
- **Criticality** – Baseline Nuclear Criticality Safety Evaluations (NCSEs) focused on the fate of iron (neutron poison) and fissile material throughout the DWPF process that ensures the validity of judging that a criticality is implausible (Ref. 2, Section 9.4.2.12).
- **LPPP (511-S) Process Tank Fire** – No vessels in the LPPP contain organics. To create a fire in the LPPP, SE must be spilled into the pit (e.g., crane load drop) allowing organics in SE to form a floating layer of organic solvent in the pump pit. This layer would then have to be ignited from an external source (Ref. 2, Section 9.4.2, p. 9.3-31 and 9.4-28). This is implausible.
- **LPPP (511-S) PPT, SPT Explosions –** Explosions in the PPT and SPT are considered implausible based on design features and operational controls in place to preclude an explosive atmosphere. Given the independence and redundancy of the two explosive atmosphere prevention systems, monitoring and surveillance requirements to allow for operator intervention well before the most conservative times to LFL are reached, and the shielded inaccessible location of material, explosions in the SPT and PPT are implausible.
- **Interarea Transfer Line Releases:** Interarea Transfer Lines (i.e., Sludge, MST/Salt Solution, SE, DSS and 512-S Filtrate lines) are constructed to contain their contents, including following a detonation in the core pipe or jacket (Ref. 2, Section 4.4.39.1). Releases from these lines are implausible.

5.6 ACTINIDE REMOVAL PROCESS (512-S)

5.6.1 Chemical Releases

None identified.

5.6.2 Radiological Releases

5.6.2.1 ARP (512-S) HEPA Filter Fire

Failure of Primary Barrier — A fire in the exhaust HEPA filter was postulated to occur based upon an outside initiator (e.g., vehicle collision or maintenance). This event would result in a release of radioactive material based upon an initial loading in the filter. The outlet filter bank has 4 parallel HEPA filters (Ref. 24, Section 5.1).

Other Barriers/Mitigative Features — Releases can be mitigated via the ventilation system, which normally provides filtration. This scenario assumes the filtration system is inoperable.

Range of Possible Releases — For a fire in a HEPA filter, the MAR, or amount of radionuclides deposited on the HEPA filter, is conservatively assumed to be one curie of Cs-137 (Ref. 24, Section 5.1). Based on this, the amount of material impacted is determined by taking a

ratio of the Cs-137 loading projected on the HEPA to the Cs-137 concentration in the waste stream. This is shown in the below table:

Tank	Waste Stream	Max Cs-137 Content (Ci/gal)	Amount for 1 Ci Cs-137 (gal)*	Pu-238eq (Ci/gal)	MAR (Ci Pu-238eq)
LWHT	Filtrate	1.11E+00	9.0E-01	2.18E-02	1.96E-02
LWPT	MST/Sludge Solids	1.77E+00	5.6E-01	7.32E-01	**4.10E-01**

*This is a ratio of how many gallons is required to have only 1 Ci of Cs-137.

For each HEPA filter involved in the fire the maximum MAR is 4.10E-01 Ci Pu-238eq. The bounding scenario for this event was determined to be four outlet filters fully loaded and impacted by the fire before mitigative actions can be initiated. The maximum MAR available to be acted upon by the event is 1.64 Ci Pu-238eq of MST/Sludge Solids. The DR is 1. The filtration is not operable. The bounding ARF/RF of 1E-04/1 is used for a fire involving HEPA filters. This is an unfiltered ground level release with duration of 20 minutes.

Release Designation 4-RD-1

MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
1.64E+00	1	1E-04	1	1	**1.64E-04**

This event does not exceed the declaration threshold ST of 1.73E-03 Ci Pu-238eq for a 20 minute, unfiltered, ground level release (Appendix B, Calculation 5).

5.6.2.2 Actinide Removal Process Feed Stream Spill

Failure of Primary Barrier — 512-S Feed Stream connection to the 512-S Facility is broken/mis-installed, etc., and results in the transfer to the LWPT being spilled on the cell floor.

Other Barriers/Mitigative Features — Release can be mitigated via the ventilation system, which provides HEPA filtration. The stack does not provide an elevated release point as the turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — 512-S ARP Stream is used for the inventory. This event is modeled as both an unfiltered ground level release and a filtered ground release. The DR is 1. The maximum flow rate for this slurry spill is 250 gal/min (Ref. 15, Table 6-1). The median ARF/RF is 2E-05/0.7 for the free-fall spill of a slurry solution (Ref. 10, Section 3.1). The LPF for the HEPA filter is 1E-03. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release from the facility. This event will be modeled as a ground level release with the spill and release duration of 10 minutes.

Release Designation 4-RD-2a, Filtered Ground Level

MAR (Pu-238eq Ci/gal)	Spill Volume (gal)	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
1.74E-02	2500*	4.35E+01	1	2E-05	0.7	1E-03	**6.09E-07**

**Volume = (Flow Rate)(Duration)* = (250 gal/min)(10 min) = 2,500 gallons

This event does not exceed the declaration threshold ST of 1.43E-03 Ci Pu-238eq for a 10 minute filtered ground level release (Appendix B, Calculation 5).

Release Designation 4-RD-2b, Unfiltered Ground Level

MAR (Pu-238eq Ci/gal)	Spill Volume (gal)	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
1.74E-02	2500*	4.35E+01	1	2E-05	0.7	1	**6.09E-04**

**Volume = (Flow Rate)(Duration)* = (250 gal/min)(10 min) = 2,500 gallons

This event does not exceed the declaration threshold ST of 1.51E-03 Ci Pu-238eq for a 10 minute, unfiltered, ground level release (Appendix B, Calculation 5).

5.6.2.3 ARP (512-S) Tank Spill/Breach

Failure of Primary Barrier — Building 512-S has several tanks that contain material. These include the LWPT, the LWHT, the Crossflow Filter, the Surge Tank and the Backpulse Tank. This spill/breach results from vessel failure and/or cell cover dropping on tank.

Other Barriers/Mitigative Features — Releases are mitigated via the ventilation system, which provides HEPA filtration. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fan interlocks to the off position within seconds of activation. This eliminates any unfiltered release from the facility. The stack does not provide an elevated release point as the turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — The overflow volume for the LWPT and the LWHT is 6204 gal (Ref. 2, Table 9.4-2). The Crossflow Filter and Backpulse Tank have a volume of 73.3 gal and 187 gal, respectively (Ref. 24, Section 5.3 and 5.8). The Surge Tank has a volume of 700 gal (Ref. 26). The LWPT is assumed to have a mixture of 1600 gal of MST/Sludge Solids Stream and 4604 gal of the dilute MST Solids Stream for a total of 6204 gal. The LWHT and Backpulse tank contain filtrate only and the Crossflow Filter and Surge Tank contain the MST/Sludge Solids Stream (Ref. 24, Section 5.10).

Location	Waste Stream	Volume (gal)	Concentration (Ci Pu-238eq/gal)	MAR (Ci Pu-238eq)
LWPT	MST/Sludge Solids	1600	7.32E-01	1.17E+03
	Filtrate	4604	2.18E-02	9.81E+01
			Total	**1.27E+03**
LWHT	Filtrate	6204	2.18E-02	1.35E+02
Crossflow Filter	MST/Sludge Solids	73.3	7.32E-01	5.37E+01
Backpulse Tank	Filtrate	187	2.18E-02	4.08E+00
Surge Tank	MST/Sludge Solids	700	7.32E-01	5.12E+02

The maximum MAR for this scenario is 1.27E+03 Ci Pu-238eq. The median ARF/RF is 2E-05/0.7 for the free-fall spill of a slurry solution (Ref. 10, Section 3.1). The LPF for the HEPA filter is 1E-03. This will be modeled as a ground level release with a release duration of 10 minutes.

Release Designation 4-RD-3

MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
1.27E+03	1	2E-05	0.7	1E-03	**1.78E-05**

This event does not exceed the declaration threshold ST of 1.43E-03 Ci Pu-238eq for a 10 minute filtered ground level release (Appendix B, Calculation 5).

5.6.2.4 ARP (512-S) Transfer Line Spill

Failure of Primary Barrier — Transfer line is broken/mis-installed, etc., and the transfer from the vessel is spilled to the floor.

Other Barriers/Mitigative Features — Releases are mitigated by the ventilation system, which provides HEPA filtration. The ventilation system has interlocks such that if there is a HEPA break through or failure, ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release. The stack does not provide an elevated release point as the turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — The maximum spill rate for a transfer into 512-S is 250 gal/min (Ref. 15). The MAR using this spill rate for a 10 minute spill is 2500 gal. In addition to the spillage from the transfer, it is assumed the maximum of material in the line is also spilled. This is reflected in the below table (see Attachment A):

Vessel	Stream	Volume (gal)	Line Volume (gal)	Total Volume Spilled (gal)	Concentration (Ci Pu-238eq/gal)*	MAR (Ci Pu-238eq)
LWPT	MST/Sludge Solids	2500	400	2900	7.32E-01	**2.12E+03**
LWHT	Filtrate	2500	400	2900	2.18E-02	6.32E+01

*Appendix B, Calculation 1

The maximum MAR for a transfer line spill is 2.12E+03 Ci Pu-238eq. The median ARF/RF is 2E-05/0.7 for a 3 m free-fall spill of slurry (Ref. 10, Section 3.1). A DR of 1 is selected to reflect the entire contents of the transfer line spilling to the floor. For conservatism a LPF of 1E-03 is used. This is a HEPA-filtered, ground level release with a duration of 10 minutes (Ref. 1, Section 4.g.1).

Release Designation 4-RD-4

Release Designation	Release Type	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
4-RD-4	Filtered	2.12E+03	1	2E-05	0.7	1E-03	**2.97E-05**

This event does not exceed the declaration threshold ST of 1.43E-03 Ci Pu-238eq for a 10 minute, filtered, ground level release (Appendix B, Calculation 5).

5.6.2.5 ARP (512-S) Crossflow Filter Detonation

Failure of Primary Barrier — A hydrogen detonation in the filter causes aerosolized MST/Sludge Solids to be released.

Other Barriers/Mitigative Features — From Reference 24, Table 15, the volume of the spill is considered to be 10% of the Crossflow Filter Volume or 7.33 gallons. Because this is a detonation and spill that is contained in the cells, the release from the cell is mitigated by the ventilation system, which provides HEPA filtration and ground level release. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release from the facility. The Crossflow Filter vessel is not directly connected to the PVVS system. In addition, the impact of the explosion is mitigated by the physical cell enclosure. A detonation in the Crossflow Filter is not anticipated to be energetic enough to break through the process

building HEPA filters and push the plume up the stack. The stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — According to Reference 24, Section 5.3, Table 15, the maximum ST for the Crossflow Filter detonation is 4.19E-02 gal. The Crossflow Filter has a MAR per gallon of 7.32E-01 Pu-238eq Ci/gal based on worst case MST/Sludge Solids. For the detonation the DR is 1 and an LPF of 1E-03 is applied for a filtered release. For the spill, the median ARF/RF is 2E-05/0.7. This is a 3 minute, ground level, filtered release.

Release Designation 4-RD-5

MAR (Pu-238eq Ci/gal)	Vaporized Volume (gal)	MAR (Pu-238eq Ci)	LPF	ST (Pu-238eq Ci)
7.32E-01	4.19E-02	3.07E-02	1E-03	3.07E-05

MAR (Pu-238eq Ci/gal)	Spilled Volume (gal)	MAR (Pu-238eq Ci)	ARF	RF	LPF	ST (Pu-238eq Ci)
7.32E-01	7.33E+00	5.37E+00	2E-05	0.7	1E-03	7.51E-08

The total amount released is 3.08E-05 Ci Pu-238eq. This event does not exceed the declaration threshold ST of 1.15E-03 Ci Pu-238eq for a 3 minute, filtered, ground level release (Appendix B, Calculation 5).

5.6.2.6 ARP (512-S) Backpulse Tank Detonation

Failure of Primary Barrier — A hydrogen detonation in the Backpulse Tank causes aerosolized Filtrate to be released.

Other Barriers/Mitigative Features — From Reference 24, Table 15, the volume of the spill is 187 gal. Because this is a detonation and spill that is contained in the backpulse enclosure, the release from the tank is mitigated by the backpulse tank enclosure exhaust system, which consists of inlet/exit HEPA filters and an exhaust fan that discharges into the process building. A release from the process building is mitigated by the ventilation system, which provides HEPA filtration and ground level release. The ventilation system has interlocks such that if there is a HEPA break through or failure, the ventilation fans interlock to the off position within seconds of activation. This eliminates any unfiltered release from the facility. The Backpulse Tank is not directly connected to the PVVS system. In addition, the impact of the explosion is mitigated by the Backpulse Tank enclosure. A detonation in the Backpulse Tank is not anticipated to be energetic enough to break through the process building HEPA filters and push the plume up the stack. The stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The turbulence from the building will pull the release down to ground level (Ref. 21).

Range of Possible Releases — According to Reference 24, the maximum ST for the Backpulse Tank detonation is 1.19E-01 gal (Ref. 24, Table 15). The Backpulse Tank has a MAR of 2.18E-02 Pu-238eq Ci/gal based on worst case filtrate. The DR is 1. A LPF of 1E-03 is applied for a filtered release. The release duration is 3 minutes.

Release Designation 4-RD-6

MAR (Pu-238eq Ci/gal)	Vaporized Volume (gal)	MAR (Pu-238eq Ci)	LPF	ST (Pu-238eq Ci)
2.18E-02	1.19E-01	2.59E-03	1E-03	2.59E-06

MAR (Pu-238eq Ci/gal)	Spilled Volume (gal)	MAR (Pu-238eq Ci)	ARF	RF	LPF	ST (Pu-238eq Ci)
2.18E-02	1.87E+02	4.08E+00	2E-05	0.7	1E-03	5.71E-08

The total amount released is 2.65E-06 Ci Pu-238eq. This event does not exceed the declaration threshold ST of 1.15E-03 Ci Pu-238eq for a 3 minute, filtered, ground level release (Appendix B, Calculation 5).

5.6.3 Hazardous Materials Requiring No Further Analysis

- **Cell Explosions** – Based on the amount of time required for the cell to reach the LFL due to flammable gas buildup, explosions in the Vitrification Building, LPPP, or 512-S process cells will not occur due to leaks or spills into the cells (Ref. 2, Section 9.4.1.2). These scenarios are not considered further in the EPHA.
- **Criticality** – The Nuclear Criticality Safety Evaluation evaluates fissionable material operations conducted at DWPF and demonstrates there are no credible mitigated scenarios (Ref. 2, Section 9.4.2.12). Nuclear incident monitors are not required. These scenarios are not considered further in the EPHA.
- **512-S Process Tank Fire** – There are no vessels in the 512-S that contain organics. This is implausible.
- **Interarea Transfer Line Releases** – Interarea Transfer Lines (i.e., Sludge, MST/salt solution, MST/sludge solids, SE, DSS and 512-S Filtrate lines) are constructed to contain their contents, including following a detonation in the core pipe or jacket (Ref. 2, Section 4.4.39.1). Releases from these lines are implausible.
- **ARP (512-S) LWHT, LWPT, or Surge Tank Explosions –** Explosions in 512-S tanks are considered implausible based on design features and operation controls in place to preclude an explosive atmosphere. Given the independence and redundancy of the two explosive atmosphere prevention systems, the monitoring system being adequate to allow for operator intervention well before the most conservative time to LFL is reached, and the shielded inaccessible location of the material, explosions in 512-S tanks are implausible.
- **Chemical (dimethyl mercury) Releases** – Releases are bounded by or equivalent to releases postulated in the LPPP (511-S; see Section 5.5.1.1). These events did not result in an operational emergency and hence are excluded from analysis.

5.7 DECONTAMINATED EQUIPMENT AND WASTE STAGING

5.7.1 Chemical Releases

None identified.

5.7.2 Radiological Releases

5.7.2.1 Sludge Contaminated SeaLand Container Spill

Failure of Primary Barrier — Material is assumed to be dry residual sludge solids acting as contamination on non-combustible surfaces (Ref. 25). It is assumed that sludge contamination in SeaLand containers could be released by vibration and impact. It is further assumed that the atmosphere inside a container is not flammable or explosive because equipment has gone through decontamination (Ref. 2, Section 9.1; see Section 5.7.3).

Other Barriers/Mitigative Features — No other barriers that would prevent a release to the environment are assumed.

Range of Possible Releases — The event is assumed to impact a single SeaLand container with sludge-contaminated equipment. The radiological inventory for a single SeaLand container is 2.11E-01 Pu-238eq Ci (Appendix B, Calculation 1). The bounding ARF/RF for a shock-vibration induced release for contaminated non-combustible solids is 1E-03/1 (Ref. 10, Section 5.1). The DR and LPF are assumed to be 1. This is a ground level release with a release duration of 10 minutes (Ref. 1, Section 4.g.1).

Release Designation 5-RD-1

Release Type	MAR (Pu-238eq Ci)	DR	ARF	RF	LPF	ST (Pu-238eq Ci)
Unfiltered	2.11E-01	1	1E-03	1	1	**2.11E-04**

This event does not exceed the declaration threshold ST of 1.51E-03 Ci Pu-238eq for a 10 minute unfiltered ground level release (Appendix B, Calculation 5). The number of containers required to exceed the declaration threshold is greater than seven (i.e., 1.51E-03/2.11E-04). An event scenario involving enough containers to exceed the declaration threshold ST is implausible.

5.7.2.2 Fire Involving SeaLand Container Containing Sludge-Contaminated Equipment

Failure of the Primary Barrier — Primary barrier preventing the release of radionuclides from the sludge contamination in a SeaLand container is the container.

Other Barriers/Mitigative Features — None identified.

Range of Possible Releases — Potential fires inside a SeaLand container are limited in severity and duration based on the availability of fuel and oxygen. Larger fires may occur outside the container where the SeaLand container would provide additional protections by providing shielding of the contents from direct thermal radiation exposure from the flame. Because the extent of this additional protection is not known, it is assumed that a fire impacts the entire inventory in a single SeaLand container. The MAR is assumed to be a combustible solid. The maximum inventory for a SeaLand container with sludge-contaminated equipment is 2.11E-01

Pu-238eq Ci (Appendix B, Calculation 1). Reference 10, Section 5.1 has a median ARF/RF or thermal stress to contaminated combustible materials heated in packages with largely non-contaminated exterior surfaces (8E-05/1). A DR and LPF of 1 are assumed. Plume rise is not credited. The release is an unfiltered, ground level release with duration of 20 minutes.

Release Designation 5-RD-2

Release Type	MAR Pu-238eq (Ci)	DR	ARF	RF	LPF	ST Pu-238eq (Ci)
Unfiltered	2.11E-01	1	8E-05 1		1	**1.7E-05**

This event does not exceed the declaration threshold ST of 1.73E-03 Ci Pu-238eq for a 20 minute, unfiltered, ground level release (Appendix B, Calculation 5). This scenario is not considered further in the EPHA.

5.7.2.3 Fire Involving B-25 Waste Container

Failure of the Primary Barrier — Primary barriers preventing the release of radionuclides from the solid waste staging areas are waste containers.

Other Barriers/Mitigative Features — None identified.

Range of Possible Releases — The fire is assumed to impact a single B-25 container. The MAR is assumed to be a combustible solid. The maximum inventory for each B-25 container in the waste staging area is 1.40E-01 Pu-238eq Ci (Appendix B, Calculation 1). Reference 10, Section 5.1 has a median ARF/RF or thermal stress to contaminated combustible materials heated in packages with largely non-contaminated exterior surfaces (8E-05/1). A DR of 1 is assumed. An LPF of 1 is conservatively assumed. Plume rise is not credited. Release is unfiltered, ground level release with a duration of 20 minutes.

Release Designation 5-RD-3

Release Type	MAR Pu-238eq (Ci)	DR	ARF	RF	LPF	ST Pu-238eq (Ci)
Unfiltered	1.40E-01	1	8E-05 1		1	**1.12E-05**

This event does not exceed the declaration threshold ST of 1.73E-03 Ci Pu-238eq for a 20 minute, unfiltered, ground level release (Appendix B, Calculation 5). The number of drums required to exceed the declaration threshold is 154 (i.e., 1.73E-03/1.12E-05). An event scenario involving enough containers to exceed the declaration threshold ST is implausible.

5.7.2.4 Impact Accident Ruptures B-25 Waste Container

Failure of the Primary Barrier — The primary barriers preventing the release of radionuclides for the solid waste staging areas are the waste containers.

Other Barriers/Mitigative Features — None identified.

Range of Possible Releases — The accident is assumed to impact one B-25 container. The MAR is assumed to be a combustible solid. The maximum inventory per B-25 container is 1.40E-01 Pu-238eq Ci (Appendix B, Calculation 1). Median ARF and RF values are 4E-04/0.2 for combustible packaged material in a relatively robust container (e.g., hard pail, drum) that is opened or fails due to impact with the floor; or, impaction by falling debris (shock-vibration

induced by impact) (Ref. 10). Containers are robust (e.g., B-25s, transport casks); however, the LPF is conservatively assumed as 1. A DR of 1 is assumed. The release is unfiltered at ground level. Duration is 10 minutes.

Release Designation 5-RD-4

Release Type	MAR Pu-238$_{eq}$ (Ci)	DR	ARF	RF	LPF	ST Pu-238$_{eq}$ (Ci)
Unfiltered	1.40E-01	1	4E-04	0.2	1	**1.12E-05**

This event does not exceed the declaration threshold ST of 1.51E-03 Ci Pu-238eq for a 10 minute, unfiltered, ground level release (Appendix B, Calculation 5). The number of drums required to exceed the declaration threshold is 134 (1.51E-03/1.12E-05). An event scenario involving enough containers to exceed the declaration threshold is implausible.

5.7.2.5 Explosion in B-25 Waste Container

Failure of the Primary Barrier — The primary barriers preventing the release of radionuclides for the solid waste staging areas are the waste containers.

Other Barriers/Mitigative Features — None identified.

Range of Possible Releases — The accident is assumed to impact one B-25 container. The MAR is assumed to be a combustible solid. The maximum inventory per B-25 container is 1.40E-01 Pu-238eq Ci (Appendix B, Calculation 1). The bounding ARF/RF (no median values available) for venting of pressurized gases over contaminated combustible waste is 1E-03/1 (Ref. 10, p. 5-3). This value is sufficiently bounding that assumption of cumulative effect of individual release mechanisms is unnecessary (Ref. 10). A DR of 1 is assumed. The release is unfiltered at ground level. Duration is 3 minutes.

Release Designation 5-RD-5

Release Type	MAR Pu-238$_{eq}$ (Ci)	DR	ARF	RF	LPF	ST Pu-238$_{eq}$ (Ci)
Unfiltered	1.40E-01	1	1E-03	1	1	**1.40E-04**

This event does not exceed the declaration threshold ST of 1.24E-03 Ci Pu-238eq for a 3 minute, unfiltered, ground level release (Appendix B, Calculation 5). The number of drums required to exceed the declaration threshold is 8 (i.e., 1.24E-03/ 1.40E-04). An event scenario involving enough containers to exceed the declaration threshold ST is implausible.

5.7.2.6 Glass contaminated SeaLand Container Spill

Failure of Primary Barrier — Material is assumed to be thin sheets of glass fixed to equipment stored in drums which are then stored in SeaLand containers (Ref. 27). It is assumed that glass contamination in SeaLand containers may be released by vibration and impact. It is assumed that two SeaLand containers are involved in the accident.

Other Barriers/Mitigative Features — None are assumed.

Range of Possible Releases —The radiological content for two glass contaminated SeaLand containers is 4.44E+03 Ci Pu-238eq Ci (Appendix B, Calculation 1). The ARFxRF for shock-

vibration for solids that undergo brittle fracture (such as glass) are calculated by the following equation (Ref. 10, Section 5.3.3.2.1):

$$ARF * RF = (A)(P)(g)(h) \quad \text{(Eq. 5-3)}$$

Where: ARF x RF = (Airborne Release Fraction) (Respirable Fraction)

A = empirical correlation, 2E-11 cm^3 per $g\text{-}cm^2/s^2$

P = specimen density, g/cm^3

g = gravitational acceleration, 980 cm/s^2 at sea level

h = fall height, cm

The bounding density is 2.823 g/cm^3 (Ref. 28). The fall height is assumed to be 3 m. The ARF*RF is then 1.66E-05.The LPF is assumed to be 1. The DR is assumed to be 0.01, consistent with Reference 27. This is a ground-level release with 10 minute duration (Ref. 1, Section 4.g.1).

Release Designation 5-RD-6

Release Type	MAR (Pu-238eq Ci)	DR	ARFxRF	LPF	ST (Pu-238eq Ci)
Unfiltered	4.43E+03	0.01*	1.66E-05	1	**7.35E-04**

* Reference 27 recommends a 1% estimate.

This event does not exceed the declaration threshold ST of 1.51E-03 Ci Pu-238eq for a 10 minute, unfiltered, ground level release (Appendix B, Calculation 5).

5.7.3 Hazardous Materials Requiring No Further Analysis

- **Explosion/Fire Events involving Glass in SeaLand Container:** Fires involving monolithic borosilicate glasses incorporating waste do not have the potential to release any significant amount of non-volatile radionuclides. These materials would have to be heated to temperatures exceeding those anticipated for most fire situations during formation and, therefore, are not anticipated to undergo any chemical change under fire conditions. From the information available, however, any release under industrial-type fire conditions appears to be negligible. In addition, DWPF glass melts at 1150 ^oC. Glass is not stored or transported under conditions that could result in the glass temperature exceeding 400 ^oC (Ref. 30, Section 6.2.2). A fire involving glass in SeaLand containers is not considered further in the EPHA.

  Explosive stresses can result from shock effects, blast effects, or venting of pressurized gases over solids. Explosions can occur as detonations or deflagrations. The glass waste is stored in 55-gallon drums with up to 40 drums in a SeaLand container (Ref. 27). According to DOE STD 5506, a deflagration in a drum will not transition to a detonation and the effect of a deflagration in a drum is to eject the drum lid and some of the contents within the drum resulting in a fall/impact stress (Ref. 29, Section 4.4.2 and Appendix B). Because the glass material is not flammable, this material would be subject to a fall/impact stress. For a deflagration, there is neither a blast wave nor shock wave effect that must be considered, and there would be no significant airborne release due to venting of pressurized gases over solid glass (Ref. 30, Section 6.2.2). Because one deflagrating drum can also cause a sympathetic deflagration, the maximum MAR for a deflagration involves only two drums not the entire MAR in the SeaLand container. The ST for a spill

(fall/impact) of two SeaLand containers was considered in Section 5.7.2.6. This scenario did not exceed the ST threshold for an Alert classification; therefore a deflagration causing a fall/impact of part of a SeaLand container does not require further consideration in the EPHA.

5.8 WATER TREAMENT AND STORAGE FACILITIES (980-S)

5.8.1 Chemical Releases

5.8.1.1 980-S Organic Acid Waste Neutralization Tank Spill

This is the bounding postulated incident for a formic acid spill in Building 980-S. The unconfined spills outside of the diked areas are postulated to be from leaking pipes and would not approach the volume or surface area of the diked area. Rupture of a tanker carrying the acid would be covered under the transportation EPHA (Ref. 19).

Failure of Primary Barrier — The primary barrier is the tank. Tank rupture will allow the liquid contents to fill the diked area.

Other Barriers/Mitigative Features — Formic acid tanks are enclosed by a berm, thus limiting the available evaporative spill area. A sump is provided in the dike to remove spills/leaks.

Range of Possible Releases — This release scenario is a catastrophic failure of an Organic Acid Waste Neutralization Tank in 980-S, spilling its entire contents of 3147 gallons of 90 wt% formic acid as an instantaneous spill but confined to the diked area (Appendix B, Calculation 3). The effective surface area is 51.5 m^2. To model this percentage of solution, the Eckert-Drake Evaporative Model (Appendix B, Calculation 3) is used to determine a direct release ST. This is used in the ALOHA model (Ref. 13) as a direct release from ground level.

Release Designation 6-RD-1

Rate of Release

Building	**Release Rate Adverse Meteorology** (g/min)	**Release Rate Average Meteorology** (g/min)
980-S	167	170

5.8.2 Radiological Releases

None identified.

5.9 FAILED EQUIPMENT STORAGE VAULT

The FESV also contains solid equipment and vitrified material and is not considered at risk as an airborne hazard. DOE G 151.1-2 states that materials that are monolithic solids under normal conditions and do not present an airborne hazard may be eliminated from consideration in the hazards assessment (Ref. 4). The FESV is not considered further in the EPHA.

5.10 MALEVOLENT ACTS

For DWPF, the extreme malevolent act is assumed to involve the maximum event for the area. The extreme malevolent act is bounded by the postulated spill of the formic acid storage tank in Building 422-S (Cold Chemical Storage). This scenario has already been analyzed under release designation 2-RD-1. No other accident scenario (i.e., explosion, fire, loss of confinement, etc.) would result in significantly higher consequences for DWPF. Therefore, no further analysis of an extreme malevolent act scenario is required.

Because this event is also considered for OEs, the consequences from the OE are considered in the EPZ determination for the facility. An operational EAL and security EAL will be developed for this event to ensure proper classification whether this event is the result of an accident or a malevolent act.

Release Designation 7-RD-1

		MAR Formic Acid	**Source Release Fraction (SRF)***	**ST g Formic Acid**
Malevolent Act	15 minute, Ground Level Release	6500 gal (2.95E+04 g)**	1.49E-01	4410***

*SRF is calculated by dividing the ST by the MAR and rounded
**6500 gal = 24.6 m^3*1.2 kg/m^3 (density) = 2.95E+04 g
***294 g/min in 15 min = 4410 g

6.0 CONSEQUENCE ASSESSMENT

This section provides an overview of the methodology and presents the results of the analysis used to transform the accident scenarios identified in Section 5.0 into projected ground-level doses and exposures at the previously identified receptor locations.

6.1 DESCRIPTION OF METHODOLOGY

6.1.1 Chemical Dispersion Modeling

Release of hazardous chemicals is modeled using the ALOHA dispersion program (Ref. 13) or by hand calculations in Appendix B. ALOHA utilizes both a straight line Gaussian model and a heavy gas computation model. For chemicals in the ALOHA database, spills are modeled using an evaporative rate (calculated by ALOHA) applied to the area of the spill/puddle. For chemicals not found in the ALOHA database, chemicals are modeled by applying a release fraction based on low impact spills to the volume of the material spilled.

All algorithms are presented and fully referenced in the ALOHA documentation. ALOHA's distance limits for footprint plotting are:

- Minimum distance: 10 m
- Maximum distance: 10 km

Model output is presented in Appendix B. DOE guidance suggests a Protective Action Guide value as a projected dose equivalent of AEGL-2 (or ERPG-2 or TEEL-2). This value (AEGL-2 or ERPG-2 or TEEL-2) is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

The key issue in using AEGL-2 (or ERPG-2 or TEEL-2) is that exposure to some materials at a concentration exceeding the AEGL-2 (or ERPG-2 or TEEL-2) value for a short period may be enough to produce health detriment. Therefore, the 60 minute AEGL-2 value is utilized.

6.1.2 Radionuclide Dispersion Modeling

The Hotspot computer code (Ref. 31) is used for dispersion modeling of all radionuclide releases. Hotspot uses the well-established Gaussian Plume Model, which is widely used for initial emergency assessment or safety analysis planning of a radionuclide release. A detailed description of the Hotspot Gaussian model equations can be found in Hotspot documentation (Ref. 31). Individual doses are produced, along with the 50-year TED. Note: Hotspot output identifies this as total effective dose equivalent because it has not been updated with this nomenclature change.

6.2 EVENT CLASSIFICATION DETERMINATION

Consequence Assessment results are evaluated against the following criteria to determine the appropriate emergency class for the event scenario (Ref. 1).

- Alert Classification – The consequence (e.g., radiation dose or 15-minute peak average concentration of a toxic chemical) at 30 meters from the release point provides the

demarcation between an accident that would require emergency response organization involvement (e.g., Alert) and one that would not.

- Site Area Emergency Classification – The facility boundary is the demarcation between the facility and its immediate vicinity and the remainder of the site. The consequence (e.g., radiation dose or 15-minute peak average concentration of a toxic chemical) at this receptor location provides the demarcation between an Alert and SAE declaration. For this analysis, the facility boundary is considered to be at 100 m.
- General Emergency Classification – The consequence (e.g., radiation dose or 15-minute peak average concentration of a toxic chemical) at the nearest site boundary is the demarcation for a GE declaration.

In each of the classification zones, releases are evaluated to determine if the PAC has been exceeded. The last zone where the PAC has been exceeded determines event classification. For operational emergencies, the PAC is a personnel radiation exposure level of 1 rem TED or toxic chemical concentration (peak 15-minute average) equal to AEGL-2 (or ERPG -2, TEEL-2).

6.3 ACCIDENTS WITH MULTIPLE RELEASE MECHANISMS

Some accident events involved multiple release mechanisms, e.g., an instantaneous release(s) followed by a longer–term release(s). In these cases, the dominating release mechanism (e.g., fire) was used for the release duration with other contributing mechanisms (e.g., spill) added together to form one release amount (Ref. 1).

6.4 CONSEQUENCE ASSESSMENT RESULTS

Tables 6.1 through 6.4 contain results of consequence assessments for releases described in Section 5.0 under both adverse and average meteorology. Consequence assessments for release designations that did not have a ST greater than the threshold value were not evaluated. Those events will have consequences less than PAC-2 at 30 m. Included in tables, are results of scenarios where mixture files were used. Events that did not result in an emergency classification were not analyzed for average conditions. No radiological events resulted in emergency classification; therefore, no radiological events were analyzed under average conditions. Hotspot and ALOHA output used to complete tables are in Calculation 2 of Appendix B.

Table 6.1 95% Adverse Consequence Assessment Results – Radiological

Release Designation	Max Dose 30m to FB (rem)	Max Dose FB to SB (rem)	Dose @ CTF (rem)	Dose @ WMA (rem)	Dose @ Site Boundary (rem)	Max Distance to PAC (m)	Max Distance to TEL (m)	Probable Event Class
1-RD-4	5.7E-04	6.4E-04	3.1E-04	1.4E-05	1.2E-05	NA	NA	NA
1-RD-6b	1.1E-04	1.2E-04	6.0E-05	3.0E-06	2.5E-06	NA	NA	NA

Table 6.2 95% Adverse Consequence Assessment Results – Formic Acid

Release Designation	Conc. at 30 m (ppm)	Conc. at Facility Boundary (ppm)	Conc. at CTF (ppm)	Conc. at WMA (ppm)	Conc. at Site Boundary (ppm)	Maximum Distance to PAC (m)	Max Distance to TEL (m)	Possible Event Class
2-RD-1	1.17E+02	1.11E+01	4.44E-01	NA*	NA*	66	20	Alert
6-RD-1	6.65E+01	6.30E+00	2.52E-01	NA*	NA*	49	16	Alert
7-RD-1	1.17E+02	1.11E+01	4.44E-01	NA*	NA*	66	20	Alert

*According to ALOHA output, either not significant concentration at receptor point or it takes >1 hr. to reach receptor point.

Table 6.3 95% Adverse Consequence Assessment Results – Dimethyl Mercury

Release Designation	Chemical	ST (mg/s)	Limiting ST to reach PAC-2 (mg/s)	Probable Event Class
3-RD-1	Dimethyl Mercury	3.42E-01	4.18	None

Table 6.4 50% Average Consequence Assessment Results – Formic Acid

Release Designation	Conc. at 30 meters (ppm)	Conc. at Facility Boundary (ppm)	Conc. at CTF Boundary (ppm)	Conc. at WMA Boundary (ppm)	Conc. at Site Boundary (ppm)	Maximum Distance to PAC (m)
2-RD-1	2.33E+01	2.10E+00	6.62E-02	NA*	NA*	29
6-RD-1	9.53E+00	8.61E-01	2.71E-02	NA*	NA*	19
7-RD-1	2.33E+01	2.10E+00	6.62E-02	NA*	NA*	29

*According to ALOHA output, either not significant concentration at receptor point or it takes >1 hr. to reach receptor point.

7.0 EMERGENCY CLASSES AND EMERGENCY ACTION LEVELS

This section documents the correlation of consequence assessment (Section 6) with requirements to classify events. Tables 6.1 through 6.4 contain results of consequence assessments for releases described in Section 5.0 for adverse meteorological conditions. For each classifiable event, an EAL is developed to identify specific criteria to indicate that the event has occurred and what the severity is.

7.1 RADIOACTIVE RELEASES

7.1.1 General Emergency Action Levels

None Identified.

7.1.2 Site Area Emergency Action Levels

None Identified.

7.1.3 Alert Emergency Action Levels

None Identified.

7.2 CHEMICAL RELEASES

7.2.1 General Emergency Action Levels

None Identified.

7.2.2 Site Area Emergency Action Levels

None Identified.

7.2.3 Alert Emergency Actions Levels

There are two chemical Alert EALs. The Alert EALs are described on page 51.

A-2.1 422-S Formic Acid Storage Tank Spill (2-RD-1)

Spill of 90 wt% formic acid from the storage tank in Building 422-S.

Event indicated by:

Determination of a spill outside the 422-S trench/sump area by:

- Visual observation of formic acid overflowing the trench/sump area in 422-S.

OR

- Decreasing FAST #1 Level (LI6464) by 410 gallons

AND

- Organic Acid Sump LAH (LAH6430).

Maximum default source term: 294 g/min

Event should be modeled as a 15 minute, ground level, Gaussian release.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 66 m (0.04 miles)

A-2.2 980-S Organic Acid Waste Neutralization Tank (OAWNT) Spill (6-RD-1)

Spill of 90 wt% formic acid from a storage tank in Building 980-S.

Event indicated by:

Determination of a spill outside the 980-S trench/sump area by:

- Visual observation of formic acid overflowing the trench/sump area in 980-S.

OR

- Decreasing tank level (OAWNT #1: LI9054; OAWNT #2: LI9084) by 224 gallons

AND

- Organic Acid Waste Sump LAH (LAH9058)

Maximum default source term: 167 g/min

Event should be modeled as a 15 minute, ground level, Gaussian release.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 49 m (0.03 miles)

7.3 OTHER (SECURITY EALS)

7.3.1 General Emergency Action Levels

None identified.

7.3.2 Site Area Emergency Action Levels

None identified.

7.3.3 Alert Action Levels

There is one malevolent act EAL. The EAL is presented below.

A-3.1 Phase II, III, or IV Security declaration for DWPF with the potential to release hazardous material.

This EAL is based upon the maximum amount of hazardous material that could be released in a worst-case malevolent act (7-RD-1) for DWPF as indicated by:

- PHASE II, III, or IV Security Declaration by Protective Force for the facility.

AND

- Involves the potential for a hazardous material release.

Maximum default source term: 294 g/min

Event should be modeled as a ground level release with release duration of 15 minutes.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 66 m (0.04 miles)

8.0 EMERGENCY PLANNING ZONE DETERMINATION

The facility EPZ is defined as an area within which special planning and preparedness efforts are warranted as a means of apportioning preparedness resources. The methodology used in determining the EPZ is outlined in EMPP 6Q–001 (Ref. 1). The distance at which the TEL would be exceeded is used in defining an EPZ for the radiological component. The dose of 100 rem TED is the TEL for radioactive material releases. The distance at which the chemical TEL is exceeded is used in defining an EPZ for the chemical component. This distance is the smallest EPZ radius that should be considered. The minimum TEL distance for the worst case quantitatively analyzed for the chemical component is 20 m (2-RD-1).

The distance at which PAC is exceeded is the maximum distance to PAC as listed in Table 6.2. This distance, or 10 miles, whichever is smaller, is the largest EPZ radius that should be considered. The maximum distance is 66 m from the point of the release (2-RD-1).

Within the limits of the largest (66 m) and smallest (20 m) EPZ radii, other factors are considered and the size and shape are adjusted in accordance with the following principles.

- If the most severe analyzed release would result from a single failure event or is believed to have a relatively high probability of occurrence, an EPZ radius closer to the maximum than the minimum should be selected.
- If the probability of the most severe analyzed release is judged to be extremely low or if it contributes a minor fraction of the total off-site risk from site emergencies, an EPZ radius closer to the minimum than the maximum value is indicated.
- The most severe analyzed release is judged to contribute only a minor fraction of the total off-site risk from site emergencies, hence, the maximum value (66 m) is indicated for the EPZ radius.
- If the hazard is radiological, an EPZ radius closer to the minimum than the maximum value should be selected.
- The EPZ should conform to the physical and jurisdictional realities of the site and surrounding area. The 66 meters radius does not conform to this requirement and should be extended to the S-Area facility boundary (100 m).

Additional considerations for final determination of the EPZ cannot be stated as quantitative guidance. A “test of reasonableness” is applied to determine if the EPZ should be further adjusted. Considerations include the following:

- The EPZ should be large enough to provide a credible basis for extending response activities outside the EPZ if conditions warrant.
- The EPZ should be large enough to support effective response at or near the scene.
- The EPZ should meet the expectations and needs of offsite agencies.

Based upon these tests, the DWPF EPZ is extended to include all of S-Area. Although, based upon this analysis, the DWPF EPZ may be confined to S-Area (Appendix A - Figure 1), enhancement of site preparedness is realized by extending the EPZ to the site boundary.

9.0 REFERENCES

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26. *Savannah River Site 200S Area Defense Waste Processing Facility Late Wash Facility Piping and Instrument Diagram Late Wash Surge Tank (U)*, M-M6-S-0020, Rev. 10, Savannah River Site, Aiken, SC, November 18, 2003.

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32. Protective Action Criteria (PAC): Chemicals with AEGLS, ERPGs, & TEELs; Rev. 29, www.atlintl.com/doe/teels/tee/complete.uspm, May 2016.

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ATTACHMENT A

Jeff Ray, January 4, 2007

Title Continued from page: 11

1/07 Interarea Transfer Line Volumes - Input to DWPF EPHA

Purpose: To determine the volumes to be assumed in DWPF EPHA scenarios for transfer spills in the LPPP-SPT -PPT and -RPT cells as well as the 512-S LWPT and LWHT cells.

				Interarea Transfer Line Volumes			
			D	A	L	V	
	Nominal Pipe Diameter (inches)	Pipe Inside Diameter (inches)	Pipe Inside Diameter (feet)	Line Area (sq. ft.)	Line Length (feet)	Line Volume (cu. ft)	Line Volume (gallons)
	See Note 2	See Note 1	Inches / 12	A=π(D/2)^2		V=A*L	Cu. Ft. * 7.481
Tank 40 to LPPP (SPT)	3	3.068	0.25566667	0.0513379	3500 (Note 2)	179.68265	1344.20591 ~1400 gal
512-S (LWPT) to LPPP **(PPT)**	3	3.068	0.25566667	0.0513379	2300 (Note 2)	118.07717	883.335309 ~900 gal
LPPP (RPT) to HDB-8	3	3.068	0.25566667	0.0513379	4800 (Note 2)	246.42192	1843.48238 ~1900 gal
Tank 49 to 512-S **(LWPT)**	3	3.068	0.25566667	0.0513379	800 (Note 2)	41.07032	307.247064 ~400 gal
512-S (LWHT) to MCU	3	3.068	0.25566667	0.0513379	839 (Note 3)	43.07250	322.22536 ~400 gal

1. Reference: Perry's Chemical Engineers Handbook 4th Edition, Table 6-2, "Properties of Ferrous Pipe"
2. Reference: Figure 3 of INTERAREA TRANSFER FACILITIES SYSTEM DESIGN DESCRIPTION, G-SYD-S-00050, Rev. 5
3. Reference: S-CLC-S-00099, Rev. 1

JWR 1/4/07

Results:

$$\text{Volume}_{\text{Cell Transfer Spill}} = \text{10-minute transfer volume} + \text{holdup volume in line (calc. in table above)}$$

$$\rightarrow \text{Volume}_{\text{LPPP-SPT}} = (100\ \text{gpm})(10\ \text{min}) + 1400\ \text{gal} = 2{,}400\ \text{gal}$$

$$\rightarrow \text{Volume}_{\text{LPPP-PPT}} = (100\ \text{gpm})(10\ \text{min}) + 900\ \text{gal} = 1{,}900\ \text{gal}$$

$$\rightarrow \text{Volume}_{\text{LPPP-RPT}} = (100\ \text{gpm})(10\ \text{min}) + 1900\ \text{gal} = 2{,}900\ \text{gal}$$

$$\rightarrow \text{Volume}_{\text{512-S LWPT}} = (100\ \text{gpm})(10\ \text{min}) + 400\ \text{gal} = 1{,}400\ \text{gal}$$

$$\rightarrow \text{Volume}_{\text{512-S LWHT}} = (100\ \text{gpm})(10\ \text{min}) + 400\ \text{gal} = 1{,}400\ \text{gal}$$

Continued on page:

Date & Date
Investigator Jeff W. Ray 1/4/07 Reviewer/Witness 1 1/4/07 Witness 2

Reviewer/witness signature required for patent information only.

Appendix A – Figure

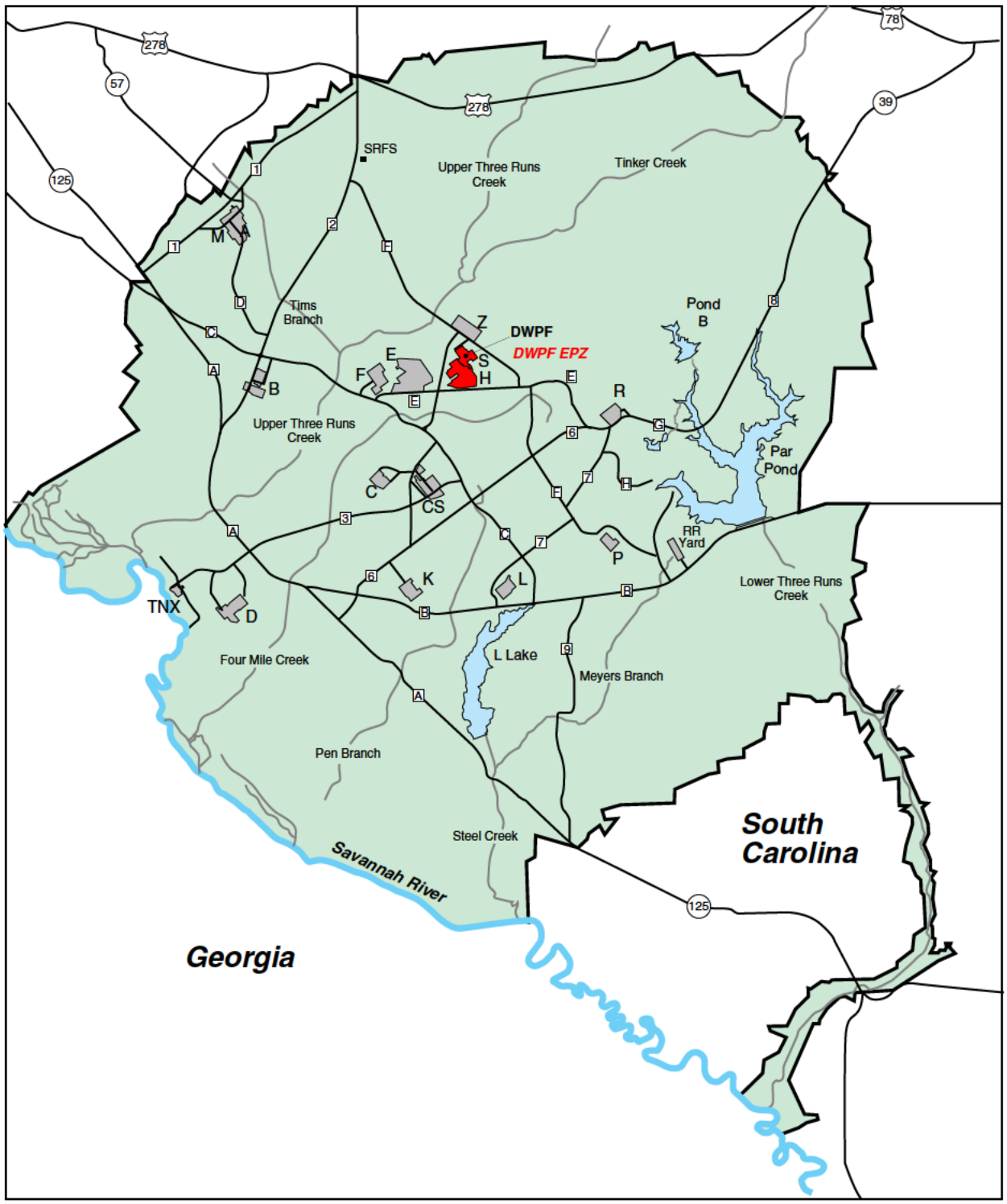

Figure 1 – DWPF Preliminary EPZ

Appendix B - Calculations

Calculation 1: Radiological Inventory for DWPF
Calculation 2: DWPF Consequence Assessment
Calculation 3: Formic Acid Source Term Determination
Calculation 4: Deflagration Source Term Determination
Calculation 5: Threshold Calculations
Calculation 6: Dimethyl Mercury Release - Source Term Determination

INTRODUCTION

This calculation documents radiological material present at Defense Waste Processing Facility (DWPF) and calculates a Pu-238 equivalent (Pu-238eq) for identified streams. According to the Hazards Survey (HS), all radiological inventory within S Area must be retained for further analysis in an Emergency Planning Hazards Assessment (EPHA, Ref. 1).

INPUT DATA

- Radiological inventory is from Final Safety Analysis Report (FSAR) Tables 9.4-1a, 9.4-1b, and URS-PS-SAE-13-0037 (Ref. 2 and 3).
- Federal Guidance Report (FGR) 13 Dose Conversion Factors (DCFs) are used for converting inventory to Pu-238 equivalent (Ref. 4).
- Up to five sludge-contaminated containers may be used to store decontaminated equipment in the Decontaminated Equipment Storage Area (Ref. 5, Section 3.0); historically, the maximum is three. The isotopic distribution for all sludge containers (including B-25s) is conservatively assumed to be from the Sludge Stream. The maximum inventory observed per SeaLand is 11.3 Ci (Ref. 6, Section 6.2).
- Two SeaLand containers may be used to store up to 80 55-gal drums containing glass-contaminated equipment (Ref. 7, 8). Isotopic distribution of glass is from Reference 7, Table 1.
    - Only 1% of drum volume is radioactive waste glass (Ref. 8). Most of the volume is void. Some of the volume is equipment; a small amount is glass.
    - Most of the equipment is contained in drums (Ref. 9, Section 3.0). The waste on glass pumps, not in drums, is bounded by the estimated of the drummed waste (Ref. 7, Assumptions). All glass-contaminated equipment (including glass pumps) will be included in drums within the SeaLand containers (Ref. 9)
    - The mass of glass in the two SeaLands is 10,350 lbs (Ref. 7, Analytical Methods and Computations).
    - Due to the low solubility of glass, radionuclides in solid glass are assigned a lung absorption type of S.
- The total number of B-25 containers that may be stored in the Waste Staging Area has been observed operationally to be a maximum of 30. The average number of B-25s used per month is typically 10. The maximum number of curies observed per B-25 is 7.5 total curies (Ref. 6, Section 6.2).
- At high temperatures, some semi-volatile isotopes may be released. In DWPF, temperatures high enough to support this phenomenon are present only in molten glass in the melter. For these types of events, two additional isotopes must be modeled: Sb-125 and its daughter Te-125m. These isotopes have insignificant impact on other events which do not involve molten glass and are therefore not included in the Curie distribution (Ref. 2, p. 9.4-9).
- In the DWPF analysis, radiological source terms for the bounding accident analyses are calculated for the isotopes of interest. The isotopes, presented in FSAR Table 9.4-1a, account for over 99.9% of the potential DWPF dose. Therefore, other isotopes in the DWPF streams can be neglected for dose contribution (Ref. 2, Section 9.4.1.2, p. 9.4-4). It should be noted that the following isotopes in FSAR Table 9.4-1a are daughter

products that were included in the radionuclide distribution to account for hydrogen generation and external dose: Y-90, Rh-106, Ba-137m, Pr-144. These isotopes contribute less than 0.01% of the dose. Metastable daughters accounted for in the DCF of the parent are excluded.

ANALYSIS METHODS AND COMPUTATION ASSUMPTIONS

Characterization of Material at Risk (MAR) for Airborne Dose

The MAR for each area is characterized to determine a Pu-238eq. This characterization reduces the number of consequence assessment runs required and simplifies the final source term (ST) calculation. The Pu-238eq is calculated using the following equation (Ref. 10):

$$Pu-238eq = \frac{1}{DCF_{Pu-238}} \sum_i (A_i)(DCF_i) . \qquad \text{[Eq. 1]}$$

where:

Pu-238eq	=	The Pu-238 equivalent. Other isotopes may be used; however, Pu-238 is the historical choice for all but noble gas & iodine.
$DCF_{Pu\text{-}238}$	=	Inhalation DCF for Pu-238 from FGR 13 (Ref. 4).
A_i	=	The number of Curies of the *i*th isotope.
DCF_i	=	Inhalation DCF for the *i*th isotope.

Using this equation, the Pu-238eq is calculated below.

RESULTS

The inventory for DWPF is given in FSAR Table 9.4-1a and Table 9.4-1b (Ref. 2) and the Pu-238eq in the following tables.

Sludge Stream			Totals:	2.49E+08	100.00%	**1.45E+00**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	1.50E-01	3.77E+04	5.66E+03	0.00%	3.31E-05
Sr-90	M	4.05E+01	1.32E+05	5.35E+06	2.15%	3.13E-02
Ru-106	M	2.00E+00	1.03E+05	2.06E+05	0.08%	1.20E-03
Cs-134	F	1.41E-01	2.48E+04	3.50E+03	0.00%	2.04E-05
Cs-137	F	1.34E+00	1.73E+04	2.32E+04	0.01%	1.36E-04
Ce-144	M	8.74E+00	1.33E+05	1.16E+06	0.47%	6.80E-03
Pm-147	M	2.14E+01	1.83E+04	3.92E+05	0.16%	2.29E-03
Eu-154	M	5.48E-01	1.97E+05	1.08E+05	0.04%	6.31E-04
Pu-238	M	1.30E+00	1.71E+08	2.22E+08	89.41%	1.30E+00
Pu-239	M	1.13E-02	1.86E+08	2.10E+06	0.85%	1.23E-02
Pu-240	M	7.59E-03	1.86E+08	1.41E+06	0.57%	8.26E-03
Pu-241	M	1.46E+00	3.33E+06	4.86E+06	1.96%	2.84E-02
Am-241	M	9.47E-03	1.54E+08	1.46E+06	0.59%	8.53E-03
Cm-244	M	9.40E-02	9.84E+07	9.25E+06	3.72%	5.41E-02

SRAT Stream			Totals:	4.54E+08	100.00%	**2.65E+00**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	2.73E-01	3.77E+04	1.03E+04	0.00%	6.02E-05
Sr-90	M	7.38E+01	1.32E+05	9.74E+06	2.15%	5.70E-02
Ru-106	M	3.64E+00	1.03E+05	3.75E+05	0.08%	2.19E-03
Cs-134	F	2.57E-01	2.48E+04	6.37E+03	0.00%	3.71E-05
Cs-137	F	3.41E+01	1.73E+04	5.90E+05	0.13%	3.45E-03
Ce-144	M	1.59E+01	1.33E+05	2.11E+06	0.47%	1.24E-02
Pm-147	M	3.90E+01	1.83E+04	7.14E+05	0.16%	4.17E-03
Eu-154	M	9.98E-01	1.97E+05	1.97E+05	0.04%	1.13E-03
Pu-238	M	2.37E+00	1.71E+08	4.05E+08	89.32%	2.37E+00
Pu-239	M	2.06E-02	1.86E+08	3.83E+06	0.84%	2.24E-02
Pu-240	M	1.38E-02	1.86E+08	2.57E+06	0.57%	1.50E-02
Pu-241	M	2.66E+00	3.33E+06	8.86E+06	1.95%	5.18E-02
Am-241	M	1.72E-02	1.54E+08	2.65E+06	0.58%	1.55E-02
Cm-244	M	1.71E-01	9.84E+07	1.68E+07	3.71%	9.84E-02

Melter Off-gas Stream			Totals:	8.50E+03	100.00%	**4.97E-05**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/ft^3)	DCF (rem/Ci)	Potential Dose Factor (rem/ft^3)	Percent Dose Contribution	Pu-238eq (M) (Ci/ft^3)
Co-60	M	5.04E-06	3.77E+04	1.90E-01	0.00%	1.11E-09
Sr-90	M	1.36E-03	1.32E+05	1.80E+02	2.11%	1.05E-06
Ru-106	M	1.34E-04	1.03E+05	1.38E+01	0.16%	8.07E-08
Cs-134	F	5.18E-05	2.48E+04	1.28E+00	0.02%	7.51E-09
Cs-137	F	6.86E-03	1.73E+04	1.19E+02	1.40%	6.94E-07
Ce-144	M	2.94E-04	1.33E+05	3.91E+01	0.46%	2.29E-07
Pm-147	M	7.18E-04	1.83E+04	1.31E+01	0.15%	7.68E-08
Eu-154	M	1.84E-05	1.97E+05	3.62E+00	0.04%	2.12E-08
Pu-238	M	4.38E-05	1.71E+08	7.49E+03	88.09%	4.38E-05
Pu-239	M	3.81E-07	1.86E+08	7.09E+01	0.83%	4.14E-07
Pu-240	M	2.56E-07	1.86E+08	4.76E+01	0.56%	2.78E-07
Pu-241	M	4.92E-05	3.33E+06	1.64E+02	1.93%	9.58E-07
Am-241	M	3.18E-07	1.54E+08	4.90E+01	0.58%	2.86E-07
Cm-244	M	3.17E-06	9.84E+07	3.12E+02	3.67%	1.82E-06

Melter Stream			Totals:	1.60E+08	100.00%	**9.38E-01**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/lb)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/lb)
Co-60	M	9.62E-02	3.77E+04	3.63E+03	0.00%	2.12E-05
Sr-90	M	2.63E+01	1.32E+05	3.47E+06	2.16%	2.03E-02
Ru-106	M	1.28E+00	1.03E+05	1.32E+05	0.08%	7.71E-04
Cs-134	F	8.22E-02	2.48E+04	2.04E+03	0.00%	1.19E-05
Cs-137	F	1.10E+01	1.73E+04	1.90E+05	0.12%	1.11E-03
Ce-144	M	5.62E+00	1.33E+05	7.47E+05	0.47%	4.37E-03
Pm-147	M	1.37E+01	1.83E+04	2.51E+05	0.16%	1.47E-03
Eu-154	M	3.52E-01	1.97E+05	6.93E+04	0.04%	4.06E-04
Pu-238	M	8.38E-01	1.71E+08	1.43E+08	89.31%	8.38E-01
Pu-239	M	7.28E-03	1.86E+08	1.35E+06	0.84%	7.92E-03
Pu-240	M	4.87E-03	1.86E+08	9.06E+05	0.56%	5.30E-03
Pu-241	M	9.42E-01	3.33E+06	3.14E+06	1.96%	1.83E-02
Am-241	M	6.10E-03	1.54E+08	9.39E+05	0.59%	5.49E-03
Cm-244	M	6.04E-02	9.84E+07	5.94E+06	3.70%	3.48E-02

Recycle Stream			Totals:	1.52E+08	100.00%	**8.90E-01**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	9.16E-02	3.77E+04	3.45E+03	0.00%	2.02E-05
Sr-90	M	2.48E+01	1.32E+05	3.27E+06	2.15%	1.91E-02
Ru-106	M	1.23E+00	1.03E+05	1.27E+05	0.08%	7.41E-04
Cs-134	F	9.00E-02	2.48E+04	2.23E+03	0.00%	1.30E-05
Cs-137	F	1.21E+01	1.73E+04	2.09E+05	0.14%	1.22E-03
Ce-144	M	5.33E+00	1.33E+05	7.09E+05	0.47%	4.15E-03
Pm-147	M	1.31E+01	1.83E+04	2.40E+05	0.16%	1.40E-03
Eu-154	M	3.35E-01	1.97E+05	6.60E+04	0.04%	3.86E-04
Pu-238	M	7.95E-01	1.71E+08	1.36E+08	89.3%	7.95E-01
Pu-239	M	6.91E-03	1.86E+08	1.29E+06	0.84%	7.52E-03
Pu-240	M	4.63E-03	1.86E+08	8.61E+05	0.57%	5.04E-03
Pu-241	M	8.92E-01	3.33E+06	2.97E+06	1.95%	1.74E-02
Am-241	M	5.77E-03	1.54E+08	8.89E+05	0.58%	5.20E-03
Cm-244	M	5.74E-02	9.84E+07	5.65E+06	3.71%	3.30E-02
Sb-125	M	4.50E-01	1.77E+04	7.97E+03	0.01%	4.66E-05
Te-125m	M	1.60E-01	1.25E+04	2.00E+03	0.00%	1.17E-05

DWTT			Totals:	9.06E+07	100%	**5.30E-01**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co 60	M	5.45E-02	3.77E+04	2.05E+03	0.00%	1.20E-05
Sr 90	M	1.47E+01	1.32E+05	1.94E+06	2.14%	1.13E-02
Ru 106	M	7.27E-01	1.03E+05	7.49E+04	0.08%	4.38E-04
Cs 134	F	5.13E-02	2.48E+04	1.27E+03	0.00%	7.44E-06
Cs 137	F	6.84E+00	1.73E+04	1.18E+05	0.13%	6.92E-04
Ce 144	M	3.17E+00	1.33E+05	4.22E+05	0.47%	2.47E-03
Pm 147	M	7.78E+00	1.83E+04	1.42E+05	0.16%	8.33E-04
Eu 154	M	1.99E-01	1.97E+05	3.92E+04	0.04%	2.29E-04
Pu 238	M	4.73E-01	1.71E+08	8.09E+07	89.32%	4.73E-01
Pu 239	M	4.11E-03	1.86E+08	7.64E+05	0.84%	4.47E-03
Pu 240	M	2.75E-03	1.86E+08	5.12E+05	0.56%	2.99E-03
Pu 241	M	5.31E-01	3.33E+06	1.77E+06	1.95%	1.03E-02
Am 241	M	3.43E-03	1.54E+08	5.28E+05	0.58%	3.09E-03
Cm 244	M	3.41E-02	9.84E+07	3.36E+06	3.71%	1.96E-02

512-S Feed Stream			Totals:	2.98E+06	100.00%	**1.74E-02**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	1.13E-03	3.77E+04	4.26E+01	0.00%	2.49E-07
Sr-90	M	3.05E-01	1.32E+05	4.03E+04	1.35%	2.35E-04
Ru-106	M	1.50E-02	1.03E+05	1.55E+03	0.05%	9.04E-06
Cs-134	F	1.06E-03	2.48E+04	2.63E+01	0.00%	1.54E-07
Cs-137	F	1.11E+00	1.73E+04	1.92E+04	0.64%	1.12E-04
Ce-144	M	6.56E-02	1.33E+05	8.72E+03	0.29%	5.10E-05
Pm-147	M	1.61E-01	1.83E+04	2.95E+03	0.10%	1.72E-05
Eu-154	M	4.11E-03	1.97E+05	8.10E+02	0.03%	4.73E-06
Pu-238	M	9.76E-03	1.71E+08	1.67E+06	56.01%	9.76E-03
Pu-239	M	1.46E-04	1.86E+08	2.72E+04	0.91%	1.59E-04
Pu-240	M	7.06E-05	1.86E+08	1.31E+04	0.44%	7.68E-05
Pu-241	M	1.12E-02	3.33E+06	3.73E+04	1.25%	2.18E-04
Am-241	M	7.08E-03	1.54E+08	1.09E+06	36.59%	6.38E-03
Cm-244	M	7.06E-04	9.84E+07	6.95E+04	2.33%	4.06E-04

MST/Sludge Solids (at LWPT vessel heel)			Totals:	1.25E+08	100.00%	**7.32E-01**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	7.49E-02	3.77E+04	2.82E+03	0.00%	1.65E-05
Sr-90	M	2.02E+01	1.32E+05	2.67E+06	2.13%	1.56E-02
Ru-106	M	9.98E-01	1.03E+05	1.03E+05	0.08%	6.01E-04
Cs-134	F	7.04E-02	2.48E+04	1.75E+03	0.00%	1.02E-05
Cs-137	F	1.77E+00	1.73E+04	3.06E+04	0.02%	1.79E-04
Ce-144	M	4.36E+00	1.33E+05	5.80E+05	0.46%	3.39E-03
Pm-147	M	1.07E+01	1.83E+04	1.96E+05	0.16%	1.15E-03
Eu-154	M	2.74E-01	1.97E+05	5.40E+04	0.04%	3.16E-04
Pu-238	M	6.49E-01	1.71E+08	1.11E+08	88.62%	6.49E-01
Pu-239	M	5.70E-03	1.86E+08	1.06E+06	0.85%	6.20E-03
Pu-240	M	3.80E-03	1.86E+08	7.07E+05	0.56%	4.13E-03
Pu-241	M	7.29E-01	3.33E+06	2.43E+06	1.94%	1.42E-02
Am-241	M	1.17E-02	1.54E+08	1.80E+06	1.44%	1.05E-02
Cm-244	M	4.69E-02	9.84E+07	4.61E+06	3.69%	2.70E-02

Filtrate Stream			Totals:	3.73E+06	100.00%	**2.18E-02**
Radionuclide	Absorption Type (F,M,S)	MAR (Ci/gal)	DCF (rem/Ci)	Potential Dose Factor (rem/gal)	Percent Dose Contribution	Pu-238eq (M) (Ci/gal)
Co-60	M	1.58E-03	3.77E+04	5.96E+01	0.00%	3.48E-07
Sr-90	M	4.27E-01	1.32E+05	5.64E+04	1.51%	3.30E-04
Ru-106	M	2.10E-02	1.03E+05	2.16E+03	0.06%	1.26E-05
Cs-134	F	1.48E-03	2.48E+04	3.67E+01	0.00%	2.15E-07
Cs-137	F	1.11E+00	1.73E+04	1.92E+04	0.51%	1.12E-04
Ce-144	M	9.18E-02	1.33E+05	1.22E+04	0.33%	7.14E-05
Pm-147	M	2.25E-01	1.83E+04	4.12E+03	0.11%	2.41E-05
Eu-154	M	5.76E-03	1.97E+05	1.13E+03	0.03%	6.64E-06
Pu-238	M	1.37E-02	1.71E+08	2.34E+06	62.76%	1.37E-02
Pu-239	M	1.80E-04	1.86E+08	3.35E+04	0.90%	1.96E-04
Pu-240	M	9.34E-05	1.86E+08	1.74E+04	0.47%	1.02E-04
Pu-241	M	1.56E-02	3.33E+06	5.19E+04	1.39%	3.04E-04
Am-241	M	7.11E-03	1.54E+08	1.09E+06	29.33%	6.40E-03
Cm-244	M	9.88E-04	9.84E+07	9.72E+04	2.60%	5.69E-04

Decontaminated Equipment Storage/Waste Staging Area Radiological Inventory

Sealand Container – Sludge Contaminated Waste (Radionuclide distribution based on Sludge Stream 1)						Totals:	3.62E+07	100%	**2.11E-01**
Radionuclide *	Absorption Type (F,M,S)	MAR (Ci/gal)	Curie %	Total Curies per Sealand	MAR (Ci)	DCF (rem/Ci)	Potential Dose Factor (rem)	Percent Dose Contribution	Pu-238eq (M) (Ci)
Co-60	M	1.50E-01	0.19%	1.13E+01*	2.18E-02	3.77E+04	8.22E+02	0.00%	4.81E-06
Sr-90	M	4.05E+01	52.12%		5.89E+00	1.32E+05	7.77E+05	2.15%	4.55E-03
Ru-106	M	2.00E+00	2.57%		2.91E-01	1.03E+05	3.00E+04	0.08%	1.75E-04
Cs-134	F	1.41E-01	0.18%		2.05E-02	2.48E+04	5.09E+02	0.00%	2.97E-06
Cs-137	F	1.34E+00	1.72%		1.95E-01	1.73E+04	3.37E+03	0.01%	1.97E-05
Ce-144	M	8.74E+00	11.25%		1.27E+00	1.33E+05	1.69E+05	0.47%	9.89E-04
Pm-147	M	2.14E+01	27.54%		3.11E+00	1.83E+04	5.70E+04	0.16%	3.33E-04
Eu-154	M	5.48E-01	0.71%		7.97E-02	1.97E+05	1.57E+04	0.04%	9.18E-05
Pu-238	M	1.30E+00	1.67%		1.89E-01	1.71E+08	3.23E+07	89.41%	1.89E-01
Pu-239	M	1.13E-02	0.01%		1.64E-03	1.86E+08	3.06E+05	0.85%	1.79E-03
Pu-240	M	7.59E-03	0.01%		1.10E-03	1.86E+08	2.05E+05	0.57%	1.20E-03
Pu-241	M	1.46E+00	1.88%		2.12E-01	3.33E+06	7.07E+05	1.96%	4.13E-03
Am-241	M	9.47E-03	0.01%		1.38E-03	1.54E+08	2.12E+05	0.59%	1.24E-03
Cm-244	M	9.40E-02	0.12%		1.37E-02	9.84E+07	1.35E+06	3.72%	7.87E-03

*Ref. 6, Section 6.2

B-25 Container - (Radionuclide distribution based on Sludge Stream 1)						Totals:	2.40E+07	100.00%	**1.40E-01**
Radionuclide*	Absorption Type (F,M,S)	MAR (Ci/gal)	Curie Fraction	Bounding MAR per B-25 (Ci)	MAR (Ci)	DCF (rem/Ci)	Dose Factor (rem)	Percent Dose	Pu-238eq (M) (Ci)
Co-60	M	1.50E-01	1.93E-03	7.5*	1.45E-02	3.77E+04	5.46E+02	0.00%	3.19E-06
Sr-90	M	4.05E+01	5.21E-01		3.91E+00	1.32E+05	5.16E+05	2.15%	3.02E-03
Ru-106	M	2.00E+00	2.57E-02		1.93E-01	1.03E+05	1.99E+04	0.08%	1.16E-04
Cs-134	F	1.41E-01	1.81E-03		1.36E-02	2.48E+04	3.38E+02	0.00%	1.97E-06
Cs-137	F	1.34E+00	1.72E-02		1.29E-01	1.73E+04	2.24E+03	0.01%	1.31E-05
Ce-144	M	8.74E+00	1.12E-01		8.44E-01	1.33E+05	1.12E+05	0.47%	6.56E-04
Pm-147	M	2.14E+01	2.75E-01		2.07E+00	1.83E+04	3.78E+04	0.16%	2.21E-04
Eu-154	M	5.48E-01	7.05E-03		5.29E-02	1.97E+05	1.04E+04	0.04%	6.09E-05
Pu-238	M	1.30E+00	1.67E-02		1.25E-01	1.71E+08	2.15E+07	89.41%	1.25E-01
Pu-239	M	1.13E-02	1.45E-04		1.09E-03	1.86E+08	2.03E+05	0.85%	1.19E-03
Pu-240	M	7.59E-03	9.77E-05		7.33E-04	1.86E+08	1.36E+05	0.57%	7.97E-04
Pu-241	M	1.46E+00	1.88E-02		1.41E-01	3.33E+06	4.69E+05	1.96%	2.74E-03
Am-241	M	9.47E-03	1.22E-04		9.14E-04	1.54E+08	1.41E+05	0.59%	8.23E-04
Cm-244	M	9.40E-02	1.21E-03		9.07E-03	9.84E+07	8.93E+05	3.72%	5.22E-03

*Ref. 6, Section 6.2

Two Sealand Containers - (Glass Contaminated Waste) (Ref. 7)				Totals:	7.59E+11	100.00%	**4.44E+03**
Radionuclide	Lung Class (F,M,S)	Distribution (Ci/lb)	MAR (Ci)	DCF (rem/Ci)	Dose Factor (rem)	Percent Dose	Pu-238eq (M) (Ci)
Co-60	S	9.62E-02	9.96E+02	1.14E+05	1.14E+08	0.01%	6.64E-01
Sr-90	S	2.63E+01	2.72E+05	5.81E+05	1.58E+11	20.87%	9.25E+02
Ru-106	S	1.28E+00	1.32E+04	2.44E+05	3.23E+09	0.43%	1.89E+01
Cs-134	S	8.22E-02	8.51E+02	7.55E+04	6.42E+07	0.01%	3.76E-01
Cs-137	S	1.10E+01	1.14E+05	1.45E+05	1.65E+10	2.18%	9.65E+01
Ce-144	S	5.62E+00	5.82E+04	1.95E+05	1.13E+10	1.50%	6.63E+01
Pm-147	S	1.37E+01	1.42E+05	1.80E+04	2.55E+09	0.34%	1.49E+01
Eu-154	S	3.52E-01	3.64E+03	1.76E+05	6.41E+08	0.08%	3.75E+00
Pu-238	S	8.39E-01	8.68E+03	5.96E+07	5.18E+11	68.22%	3.03E+03
Pu-239	S	7.29E-03	7.55E+01	5.92E+07	4.47E+09	0.59%	2.61E+01
Pu-240	S	4.86E-03	5.03E+01	5.92E+07	2.98E+09	0.39%	1.74E+01
Pu-241	S	9.43E-01	9.76E+03	6.48E+05	6.32E+09	0.83%	3.70E+01
Am-241	S	6.10E-03	6.31E+01	5.92E+07	3.74E+09	0.49%	2.19E+01
Cm-244	S	6.04E-02	6.25E+02	4.96E+07	3.10E+10	4.09%	1.81E+02

CONCLUSION

The following radionuclides remain for further screening in the streams listed below

Radionuclides
Co-60, Sr-90, Ru-106, Cs-134, Cs-137, Ce-144, Pm-147, Eu-154, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-244

Pu-238eq values from MAR characterization are listed below. Note that the Strip Effluent Stream is based on Cs-137 (1.65E+01 Ci/gal).

Description	**Pu-238eq**
Sludge Stream	1.45E+00 Ci/gal
SRAT Stream	2.65E+00 Ci/gal
Melter Off-gas Stream	4.97E-05 Ci/ft^3
Melter Stream (includes volatile component)	9.38E-01 Ci/lb
Recycle Stream	8.90E-01 Ci/gal
DWTT Stream	5.30E-01 Ci/gal
512-S Feed Stream	1.74E-02 Ci/gal
MST/Sludge Solids Stream (at LWPT Vessel Heel)	7.32E-01 Ci/gal
Filtrate Stream	2.18E-02 Ci/gal
SeaLand Container - Sludge	2.11E-01 Ci
2 SeaLand Containers - Glass	4.44E+03 Ci
B-25 Container	1.40E-01 Ci

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2. *S-Area DWPF Final Safety Analysis Report,* WSRC-SA-6, Rev. 34, Savannah River Site, July 2015.

3 Denny Armstrong to Jeff Ray, *New Bounding Streams – Impact to DWPF EPHA*, URS-PS-SAE-13-0037, URS Professional Solutions, Aiken, SC, March 4, 2013.

4. Federal Guidance Report 13, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides: CD Supplement*, EPA-402-C-99-001, Rev. 1, U.S. EPA, April 2002.

5. *Accident Analysis of DWPF Decontaminated Equipment Storage Containers,* S-CLC-S-00114, Rev. 0, Savannah River Site, Aiken, SC, May 2004.

6. *Waste Stream Distribution for Low Level Waste Generated in 221-S During Processing of SB7a and ISDP Batch 3 Strip Effluent and MST/Sludge Solids.* Q-CLC-S-00082, Rev. 0, Savannah River Site, July 2011.

7 *Curie Content of Seabox Containers Storing Equipment Contaminated with Radioactive Defense Waste Processing Facility (DWPF) Waste Glass*, N-CLC-S-00121, Rev. 1, Savannah River Site, March 2012.

8 *Revised Estimate of Glass Stored in SeaBox Containers*, SRR-WSE-2012-00106, September 2012, Savannah River Site, Aiken, SC.

9 *Dose Calculations for Glass Waste Storage Accidents*, S-CLC-S-00139, Rev. 0, Savannah River Site, July 2011.

10 *Standards for Development and Maintenance of an Emergency Planning Hazards Assessment*, EMPP 6Q-001, Revision 10, Savannah River Nuclear Solutions, Aiken, SC, November 2010.

INTRODUCTION

This calculation develops the downwind centerline doses for chemical releases from the DWPF. The Hotspot and ALOHA dispersion codes (Ref. 1, 2, respectively) are utilized and all information is input as required by Emergency Management Program Procedure (EMPP) 6Q-001 (Ref. 3).

Releases are considered under adverse and average meteorological conditions as directed by procedures EMPP 6Q-001 (Ref. 3).

INPUT DATA

1. The accident scenarios and radioactive source terms (STs) were developed in Section 5 of the main body of the EPHA and are input as Total Activity Released in the mixture file. Only scenarios that exceeded the threshold calculation found in Appendix B, Calculation 5 and those that require a mixture file for the consequence assessment are evaluated in the calculation.
2. The release rates for formic acid and dimethyl mercury were developed in Calculations 3 and 4, respectively.
3. General plume dispersion modeling parameters are as follows:
   - Wind input height 2 m (Hotspot) or 3 m (ALOHA) for ground level releases, 10 m for elevated releases
   - Ground-level release height is 0 m, stack-level release height is 45 meters
   - Complex Source Term (ST) geometry is used with a 3-m by 3-m source term geometry
   - City terrain option is used
   - Since the ST already has airborne and respirable fractions applied, values of 1 are set for model inputs
   - Sample time is the duration is 10 minutes for radiological releases and 15 for chemical releases unless otherwise specified for a specific scenario
   - Deposition velocity of 1 cm/s is used for particulate deposition for unfiltered releases and 0.1 cm/s for filtered releases.
   - Receptor height of zero is used
   - The dose is calculated for the following receptor locations of interest:
     - 30 meters (Ref. 3)
     - Facility Boundary (FB) 100 meters (Ref. 3)
     - The distance from DWPF to Central Training Facility (CTF) 570 meters (Ref. 3)
     - The distance from the DWPF to Crackerneck Wildlife Management Area (WMA) 9400 m (Ref. 3)
     - The nearest Site Boundary (SB) 10.94 km (Ref. 3)
   - The stability classes and corresponding wind speeds used for the appropriate release heights and meteorological conditions (95% adverse or 50% average) are as follows:

Meteorological Input Parameters

Release Height (m)*	Meteorological Conditions*	Stability Class*	Wind Speed (m/s)*	Temperature °C**	Inversion Layer (m)**	Cloud Cover**	Humidity %**
≤10	Average	C	2.5	25	500	80%	50
≤10	Adverse	E	1.7	29	300	10%	50
>10	Average	C	2.5	25	500	80%	50
>10	Adverse	A E	1.7 1.7	29 29	None 300	10% 10%	50

*Ref. 5
**Ref. 6

4. The Protective Action Criteria (PAC) for radiological sources is 1 rem Total Effective Dose (TED) and the Threshold for Early Lethality is 100 rem. The PAC for formic acid is the ERPG values (Ref. 4):

Chemical	PAC-1 (ppm)	PAC-2 (ppm)	PAC-3 (ppm)
Formic Acid	3	25	250

ANALYSIS METHODS

The Hotspot dispersion model (Ref. 1) will be used to determine the dose for each radiological accident scenario and the ALOHA model (Ref. 2) will be used to model formic acid accident scenarios. Only those release designations in Section 5 of the EPHA where the ST from a chemical release is greater than the threshold determination (Appendix B, Calculation 5), or requires a mixture file for modeling are developed in this calculation. All other STs are screened from further consideration in the EPHA. Releases are evaluated under Adverse Meteorological conditions (see Meteorological Input Parameters Table) first. If the release does not reach PAC under Adverse conditions (Stability Class A and E for elevated releases and Stability Class E for ground level releases) then the average meteorology (Stability Class C) does not need to be evaluated.

RESULTS

The results of the consequence assessments are in Attachment A and Attachment B of this calculation and in Section 6 of the EPHA. Those distances presented to bold and yellow highlights are carried forward into Tables 6.2 and 6.4 in the body of the document.

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2. *ALOHA, Version 5.3.1*. U.S. Environmental Protection Agency and U.S. National Oceanic and Atmospheric Administration, Washington, DC, July 1997.
3. *Standards for Development and Maintenance of an Emergency Planning Hazards Assessment*, Manual 6Q, EMPP 6Q-001, Revision 10, Savannah River Site, Aiken, SC, November 2010.
4. *Protective Action Criteria (PAC) with AEGLs, ERPGs, & TEELs: Rev. 29 for Chemicals of Concern,* U.S. Department of Energy, Office of Health, Safety and Security, Washington, DC, May 2016.
5. Hunter, C.H., *Revised Onsite Meteorological Data for Emergency Planning Hazards Assessments.* SRT-ETS-931167, Savannah River Site, Aiken, SC, November 1993.
6. Holzworth, G.C., *Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States,* U.S. Environmental Protection Agency, Division of Meteorology, Research Triangle Park, North Carolina, January 1972.

ATTACHMENT A - HOTSPOT OUTPUT

1-RD-4 Melter Spill/Breach (Elevated Filtered Release) – Adverse Meteorology

Mixture File

```
HotSpot User Mixture Database
 User Mixture Name  : DWPF 1-RD-4 Rev 13.mix

 Mixture Scale Factor                        : 1.0000E+00
 ____________________________________________________________________________
 Nuclide [01] : Ru-106  M    368.2d
 Halflife                            (Years): 1.0088E+00
 Inhalation        50-yr CEDE        (Sv/Bq): 2.7900E-08
 Submersion                (Sv-m3)/(Bq-sec): 1.0700E-14
 Ground Shine              (Sv-m2)/(Bq-sec): 3.4600E-16
 Total Activity Released             (Ci)   : 2.3800E-05
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [02] : Cs-137  F     30.0y
 Halflife                        (Years)    : 3.0000E+01
 Inhalation        50-yr CEDE    (Sv/Bq)    : 4.6700E-09
 Submersion              (Sv-m3)/(Bq-sec)   : 2.5500E-14
 Ground Shine            (Sv-m2)/(Bq-sec)   : 5.4900E-16
 Total Activity Released             (Ci)   : 1.2200E-03
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [03] : Sb-125  M     2.77y
 Halflife                        (Years)    : 2.7700E+00
 Inhalation        50-yr CEDE    (Sv/Bq)    : 4.7900E-09
 Submersion              (Sv-m3)/(Bq-sec)   : 1.9000E-14
 Ground Shine            (Sv-m2)/(Bq-sec)   : 4.1400E-16
 Total Activity Released             (Ci)   : 4.3900E-06
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [04] : Te-125m M       58d
 Halflife                        (Years)    : 1.5890E-01
 Inhalation        50-yr CEDE    (Sv/Bq)    : 3.3700E-09
 Submersion              (Sv-m3)/(Bq-sec)   : 3.3600E-16
 Total Activity Released             (Ci)   : 9.1500E-06
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [05] : Co-60   M    5.271y
 Halflife                        (Years)    : 5.2710E+00
 Inhalation        50-yr CEDE    (Sv/Bq)    : 1.0200E-08
 Submersion              (Sv-m3)/(Bq-sec)   : 1.1900E-13
 Ground Shine            (Sv-m2)/(Bq-sec)   : 2.3000E-15
 Total Activity Released             (Ci)   : 2.5700E-05
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [06] : Sr-90   M    29.12y
 Halflife                        (Years)    : 2.9120E+01
 Inhalation        50-yr CEDE    (Sv/Bq)    : 3.5600E-08
 Submersion              (Sv-m3)/(Bq-sec)   : 8.8900E-16
 Ground Shine            (Sv-m2)/(Bq-sec)   : 1.1200E-16
 Total Activity Released             (Ci)   : 7.0200E-03
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [07] : Ru-106  M    368.2d
 Halflife                        (Years)    : 1.0088E+00
 Inhalation        50-yr CEDE    (Sv/Bq)    : 2.7900E-08
 Submersion              (Sv-m3)/(Bq-sec)   : 1.0700E-14
 Ground Shine            (Sv-m2)/(Bq-sec)   : 3.4600E-16
 Total Activity Released             (Ci)   : 3.4200E-04
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
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```
Nuclide [08] : Cs-134  F    2.062y
Halflife                        (Years)   : 2.0620E+00
Inhalation        50-yr CEDE    (Sv/Bq)   : 6.6900E-09
Submersion              (Sv-m3)/(Bq-sec)   : 7.0700E-14
Ground Shine            (Sv-m2)/(Bq-sec)   : 1.4800E-15
Total Activity Released             (Ci)   : 2.2000E-05
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [09] : Cs-137  F     30.0y
Halflife                        (Years)   : 3.0000E+01
Inhalation        50-yr CEDE    (Sv/Bq)   : 4.6700E-09
Submersion              (Sv-m3)/(Bq-sec)   : 2.5500E-14
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.4900E-16
Total Activity Released             (Ci)   : 2.9400E-03
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [10] : Ce-144  M    284.3d
Halflife                        (Years)   : 7.7890E-01
Inhalation        50-yr CEDE    (Sv/Bq)   : 3.6000E-08
Submersion              (Sv-m3)/(Bq-sec)   : 7.3500E-16
Ground Shine            (Sv-m2)/(Bq-sec)   : 1.7300E-17
Total Activity Released             (Ci)   : 1.5000E-03
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [11] : Pm-147  M   2.6234y
Halflife                        (Years)   : 2.6234E+00
Inhalation        50-yr CEDE    (Sv/Bq)   : 4.9400E-09
Submersion              (Sv-m3)/(Bq-sec)   : 8.6600E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 2.8100E-20
Total Activity Released             (Ci)   : 3.6600E-03
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [12] : Eu-154  M      8.8y
Halflife                        (Years)   : 8.8000E+00
Inhalation        50-yr CEDE    (Sv/Bq)   : 5.3200E-08
Submersion              (Sv-m3)/(Bq-sec)   : 5.7800E-14
Ground Shine            (Sv-m2)/(Bq-sec)   : 1.1700E-15
Total Activity Released             (Ci)   : 9.4000E-05
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [13] : Pu-238  M    87.74y
Halflife                        (Years)   : 8.7740E+01
Inhalation        50-yr CEDE    (Sv/Bq)   : 4.6200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.3600E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.9900E-19
Total Activity Released             (Ci)   : 2.2400E-04
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [14] : Pu-239  M    24065y
Halflife                        (Years)   : 2.4065E+04
Inhalation        50-yr CEDE    (Sv/Bq)   : 5.0200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.7700E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 3.0600E-19
Total Activity Released             (Ci)   : 1.9400E-06
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00

Nuclide [15] : Pu-240  M     6537y
Halflife                        (Years)   : 6.5370E+03
Inhalation        50-yr CEDE    (Sv/Bq)   : 5.0200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.2900E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.6800E-19
Total Activity Released             (Ci)   : 1.3000E-06
Airborne Fraction                          : 1.0000E+00
```

```
Respirable Fraction                          : 1.0000E+00
Respirable Deposition Velocity (cm/sec)      : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)      : 8.0000E+00
_____________________________________________________________
Nuclide [16] : Pu-241  M     14.4y
Halflife                          (Years)    : 1.4400E+01
Inhalation        50-yr CEDE      (Sv/Bq)    : 9.0100E-07
Submersion              (Sv-m3)/(Bq-sec)     : 6.1500E-20
Ground Shine            (Sv-m2)/(Bq-sec)     : 1.4300E-21
Total Activity Released             (Ci)     : 2.5200E-04
Airborne Fraction                            : 1.0000E+00
Respirable Fraction                          : 1.0000E+00
Respirable Deposition Velocity (cm/sec)      : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)      : 8.0000E+00
_____________________________________________________________
Nuclide [17] : Am-241  M    432.2y
Halflife                          (Years)    : 4.3220E+02
Inhalation        50-yr CEDE      (Sv/Bq)    : 4.1700E-05
Submersion              (Sv-m3)/(Bq-sec)     : 6.7200E-16
Ground Shine            (Sv-m2)/(Bq-sec)     : 2.1800E-17
Total Activity Released             (Ci)     : 1.6300E-06
Airborne Fraction                            : 1.0000E+00
Respirable Fraction                          : 1.0000E+00
Respirable Deposition Velocity (cm/sec)      : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)      : 8.0000E+00
_____________________________________________________________
Nuclide [18] : Cm-244  M    18.11y
Halflife                          (Years)    : 1.8110E+01
Inhalation        50-yr CEDE      (Sv/Bq)    : 2.6600E-05
Submersion              (Sv-m3)/(Bq-sec)     : 4.0000E-18
Ground Shine            (Sv-m2)/(Bq-sec)     : 5.8500E-19
Total Activity Released             (Ci)     : 1.6100E-05
Airborne Fraction                            : 1.0000E+00
Respirable Fraction                          : 1.0000E+00
Respirable Deposition Velocity (cm/sec)      : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)      : 8.0000E+00
_____________________________________________________________
```

1-RD-4 Adverse Meteorology E-Stability

```
HotSpot  Version 2.07.1  General Plume
Feb 04, 2016 09:16 AM
Source Term                : DWPF 1-RD-4 Rev 13.mix (Mixture Scale Factor = 1.0000E+00)
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 3.10 m/s
Stability Class (City)     : E
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.49 km
MAXIMUM  TED               : 3.18E-04 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	0.0E+00	0.0E+00	0.0E+00	0.0E+00	<00:01
0.100	3.3E-09	4.0E-12	4.0E-08	1.1E-13	<00:01
0.570	3.1E-04	3.8E-07	3.8E-03	9.9E-09	00:03
9.400	1.4E-05	1.7E-08	1.7E-04	4.5E-10	00:50
10.940	1.2E-05	1.4E-08	1.4E-04	3.8E-10	00:58

1-RD-4 Adverse Meteorology A-Stability

```
HotSpot  Version 2.01.2  General Plume
Feb 04, 2016 09:19 AM
Source Term                : DWPF 1-RD-4 Rev 13.mix (Mixture Scale Factor = 1.0000E+00)
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 6.37E-04 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	4.7E-09	5.8E-12	5.8E-08	1.5E-13	<00:01
0.100	5.7E-04	6.9E-07	6.9E-03	1.8E-08	<00:01
0.570	7.1E-05	8.6E-08	8.6E-04	2.3E-09	00:04
9.400	2.0E-07	2.5E-10	2.5E-06	6.5E-12	01:13
10.940	1.5E-07	1.8E-10	1.8E-06	4.8E-12	01:25

Because consequence does not reach PAC, average meteorology is not needed.

1-RD-6b Transfer Spill Involving the CPC (Elevated Filtered Release) – Adverse Meteorology

Mixture File: MCU Strip Effluent Stream (62.5% SE and 37.5% LWPT Vessel Heel)

```
HotSpot User Mixture Database
 User Mixture Name  : DWPF 1-RD-6b Rev 13.mix

 Mixture Scale Factor                        : 1.0000E+00
 ____________________________________________________________________________
 Nuclide [01] : Cs-137  F     30.0y
 Halflife                            (Years): 3.0000E+01
 Inhalation        50-yr CEDE        (Sv/Bq): 4.6700E-09
 Submersion                (Sv-m3)/(Bq-sec): 2.5500E-14
 Ground Shine              (Sv-m2)/(Bq-sec): 5.4900E-16
 Total Activity Released             (Ci)   : 3.6100E-03
 Airborne Fraction                          : 1.0000E+00
 Respirable Fraction                        : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [02] : Co-60   M    5.271y
 Halflife                          (Years)   : 5.2710E+00
 Inhalation        50-yr CEDE      (Sv/Bq)   : 1.0200E-08
 Submersion              (Sv-m3)/(Bq-sec)    : 1.1900E-13
 Ground Shine            (Sv-m2)/(Bq-sec)    : 2.3000E-15
 Total Activity Released             (Ci)    : 4.9100E-06
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)     : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)     : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [03] : Sr-90   M    29.12y
 Halflife                          (Years)   : 2.9120E+01
 Inhalation        50-yr CEDE      (Sv/Bq)   : 3.5600E-08
 Submersion              (Sv-m3)/(Bq-sec)    : 8.8900E-16
 Ground Shine            (Sv-m2)/(Bq-sec)    : 1.1200E-16
 Total Activity Released             (Ci)    : 1.3300E-03
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)     : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)     : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [04] : Ru-106  M    368.2d
 Halflife                          (Years)   : 1.0088E+00
 Inhalation        50-yr CEDE      (Sv/Bq)   : 2.7900E-08
 Submersion              (Sv-m3)/(Bq-sec)    : 1.0700E-14
 Ground Shine            (Sv-m2)/(Bq-sec)    : 3.4600E-16
Total Activity Released              (Ci)    : 6.5600E-05
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)     : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)     : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [05] : Cs-134  F    2.062y
 Halflife                          (Years)   : 2.0620E+00
 Inhalation        50-yr CEDE      (Sv/Bq)   : 6.6900E-09
 Submersion              (Sv-m3)/(Bq-sec)    : 7.0700E-14
 Ground Shine            (Sv-m2)/(Bq-sec)    : 1.4800E-15
 Total Activity Released             (Ci)    : 4.6200E-06
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)     : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)     : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [06] : Cs-137  F     30.0y
 Halflife                          (Years)   : 3.0000E+01
 Inhalation        50-yr CEDE      (Sv/Bq)   : 4.6700E-09
 Submersion              (Sv-m3)/(Bq-sec)    : 2.5500E-14
 Ground Shine            (Sv-m2)/(Bq-sec)    : 5.4900E-16
 Total Activity Released             (Ci)    : 1.1600E-04
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
 Respirable Deposition Velocity (cm/sec)     : 1.0000E-01
 Non-resp.  Deposition Velocity (cm/sec)     : 8.0000E+00
 ____________________________________________________________________________
 Nuclide [07] : Ce-144  M    284.3d
 Halflife                          (Years)   : 7.7890E-01
 Inhalation        50-yr CEDE      (Sv/Bq)   : 3.6000E-08
 Submersion              (Sv-m3)/(Bq-sec)    : 7.3500E-16
 Total Activity Released             (Ci)    : 2.8600E-04
 Airborne Fraction                           : 1.0000E+00
 Respirable Fraction                         : 1.0000E+00
```

```
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [08] : Pm-147  M   2.6234y
Halflife                        (Years)    : 2.6234E+00
Inhalation        50-yr CEDE    (Sv/Bq)    : 4.9400E-09
Submersion              (Sv-m3)/(Bq-sec)   : 8.6600E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 2.8100E-20
Total Activity Released             (Ci)   : 7.0400E-04
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [09] : Eu-154  M      8.8y
Halflife                        (Years)    : 8.8000E+00
Inhalation        50-yr CEDE    (Sv/Bq)    : 5.3200E-08
Submersion              (Sv-m3)/(Bq-sec)   : 5.7800E-14
Ground Shine            (Sv-m2)/(Bq-sec)   : 1.1700E-15
Total Activity Released             (Ci)   : 1.8000E-05
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [10] : Pu-238  M    87.74y
Halflife                        (Years)    : 8.7740E+01
Inhalation        50-yr CEDE    (Sv/Bq)    : 4.6200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.3600E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.9900E-19
Total Activity Released             (Ci)   : 4.2500E-05
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [11] : Pu-239  M    24065y
Halflife                        (Years)    : 2.4065E+04
Inhalation        50-yr CEDE    (Sv/Bq)    : 5.0200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.7700E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 3.0600E-19
Total Activity Released             (Ci)   : 3.7500E-07
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [12] : Pu-240  M     6537y
Halflife                        (Years)    : 6.5370E+03
Inhalation        50-yr CEDE    (Sv/Bq)    : 5.0200E-05
Submersion              (Sv-m3)/(Bq-sec)   : 3.2900E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.6800E-19
Total Activity Released             (Ci)   : 2.4900E-07
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [13] : Pu-241  M     14.4y
Halflife                        (Years)    : 1.4400E+01
Inhalation        50-yr CEDE    (Sv/Bq)    : 9.0100E-07
Submersion              (Sv-m3)/(Bq-sec)   : 6.1500E-20
Ground Shine            (Sv-m2)/(Bq-sec)   : 1.4300E-21
Total Activity Released             (Ci)   : 4.7800E-05
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [14] : Am-241  M    432.2y
Halflife                        (Years)    : 4.3220E+02
Inhalation        50-yr CEDE    (Sv/Bq)    : 4.1700E-05
Submersion              (Sv-m3)/(Bq-sec)   : 6.7200E-16
Ground Shine            (Sv-m2)/(Bq-sec)   : 2.1800E-17
Total Activity Released             (Ci)   : 7.6900E-07
Airborne Fraction                          : 1.0000E+00
Respirable Fraction                        : 1.0000E+00
Respirable Deposition Velocity (cm/sec)    : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)    : 8.0000E+00
_____________________________________________________________
Nuclide [15] : Cm-244  M    18.11y
Halflife                        (Years)    : 1.8110E+01
Inhalation        50-yr CEDE    (Sv/Bq)    : 2.6600E-05
Submersion              (Sv-m3)/(Bq-sec)   : 4.0000E-18
Ground Shine            (Sv-m2)/(Bq-sec)   : 5.8500E-19
```

```
Total Activity Released            (Ci)   : 3.0700E-06
Airborne Fraction                         : 1.0000E+00
Respirable Fraction                       : 1.0000E+00
Respirable Deposition Velocity (cm/sec)   : 1.0000E-01
Non-resp.  Deposition Velocity (cm/sec)   : 8.0000E+00
```

1-RD-6b Adverse Meteorology E- Stability

```
HotSpot  Version 2.07.1  General Plume
Feb 04, 2016 09:42 AM
Source Term                : DWPF 1-RD-6b Rev 13.mix (Mixture Scale Factor = 1.0000E+00)
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 3.10 m/s
Stability Class (City)     : E
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.49 km
MAXIMUM  TED               : 6.17E-05 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	0.0E+00	0.0E+00	0.0E+00	0.0E+00	<00:01
0.100	6.4E-10	1.4E-12	1.4E-09	6.9E-15	<00:01
0.570	6.0E-05	1.4E-07	1.4E-04	6.6E-10	00:03
9.400	3.0E-06	6.7E-09	6.7E-06	3.2E-11	00:50
10.940	2.5E-06	5.7E-09	5.7E-06	2.7E-11	00:58

1-RD-6b Adverse Meteorology A-Stability

```
HotSpot  Version 2.07.1   General Plume
Feb 04, 2016 09:44 AM
Source Term                : DWPF 1-RD-6b Rev 13.mix (Mixture Scale Factor = 1.0000E+00)
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 1.23E-04 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	9.1E-10	2.1E-12	2.1E-09	1.0E-14	<00:01
0.100	1.1E-04	2.5E-07	2.5E-04	1.2E-09	<00:01
0.570	1.4E-05	3.2E-08	3.2E-05	1.5E-10	00:04
9.400	4.1E-08	9.2E-11	9.2E-08	4.5E-13	01:13
10.940	3.0E-08	6.8E-11	6.8E-08	3.3E-13	01:25

Because consequence does not reach PAC, average meteorology is not needed.

Attachment B

ALOHA OUTPUT

2-RD-1 422-S Formic Acid Storage Tank Spill Adverse Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 294 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 294 grams/min
   Total Amount Released: 4.41 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red    : 20 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 66 meters --- (25 ppm = ERPG-2)
   Yellow: 199 meters --- (3 ppm = ERPG-1)


THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 117 ppm
      Indoor:  12.4 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 11.1 ppm
      Indoor:  1.17 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.444 ppm
      Indoor:  0.0467 ppm


At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because it is outside
of the 1 hour release time limit.
```

2-RD-1 422-S Formic Acid Storage Tank Spill Average Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.54 (unsheltered single storied)
   Time: June 30, 2016  1159 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.056 atm
   Ambient Saturation Concentration: 57,124 ppm or 5.71%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 2.5 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 8 tenths
   Air Temperature: 25° C                 Stability Class: C
   Inversion Height: 500 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 408 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 408 grams/min
   Total Amount Released: 6.12 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : less than 10 meters(10.9 yards) --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 29 meters --- (25 ppm = ERPG-2)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Yellow: 84 meters --- (3 ppm = ERPG-1)

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 23.3 ppm
      Indoor:  2.94 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 2.1 ppm
      Indoor:  0.265 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.0662 ppm
      Indoor:  0.00829 ppm

At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because it is outside
of the 1 hour release time limit.
```

6-RD-1 980-S Organic Acid Waste Neutralization Tank Spill Adverse Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 167 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 167 grams/min
   Total Amount Released: 2.51 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 16 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 49 meters --- (25 ppm = ERPG-2)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Yellow: 147 meters --- (3 ppm = ERPG-1)

 THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 66.5 ppm
      Indoor:  7.06 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 6.3 ppm
      Indoor:  0.666 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.252 ppm
      Indoor:  0.0265 ppm

At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because there is no
significant concentration/dose at the point selected.
```

6-RD-1 980-S Organic Acid Waste Neutralization Tank Spill Average Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.54 (unsheltered single storied)
   Time: June 30, 2016  1159 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.056 atm
   Ambient Saturation Concentration: 57,124 ppm or 5.71%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 2.5 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 8 tenths
   Air Temperature: 25° C                 Stability Class: C
   Inversion Height: 500 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 167 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 167 grams/min
   Total Amount Released: 2.51 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : less than 10 meters(10.9 yards) --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 19 meters --- (25 ppm = ERPG-2)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Yellow: 53 meters --- (3 ppm = ERPG-1)

 THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 9.53 ppm
      Indoor:  1.2 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.861 ppm
      Indoor:  0.109 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.0271 ppm
      Indoor:  0.00339 ppm

At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because there is no
significant concentration/dose at the point selected.
```

7-RD-1 Malevolent Act Adverse Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 294 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 294 grams/min
   Total Amount Released: 4.41 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 20 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 66 meters --- (25 ppm = ERPG-2)
   Yellow: 199 meters --- (3 ppm = ERPG-1)


THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 117 ppm
      Indoor:  12.4 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 11.1 ppm
      Indoor:  1.17 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.444 ppm
      Indoor:  0.0467 ppm


At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because it is outside
of the 1 hour release time limit.
```

7-RD-1 Malevolent Act Average Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.54 (unsheltered single storied)
   Time: June 30, 2016  1159 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.056 atm
   Ambient Saturation Concentration: 57,124 ppm or 5.71%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 2.5 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 8 tenths
   Air Temperature: 25° C                 Stability Class: C
   Inversion Height: 500 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 408 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 408 grams/min
   Total Amount Released: 6.12 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : less than 10 meters(10.9 yards) --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 29 meters --- (25 ppm = ERPG-2)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Yellow: 84 meters --- (3 ppm = ERPG-1)

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 23.3 ppm
      Indoor:  2.94 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 2.1 ppm
      Indoor:  0.265 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.0662 ppm
      Indoor:  0.00829 ppm

At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because it is outside
of the 1 hour release time limit.
```

INTRODUCTION

This calculation establishes the rate of release of formic acid spills at Defense Waste Processing Facility (DWPF). Releases are considered under adverse and average meteorological conditions as directed by procedures Emergency Management Program Procedure (EMPP) 6Q-001 (Ref.1). The results of this calculation are inputs for Calculations 2 and 5.

INPUT

1. Potential Spill Volumes:

Formic acid is present in Buildings 221-S, 422-S and 980-S. The respective tank capacities are: 615 gallons, 6,500 gallons, and 3,147 gallons (Ref. 2, Table B-2).

There are no consequences from releases from a formic acid release in Building 221-S. The Organic Acid Drain Catch Tank will capture any formic acid tank overflow or spill in Building 221-S (Ref. 3, Section 5.4.13.3), effectively eliminating any formic acid release to the environment from 221-S. This tank has a 1,205 gallon capacity well over the 615 gallon capacity of the Formic Acid Feed Tank in 221-S (Ref. 3, Table 9.4-11).

Formic acid releases in Buildings 422-S and 980-S are ground level spill events. The entire contents of any tank is subject to being spilled.

2. Airflow Velocity:

Formic acid spills in Buildings 422-S and 980-S will not be subject to direct wind effects. Instead, the air flow velocities used in establishing the average and adverse meteorological evaporation rates will be taken as 0.5 m/s for adverse conditions and 0.8 m/s for average conditions. The logic for these values is:

- The Environmental Protection Agency's Risk Management Program assumes a 0.1 m/s wind speed for releases inside of a building (Ref. 4, Appendix D, Section D.2.4). Because the trench and sump areas are semi-covered and located below the surface of the diked areas, a reduced air flow velocity is justified.
- For adverse conditions an airflow velocity of 0.5 m/s is assumed in the trench area due to the protection from the wind offered by the trench, the dike, buildings and equipment. This wind speed is similar to the value determined by the power-law formula for calculating wind speeds at differing effective heights. The 0.5 m/s for adverse wind speed is approximately 30% of the 1.7 m/s wind speeds at 2 m.
- For average conditions an airflow velocity of 0.8 meters is assumed. This is based on taking 30 percent (derived in the previous bullet) of the average wind speed of 2.5 m/s and rounding to 0.8 m/s.
- These reduced wind speeds are only applied to the Eckert-Drake Evaporative Model (Ref. 5) to determine the amount of material released from the pool. The standard meteorological inputs (i.e., 1.7 m/s for adverse wind speed and 2.5 m/s for average wind speeds) are used for the dispersion modeling in Calculations 2 and 5.

3. Trench and Sump Geometry, 422-S:

There is a trench and sump in the diked area around the formic acid tanks in 422-S; it is designed to hold the contents of the largest tank within the dike.

- The total volume of the sump and trenches in Building 422-S is 377.95 gal (1.43 m^3)(see Appendix B, Calculation 5, Attachment C).
- The surface area for the dike in Building 422-S is 1,182 ft^2 (110 m^2) (see Analysis Methods and Computations section, following).

4. Trench and Sump Geometry, 980-S:

There is a trench and sump in the diked area around the formic acid tanks in 980-S; it is designed to hold the contents of the largest tank within the dike.

- The total volume of the sump and trench in Building 980-S is 194.49 gal (0.74 m^3) (see Appendix B, Calculation 5, Attachment C)
- The surface area for the dike in Building 980-S is 554.4 ft^2 (51.5 m^2) (see Appendix B, Calculation 5, Attachment C).

5. Miscellaneous Inputs and Material Properties:

- The vapor pressure used in obtaining the direct release source term is 37.2 mmHg for a 89.53% concentration of formic acid at 29° C for adverse meteorological conditions and 30.1 mmHg for a 89.53% concentration of formic acid at 25° C for average meteorological conditions (Ref. 6).
- The sumps/trenches of 980-S and 422-S do not contain any residual fluids for the computation of threshold spill volumes.
- The diffusion coefficient, D, used in the Eckert-Drake Evaporative Model (Ref. 5) for formic acid in air at 25º C and 29º C is 1.39E-05 m^2/s and 1.42E-05 m^2/s, respectively (Ref. 7).
- The density and viscosity of air used in the Eckert-Drake Evaporative Model (Ref. 5) for formic acid in air at 25º C through 29º C are 1.2 kg/m^3 and 1.9E-05 kg/m-s, respectively (Ref. 8, 9).

ANALYSIS METHODS AND COMPUTATIONS

Rate of release of the formic acid from the diked areas are determined using the Eckert-Drake Evaporative Model (Ref. 5). This is used as a direct release in the dispersion model to determine the downwind consequences.

Spill Surface Area in Building 422-S

The evaporative release is dependent upon the surface area of the spill. The net surface area, A_n, can be obtained by taking the difference between the dike footprint area and the sum of the surface areas of the bases of: 4 pumps, Dilute Formic Acid Feed Tank, Formic Acid Dilution Tank, Formic Acid Storage Tanks 1 and 2.

a. Dike footprint area, A_T

The dike footprint can be represented using two rectangles (Ref. 10):

- Rectangle 1 (containing Dilute Formic & Formic Dilution): 35.2 ft x 22 ft (774 ft^2)
- Rectangle 2 (containing storage tanks): 39.9 ft x 21.7 ft (866 ft^2)
- The total area is 1,640 ft^2 (744 ft^2 + 866 ft^2)

b. Surface areas of pump pads, A_p

There are four pump pads in the diked area. Two are Type I & AB, two are Type II & AB (Ref. 9).

- Type I & AB approximate footprint dimensions: 3 ft x 3 ft (9 ft^2)
- Type II & AB approximate footprint dimensions: 2 ft x 2 ft (4 ft^2).
- The total area of the 4 pump pads is: 26 ft^2 (9 ft^2 + 9 ft^2 + 4 ft^2 + 4 ft^2)

c. Surface areas of tank pads, A_o

There are four octagonal pads in the diked area (Ref. 10). The nomenclature used in discussing these pads is presented in Figure 1:

	a	b	c	Area, ft^2
Dilute Formic Acid Feed Tank	4.75	2.00	2.75	75
Formic Acid Feed Tank	4.75	2.00	2.75	75
Formic Acid Storage Tank 1	6.5	2.75	3.75	141
Formic Acid Storage Tank 2	6.5	2.75	3.75	141
Total footprint				432

The footprint for an octagon as shown in Figure 1, when represented as a large square with four triangular corners removed, is:

$$A_o = (2a)^2 - 4\left(\frac{c^2}{2}\right)$$

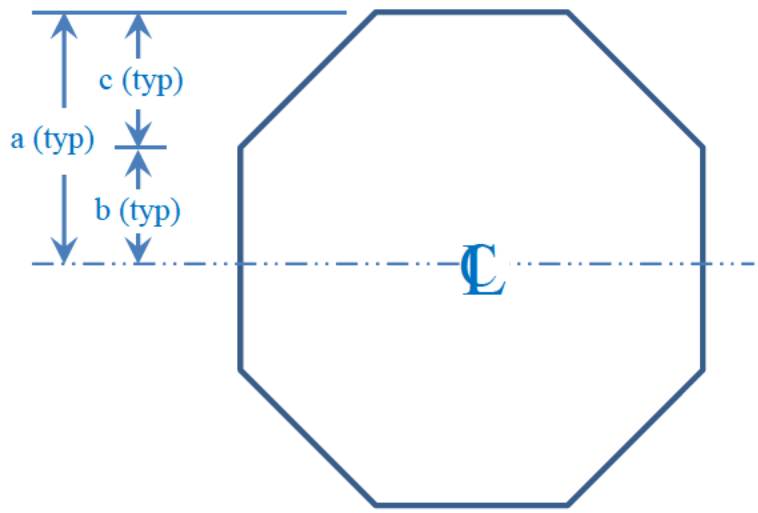

Figure 1, Octagonal Pad Nomenclature

d. Spill surface area, A_s

The spill surface area is:

$$A_S = A_T - A_p - A_o = 1{,}640\ \text{ft}^2 - 26\ \text{ft}^2 - \ 432\ \text{ft}^2 = 1{,}182\ \text{ft}^2 = 110\ \text{m}^2$$

Evaporation Rates

The evaporation rates are developed in Attachment A.

RESULTS

The rate release estimates from Attachment A are:

Building	Release Rate Adverse Meteorology (g/min)	Release Rate Average Meteorology (g/min)
422-S	294	408
980-S	167	170

REFERENCES

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4. *Risk Management Program for Offsite Consequence Assessment,* EPA 550-99-009, U.S. Environmental Protection Agency, Washington D.C., March 2009.

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ATTACHMENT A

This attachment presents the mass transfer rate calculations for the release of formic acid associated with potential spills in Building 422-S and Building 980-S. Page 7 presents the methodology used for the source term estimate. The remaining pages provide the bases for the results presented in this calculation.

Value/Parameter	Nomenclature	Comment [units]
Mass Transfer Rate	$\dot{m}$	$h_d A \frac{M\,p}{R_g T_K}$ [kg/s]
Molecular Weight	M	For formic acid: 46.03 [g/g-mole]
Vapor Pressure	p_{Hg}	37.2 [mm Hg] (Input 5)
Gas Law Constant	R_g	Fixed value: 8.3144E-02 [bar-m^3/kg-mol-K]
Temperature	T	29 [°C] (Input 5)
Volume of Spill	V_{gal}	Input 1 [gal]
Depth of Pool	d	Not used for this appendix [m]
Surface Area of Spill	A	422-S: 110 [m^2] (Input 3) 980-S: 51.5 [m^2] (Input 4)
Mass Transfer Coefficient	h_d	$h_{d,M}$ if Re >500,000, otherwise $h_{d,L}$ [m/s]
Diffusion Coefficient	D	Input 5 [m^2/s]
Pool Length	L	$\sqrt{\frac{4\,A}{\pi}}$ [m]
Reynolds Number	Re	$\frac{L\,u\,\rho}{\mu}$ [unitless]
Schmidt Number	Sc	$\frac{\mu}{D\,\rho}$ [unitless]
Wind speed	u	Indoors per (Input 2) [m/s]
Density of air	ρ	1.2 [kg/m^3] (Input 5)
Viscosity of air	μ	1.9E-05 [kg/m-s] (Input 5)
Conditional		
Laminar h_d	$h_{d,L}$	$0.644 \left(\frac{D}{L}\right) Re^{(1/2)}\, Sc^{(1/3)}$ [unitless]
Mixed h_d	$h_{d,M}$	$\left(\frac{D}{L}\right) \left[0.037\, Re^{(1/2)} - 871\right] Sc^{(1/3)}$ [unitless]
Conversions		
Temperature (absolute)	T_K	T + 273.15 [K]
Volume	V	0.0037853 V_{gal} [m^3]
p_{bar}	p_{bar}	p_{Hg} ÷ 750.06 [bar]
p_{Pa}	p_{Pa}	P_{bar} x 10^{+5} [Pa]
Evaporation Rate	$\dot{m}_g$	$\left(1000\,\frac{g}{kg}\right)\left(60\,\frac{s}{min}\right)\dot{m}$ [g/min]
2 hr Evaporation	m	(2 hrs) $\left(60\,\frac{min}{hr}\right)\left(60\,\frac{sec}{min}\right)\dot{m}$ [kg]

Release maximum source term input determination for diked spill area for 422-S (adverse met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	4.90E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	37.2	mm Hg
Rg (Gas Law Constant)	8.31E-02	bar-m^3/kg-mol-K
Temperature	29	°C
Volume of Spill	6,500	gal
d (depth of pool)		m
A (surface area of spill)	110	m^2
h_d (mass transfer coefficient)	4.90E-04	m/s
D (diffusion coefficient)	1.42E-05	m^2/s
L (pool length)	12	m
Re (Reynolds Number)	374,000	
Sc (Schmidt Number)	1.12	
u (wind speed)	0.5	m/s
ρ(density of air)	1.2	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	4.90E-04	
$h_{d,M}$ (if mixed)	2.38E-04	
Conversions		
T (absolute)	302.15	K
V (volume)	24.60	m^3
p_{bar}	4.96E-02	bar
p_{Pa}	4.96E+03	Pa
Evaporation Rate	294	g/min
2 hr Evaporation	35	kg

Release maximum source term input determination for diked spill area for 422-S (average met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	6.80E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	30.1	mm Hg
Rg (Gas Law Constant)	8.31E-02	bar-m^3/kg-mol-K
Temperature	25	°C
Volume of Spill	6,500	gal
d (depth of pool)		m
A (surface area of spill)	110	m^2
h_d (mass transfer coefficient)	8.29E-04	m/s
D (diffusion coefficient)	1.39E-05	m^2/s
L (pool length)	12	m
Re (Reynolds Number)	598,000	
Sc (Schmidt Number)	1.114	
u (wind speed)	0.8	m/s
ρ(density of air)	1.2	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	6.11E-04	
$h_{d,M}$ (if mixed)	8.29E-04	
Conversions		
T (absolute)	298.15	K
V (volume)	24.60	m^3
p_{bar}	4.01E-02	bar
p_{Pa}	4.01E+03	Pa
Evaporation Rate	408	g/min
2 hr Evaporation	49	kg

Release maximum source term input determination for diked spill area for 980-S (adverse met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	2.78E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	37.2	mm Hg
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mol-K
Temperature	29	°C
Volume of Spill	3,147	gal
d (depth of pool)		m
A (surface area of spill)	51.5	m^2
h_d (mass transfer coefficient)	5.94E-04	m/s
D (diffusion coefficient)	1.42E-05	m^2/s
L (pool length)	8.1	m
Re (Reynolds Number)	261042	
Sc (Schmidt Number)	1.09	
u (wind speed)	0.5	m/s
ρ(density of air)	1.2250	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	5.94E-04	
$h_{d,M}$ (if mixed)	-1.33E-04	
Conversions		
T (absolute)	302.15	K
V (volume)	11.91	m^3
p_{bar}	4.96E-02	bar
p_{Pa}	4.96E+03	Pa
Evaporation Rate	166.9	g/min
2 hr Evaporation	20	kg

Release maximum source term input determination for diked spill area for 980-S (average met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	2.84E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	30.1	mm Hg
Rg (Gas Law Constant)	8.31E-02	bar-m^3/kg-mol-K
Temperature	25	°C
Volume of Spill	3,147	gal
d (depth of pool)		m
A (surface area of spill)	51.5	m^2
h_d (mass transfer coefficient)	7.38E-04	m/s
D (diffusion coefficient)	1.39E-05	m^2/s
L (pool length)	8	m
Re (Reynolds Number)	409,000	
Sc (Schmidt Number)	1.114	
u (wind speed)	0.8	m/s
ρ(density of air)	1.2	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	7.38E-04	
$h_{d,M}$ (if mixed)	4.86E-04	
Conversions		
T (absolute)	298.15	K
V (volume)	11.91	m^3
p_{bar}	4.01E-02	bar
p_{Pa}	4.01E+03	Pa
Evaporation Rate	170	g/min
2 hr Evaporation	20	kg

INTRODUCTION

This calculation determines the amount of material vaporized in DWPF deflagration events.

INPUT DATA AND ASSUMPTIONS

The following assumptions were used for hydrogen deflagration (Ref. 1, 2):

	SEFT, SRAT, SME, SMECT, MFT	PRFT
Tank Volume (gal)	12,000	9000
Fill Factor (gal/in)	76.6	57.5
Tank Height (m)	3.98	3.98
Tank Inside Diameter (m)	3.66	2.74
Hydrogen Concentration (%)	12	12
Latent heat of vaporization of water (kJ/kg)	2257	2257
Specific volume of gas (l/mol)	22.4	22.4
Specific combustion energy of hydrogen (kcal/mol)	57.8	57.8
Waste Density (g/cm^3)	1.0	1.0

The following conversion factors were used:

Conversion Factors	Units
12	in/ft
0.3048	ft/m
3.79	l/gal
4.186	kJ/kcal
1000	g/kg
3790	cm^3/gal

ANALYSIS METHODS AND COMPUTATIONS

A postulated explosion scenario is considered for 221-S tanks in the DWPF Facility in which the ventilation fails and allows the hydrogen to build up. The scenario involves a waste tank full of vapor space, a hydrogen concentration of 4 vol % in the vapor space, and 1.0 g/cm^3 liquid density.

The model states that the energy from the deflagration is used to vaporize the solution.

The amount vaporized is given by the following equation(s) (Ref. 3):

$$M_v = MARxDR = \frac{Fn_H E_c}{h_{fg}} \qquad \text{[Eq. 1]}$$

where:

M_v = mass of vaporized liquid, kg
n_H = number of moles of hydrogen
E_c = specific energy of combustion for hydrogen, kJ/mole
h_{fg} = latent heat of vaporization of water, kJ/kg
F = fraction of energy deposited on liquid surface

Only a fraction of the energy is deposited to the liquid. The rest is deposited to deflagration the tank ceiling and side wall. Therefore, the energy deposition factor is calculated from:

$$F = \frac{A_l}{A_v} \qquad \text{[Eq. 2]}$$

where:

A_l = area of liquid surface = $\frac{\pi D_i^2}{4}$, m^2

D_i = inside diameter of tank, m

A_v = surface area (liquid, ceiling, and side wall) contacted by vapor space

$= 2A_l + \pi D_i (h_t - h_w)$, m^2

h_t = tank height, m

h_w = waste height, m

The vapor volume is calculated from:

$$V_v = V_t - V_w = V_t - \text{fill} \times h_w \qquad \text{[Eq. 3]}$$

where:

V_v	=	vapor volume, gal
V_t	=	tank volume, gal
V_w	=	waste volume, gal
fill	=	fill factor, gal/in

Therefore, the volume of hydrogen in the tank is:

$$V_H = (C_H/100)V_v \times 3.79 \text{ l/gal} \qquad \text{[Eq. 4]}$$

where:

V_H	=	volume of hydrogen, liters
C_H	=	hydrogen concentration, vol %

Since the specific volume of gas (v_{gas}) at STP is 22.4 liters/mole, the number of moles of hydrogen is:

$$N_H = V_H/v_{gas} \qquad \text{[Eq. 5]}$$

Using a low temperature is conservative since it maximizes the number of moles of hydrogen in the vapor space.

The specific combustion energy of hydrogen (57.8 kcal/mole) is converted to kJ/mole by using a multiplication factor of 4.186 kJ/kcal. The mass of water vaporized can then be calculated from equation 1 as E_c and h_{fg} are inputs and F has been determined from equation 2 and N_H from equation 5.

The mass of vaporized liquid at various vapor volumes are calculated as given in Attachment A.

RESULTS

The amount of material vaporized in a deflagration is given below.

Tank	Mass Vaporized	Volume Vaporized
SEFT, SRAT, SME, SMECT, MFT	4.11 kg	1.09E+00 gal
PRFT	2.51 kg	6.63E-01 gal

REFERENCES

1. *512-S Facility Consolidated Hazard Analysis Process (CHAP) Basis (U)*, S-CLC-S-00104, Rev. 1, Savannah River Site, Aiken, SC, August 2006.
2. *S-Area DWPF Final Safety Analysis Report,* WSRC-SA-6, Rev. 34, Savannah River Site, Aiken, SC, July 2015.
3. Winkler, E.N., *Waste Tank Explosion (U)*, S-CLC-G-00258, Rev. 1, Savannah River Site, Aiken, SC (Confirmed), June 2004.

Attachment A: Material Vaporized in Deflagration

Deflagration Model for SEFT, SRAT, SME, SMECT, MFT			
		Units	Cell Name
Tank Vol	12000	gal	Vtg
Fill Factor	76.6	gal/in	fill
Waste Height	0.00	m	hw
Tank Height	3.97764	m	htk
Tank Inside Diameter	3.6576	m	Dtk
Hydrogen Concentration	12	vol %	Chydrogen
Latent heat of vaporization of water	2257	kJ/kg	hfg
Specific volume of gas	22.4	l/mol	vgas
Specific combustion energy of hydrogen	57.8	Kcal/mol	ehydrogen
Calculations			
Liquid Surface Area	10.52	m2	Aliq
Vapor Surface Area	66.80	m2	Avap
Energy Deposition Factor	0.16		Fview
Waste Volume	0	gal	Vwg
Vapor Volume	12000	gal	Vvg
Vapor Volume	45480.00	l	Vv
Hydrogen Volume	5457.60	l	Vhydrogen
Total Mole of Hydrogen	243.64	mol	nhydrogen
Combustion Energy of Hydrogen	58949.58	KJ	Ecomb
Mass of water Vaporized	**4.11**	**kg**	mvap
ST vap	**1.09E+00**	**gal**	

Deflagration Model for PRFT				
		Units	Cell Name	
Tank Vol	9000	gal	Vtg	
Fill Factor	57.5	gal/in	fill	
Waste Height	0.00	m	hw	max gas volume
Tank Height	3.97764	m	htk	
Tank Inside Diameter	2.7432	m	Dtk	
Hydrogen Concentration	12	vol %	Chydrogen	
Latent heat of vaporization of water	2257	kJ/kg	hfg	
Specific volume of gas	22.4	l/mol	vgas	
Specific combustion energy of hydrogen	57.8	Kcal/mol	ehydrogen	
Calculations				
Liquid Surface Area	5.90	m2	Aliq	
Vapor Surface Area	46.05	m2	Avap	
Energy Deposition Factor	0.13		Fview	
Waste Volume	0	gal	Vwg	
Vapor Volume	9000	gal	Vvg	
Vapor Volume	34110.00	l	Vv	
Hydrogen Volume	4093.20	l	Vhydrogen	
Total Mole of Hydrogen	182.73	mol	nhydrogen	
Combustion Energy of Hydrogen	44212.19	KJ	Ecomb	
Mass of water Vaporized	2.51	kg	mvap	
ST vap	**0.662**	**gal**		

INTRODUCTION

This calculation calculates the downwind threshold source term and related material at risk (MAR) for releases from Defense Waste Processing Facility (DWPF). The Hotspot model (Ref. 1) is used for radiological releases and the ALOHA model (Ref. 2) is used for chemical releases; information is input as required by Emergency Management Program Procedure (EMPP) 6Q-001 (Ref. 3). Releases are considered under adverse and average meteorological conditions as directed by procedures EMPP 6Q-001 (Ref. 3).

DISCUSSION/ASSUMPTIONS

The accident scenarios and radioactive source terms were developed in Section 5.0 of the main body of the Emergency Planning Hazards Assessment.

INPUT

1. General plume dispersion modeling parameters are as follows:
   - Reference wind input height is 2 meters (Hotspot) and 3 meters (ALOHA) for ground level releases.
   - Ground-level release height is at 0 m.
   - Elevated release height is at 45 m.
   - Dry deposition and city terrain options.
   - Since the source term (ST) already has a release fraction applied, a value of 1 is input for modeling.
   - Filter % is 0 as it has been applied in the source term.
   - Sample time, the duration of the release, is 10 minutes for a spill or impact scenario and 3 minutes for an explosion unless otherwise specified for a specific scenario (Ref. 3). For fire scenarios, the release duration will be 20 minutes in accordance with the approved safety basis (Ref. 4, Section 9.4.1.3, p. 9.4-21).
   - Deposition velocity of 1 cm/s for unfiltered particulates and tritium oxide; 0.1 cm/s for HEPA filtered particulate releases.
   - Receptor height = 0.
   - A 3-meter by 3-meter ST geometry.
2. The 1 rem Protective Action Criteria (PAC) for radiological releases is 1 rem TED.
3. The PAC for formic acid and dimethyl mercury are given below. The PAC values for formic acid are the ERPG values. (Ref. 5):

Chemical	PAC-1	PAC-2	PAC-3
Formic Acid	3 ppm	25 ppm	250 ppm
Dimethyl Mercury	0.034 mg/m^3	0.046 mg/m^3	2.3 mg/m^3

4. The stability classes and corresponding wind speeds used for the appropriate release heights and meteorological conditions (95% adverse or average) are (Ref. 6, 7):

Meteorological Input Parameters for Dispersion Modeling

Release Height (m)	Meteorological Conditions	Stability Class	Wind Speed (m/s)	Temperature °C	Inversion Layer (m)	Cloud Cover	Humidity %
≤10	Average	C	2.5	25	500	80%	50
≤10	Adverse	E	1.7	29	300	10%	50
>10	Average	C	2.5	25	500	80%	50
>10	Adverse	A E	1.7 1.7	29 29	None 300	10% 10%	50

5. The stack height for the Zone 1 ventilation system from the top to the concrete foundation is 147 ft (45 m) to provide elevated release and preclude released radioactive materials from being drawn back into the Vitrification Building air inlets. An inspection port is provided at the bottom of the exhaust stack (Ref. 4, Section 5.3.2.3). All elevated releases are filtered releases.

6. Formic Acid:

   - Formic acid releases are ground level spill events only from Buildings 422-S and 980-S. There are no consequences from releases from the formic acid area in Building 221-S because they are mitigated by the sand filter and exhausted by the 147 ft (45 m) stack.
   - The EPA's Risk Management Program assumes a 0.1 m/s wind speed for releases inside of a building (Ref. 8, Appendix D, Section D.2.4). Because the trench and sump areas are semi-covered and located below the surface of the diked areas, 0.1 m/s wind speed is assumed for the evaporative release from the trench and sump areas for 422-S and 980-S. A wind speed of 0.5 m/s is assumed in the dike area due to the protection from the wind offered by the trench, the dike walls, buildings and equipment. This wind speed is similar to the value determined by the power-law formula for calculating wind speeds at differing effective heights. This wind speed is only applied to the Eckert-Drake Evaporative Model (Ref. 9) – the standard meteorological inputs shown above are used for dispersion modeling.
   - There is a trench and sump in the diked area around the formic acid tanks in 422-S and 980-S.
     - The effective surface area of the dike for 422-S is determined in Appendix B, Calculation 3 to be 1,182 ft^2 (110 m^2). The surface area for the dike for 980-S is 554.5 ft^2 (51.5 m^2) (see Attachment C). These dikes are designed to hold the contents of the largest tank within the dike. The formic acid tanks in 422-S and 980-S are 6,500 gal and 3,147 gal, respectively.
     - The dimensions of the sump and trench for 980-S are 2 ft x 2 ft x 1 ft and 1 ft x 1 ft x 22 feet, respectively. The total volume of the sump and trench is 194.49 gal (see Attachment C).

- The dimensions of the sump and trench for 422-S are (see Attachment C):
  - Sump: 2.5 ft x 2.5 ft x 1 ft
  - Trench 1: 1 ft x 1 ft x 37.67 ft
  - Trench 2: 0.5 ft x 0.5 ft x 26.42 ft
  - The total volume of the sump and trenches is 377.95 gal (see Attachment C)

ANALYSIS METHODS

Radiological Releases:

The Hotspot consequence assessment model is used to determine the Total Effective Dose (TED) at 30 m corresponding to an Alert classification and at 100 m corresponding to a Site Area Emergency (SAE) classification. The ST that produces 1 rem between 30 m and the FB (100 m) is the Alert ST threshold and the ST that produces 1 rem between 100 m and the site boundary is the SAE ST threshold. For the scenario specific releases, the generic ST threshold that represents the type of release and the duration of the release is entered as the ST threshold for that scenario. The source release fraction (SRF) is calculated by dividing the ST by the material at risk (MAR) for that scenario. The MAR threshold is calculated by dividing the ST threshold for an Alert or a SAE by the SRF for the particular scenario.

Formic Acid Releases:

The ALOHA consequence assessment model is used to determine the concentration at 30 m and at 100 m for the ground level formic acid release. The rate of release that meets the PAC at 30 m and at 100 m are the Alert and SAE ST thresholds, respectively. The total amount of material released is calculated using the Eckert-Drake Evaporative Model (see Attachment B).

Releases from 422-S and 980-S involve a release from the sump/trench area and the dike area. Because the rate of release to reach an ALERT or SAE has been calculated using the ALOHA model, the contribution of each of these areas must be determined. The total length of the trench and sump is calculated to be 24 ft (7.32 m) and the total surface area for the pump pads is calculated to be 26 ft^2 (2.42 m^2) for 980-S. The total length of the trenches and sump for 422-S is calculated to be 65.04 ft (19.8 m) and the surface area is calculated to be 1,182 ft^2 (110 m^2). These are used in the Eckert-Drake Evaporative Model to determine the contribution to the overall ST from an evaporative release from the sump/trench area (see Attachment B).

Once the rate of release to reach an ALERT or SAE and the amount of contribution to the ST from the sump/trench areas is determined, the rate of release from the diked area can be determined. The amount of material required to reach this rate of release can be determined using the Eckert-Drake Evaporative Model.

Dimethyl Mercury Releases:

The Hotspot consequence assessment model is used to determine the dispersion factor for a release of dimethyl mercury because dimethyl mercury is not listed as an Aloha chemical.

$$ST = C/ (X/Q)$$

where: ST = Source Term, mg/s
C = concentration, mg/m^3
X/Q = Dispersion factor, s/m^3

The resulting ST is compared to the total potential amount released from the bounding concentration in the spilled volume.

Source Terms

The following calculations are performed to determine the limiting STs for a release of dimethyl mercury (Attachment D).

Input	Value (s/m^3)
Dispersion Factor (X/Q) - 15 min – Adverse – 30 m	1.1E-02
Dispersion Factor (X/Q) - 15 min – Adverse – 100 m	1.5E-03

Dimethyl Mercury Limiting ST

Scenario Description	X/Q (s/m^3)	PAC-2 Concentration (mg/m^3)	ST* (mg/s)
15 min – Adverse – Alert	1.1E-02	0.046	4.18E+00
15-min – Adverse - SAE	1.5E-03	0.046	3.06E+01

*ST = PAC-2/(X/Q)

RESULTS

The results of consequence assessments output are in Attachment A of this calculation. The below table summarizes the ST thresholds and MAR thresholds.

Release ID	Description	MAR Ci Pu238 eq	ST Ci Pu238 eq	ST Threshold			MAR Threshold	
				Alert Ci @ 30 m	SAE Ci @ 100 m	SRF	Alert Ci @ 30 m	SAE Ci @ 100 m
Ground Level Unfiltered Release				**Pu238 eq**	**Pu238 eq**			
	20 minute duration	--	--	1.73E-03	1.24E-02	--	--	--
	10 minute duration	--	--	1.51E-03	1.08E-02	--	--	--
	3 minute duration	--	--	1.24E-03	8.91E-03	--	--	--
Ground Level Filtered Release				**Pu238 eq**	**Pu238 eq**			
	20 minute duration	--	--	1.65E-03	1.10E-02	--	--	--
	10 minute duration	--	--	1.43E-03	9.55E-03	--	--	--
	3 minute duration	--	--	1.15E-03	7.51E-03		--	--
Elevated (45 m) Filtered Release				**Pu238 eq**	**Pu238 eq**			
	20 minute duration	--	--	NA*	4.52E-01		--	--
	10 minute duration	--	--	NA*	3.95E-01		--	--
	3 minute duration	--	--	NA*	3.10E-01		--	--
Cs-137 (F) Filtered 10-minute Release								
	Ground Level			1.25E+01	8.30E+01			
	Elevated (45 m)			NA	6.80E+03			
Ground Level Formic Acid Release				**g/min**	**g/min**		--	--
422-S		--	--	6.10E+01	6.60E+02	--	410 gal	NA**
980-S		--	--	6.10E+01	6.60E+02	--	224 gal	NA**
Ground Level Dimethyl Mercury Release				**mg/s**	**mg/s**			
511-S		--	--	4.18E+00	3.06E+01	--	--	--

* Plume does not touch down between 30 m and 100 m.

**With reduced wind speeds at the surface of the spilled pool, the surface area of the dike is completely covered before the evaporation rate for an SAE is reached. Note: For 422-S, 660 gal will fill the trenches/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE. For 980-S, 330 gal will fill the trench/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE.

REFERENCES

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2. *ALOHA, Version 5.3.1*. U.S. Environmental Protection Agency and U.S. National Oceanic and Atmospheric Administration, Washington, DC, July 1997 [Containing chemical database modified for dilute acids by Westinghouse Safety Management Solutions, November 22, 1999].
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4. *S-Area DWPF Final Safety Analysis Report,* WSRC-SA-6, Rev. 34, Savannah River Site, Aiken, SC, July 2015.
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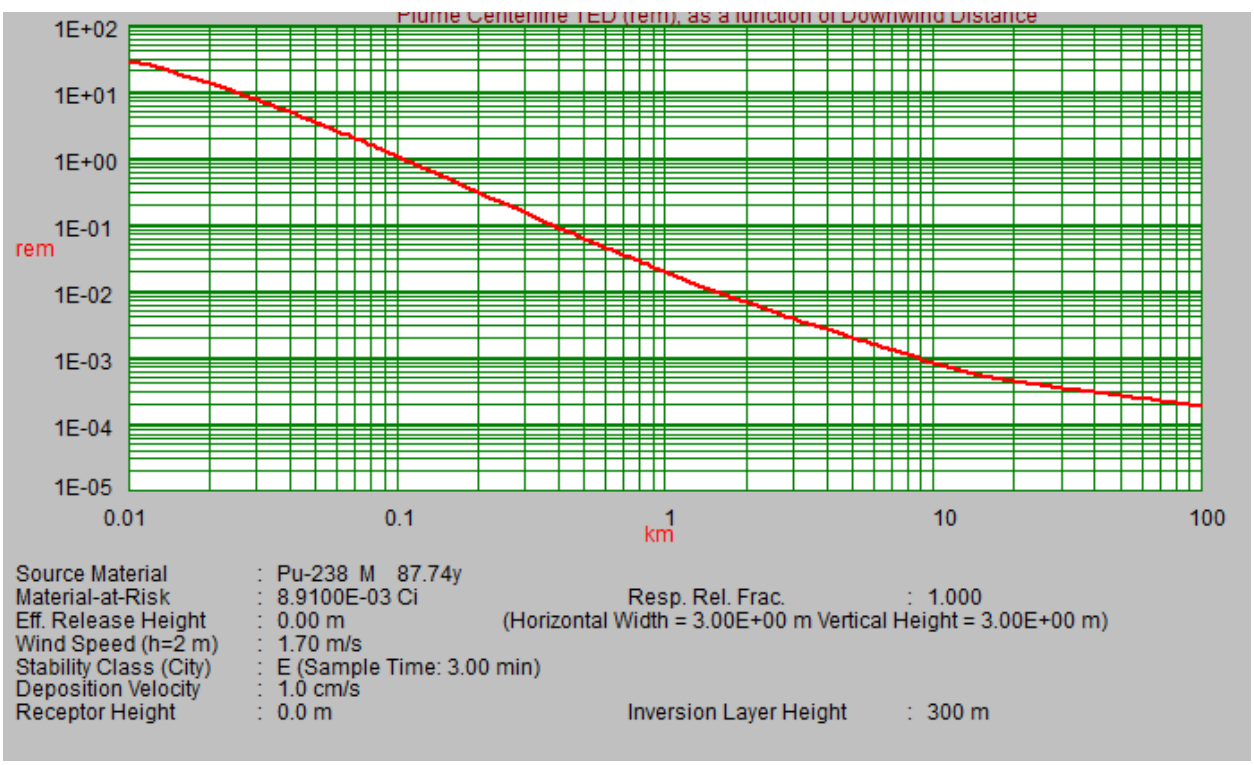
7 *Revised Meteorological Data Sets for Safety Related Atmospheric Dispersion Modeling (U),* SRNL-STI-2012-00648, Rev. 1, Savannah River National Laboratory, Aiken, SC, April 2013.
8. *Risk Management Program for Offsite Consequence Assessment,* EPA 550-B-99-009, U.S. Environmental Protection Agency, Washington D.C., March 2009.
9. Eckert, ERG, Drake, RM, *Heat and Mass Transfer*. 1959 McGraw-Hill.

ATTACHMENT A - HOTSPOT OUTPUT FOR THRESHOLD DETERMINATION

SAE Threshold - Adverse Meteorology E Stability 3 minute Ground Level -- Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 11:29 AM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 8.9100E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 8.91E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 3.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 29 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.039 km
Exceeds Outer  Dose Out To : 0.10 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

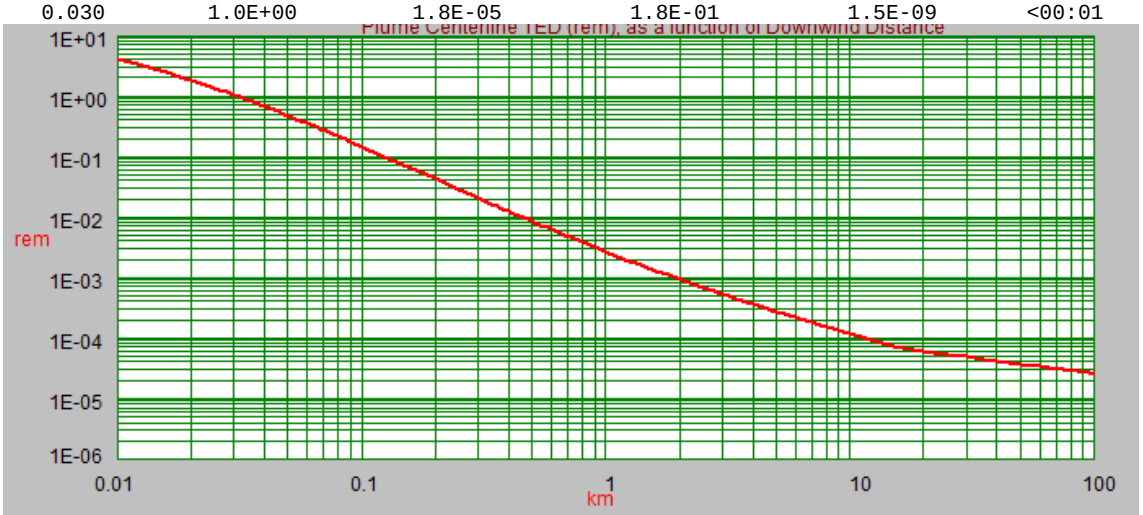
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.8E-05	1.8E-01	1.5E-09	<00:01



Alert Threshold – Adverse Meteorology E Stability 3 minute Ground Level - Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 11:42 AM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.2400E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.24E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 3.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 4.0 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.031 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

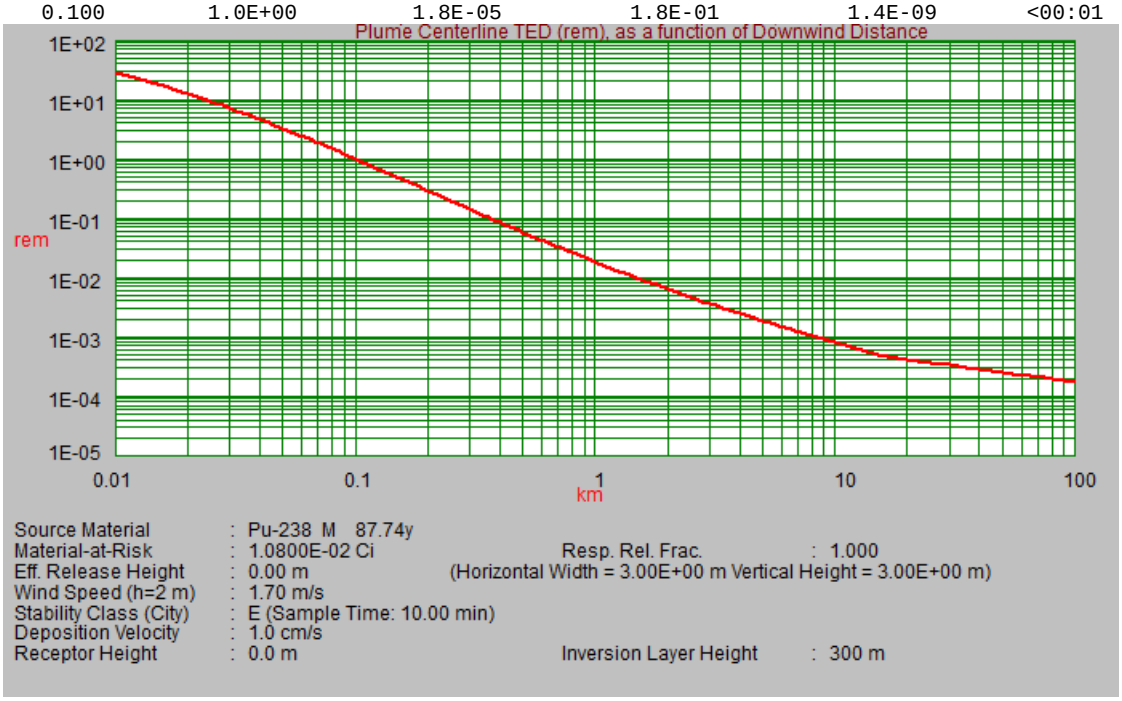
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.8E-05	1.8E-01	1.5E-09	<00:01



SAE Threshold - Adverse Meteorology E Stability 10 minute Ground Level - Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:07 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.0800E-02 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.08E-02 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 27 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.038 km
Exceeds Outer  Dose Out To : 0.100 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

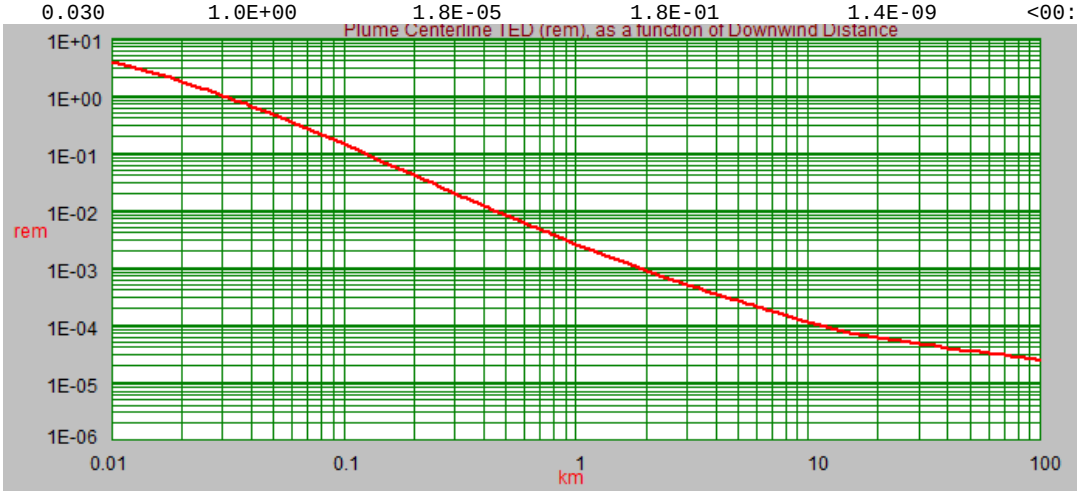
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.8E-05	1.8E-01	1.4E-09	<00:01



Alert Threshold - Adverse Meteorology E Stability 10 minute Ground Level -- Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:11 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.5100E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.51E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 3.8 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.8E-05	1.8E-01	1.4E-09	<00:01

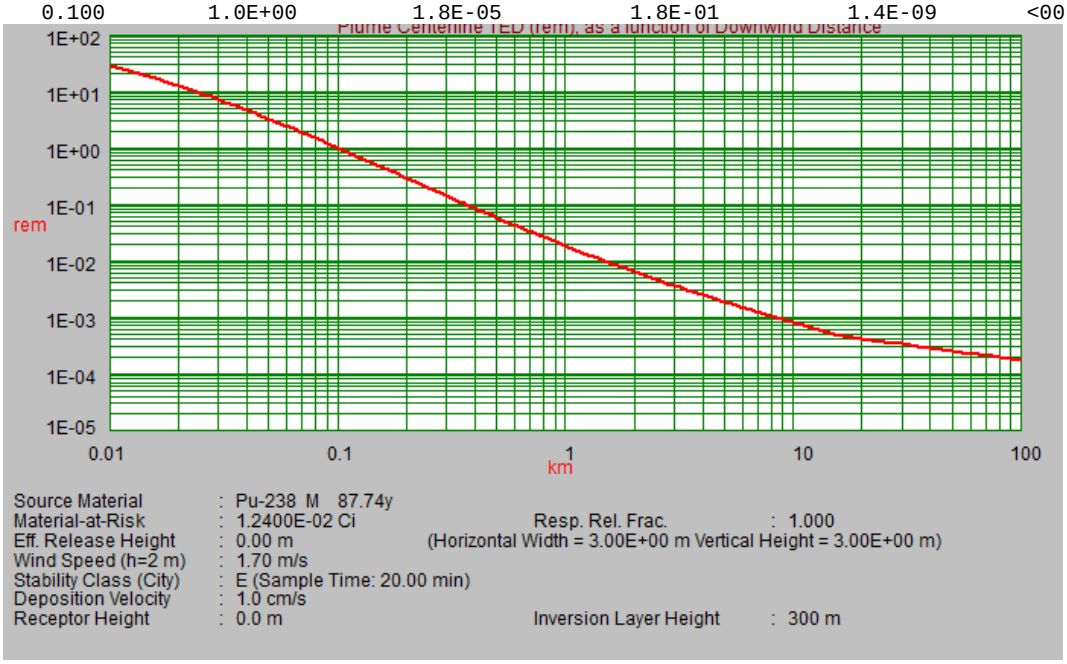


Source Material : Pu-238 M 87.74y
Material-at-Risk : 1.5100E-03 Ci Resp. Rel. Frac. : 1.000
Eff. Release Height : 0.00 m (Horizontal Width = 3.00E+00 m Vertical Height = 3.00E+00 m)
Wind Speed (h=2 m) : 1.70 m/s
Stability Class (City) : E (Sample Time: 10.00 min)
Deposition Velocity : 1.0 cm/s
Receptor Height : 0.0 m Inversion Layer Height : 300 m

SAE Threshold - Adverse Meteorology E Stability 20 minutes Ground Level - Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:19 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.2400E-02 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.24E-02 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 20.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 27 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.038 km
Exceeds Outer  Dose Out To : 0.100 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

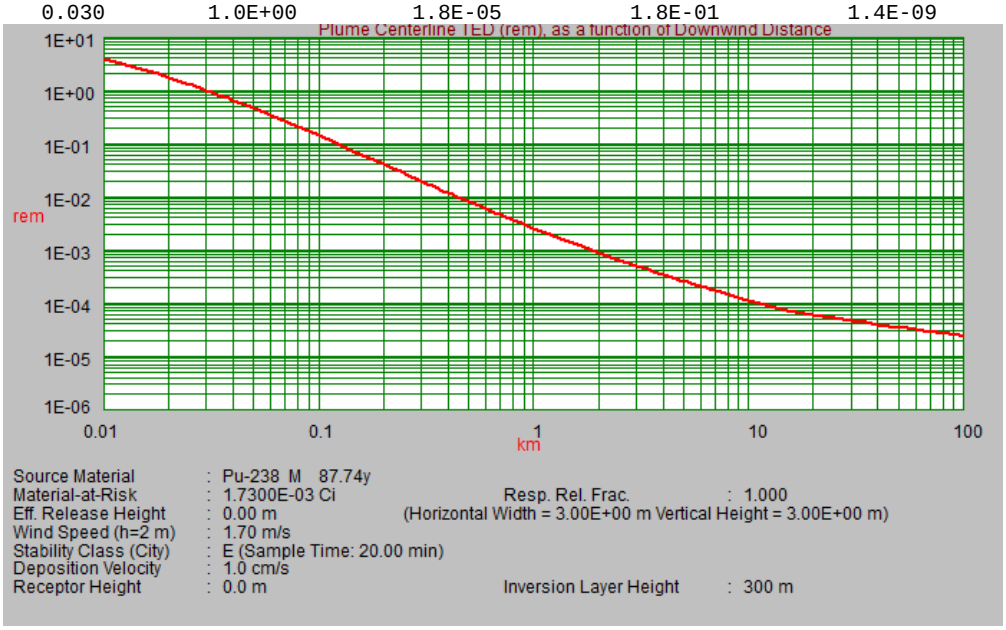
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.8E-05	1.8E-01	1.4E-09	<00:01



Alert Threshold - Adverse Meteorology E Stability 20 minute Ground Level - Unfiltered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:21 PM
Source Material              : Pu-238  M    87.74y
Material-at-Risk   (MAR)     : 1.7300E-03 Ci
Damage Ratio        (DR)     : 1.00
Airborne Fraction  (ARF)     : 1.000
Respirable Fraction (RF)     : 1.000
Leakpath Factor    (LPF)     : 1.000
Respirable Source Term       : 1.73E-03 Ci
Non-respirable Source Term   : 0.00E+00 Ci
Vertical Height              : 3.00E+00 m
Horizontal Width             : 3.00E+00 m
Effective Release Height     : 0.00 m
Wind Speed (h=2 m)           : 1.70 m/s
Wind Speed (h=H-eff)         : 1.70 m/s
Stability Class (City)       : E
Respirable Dep. Vel.         : 1.00 cm/s
Non-respirable Dep. Vel.     : 8.00 cm/s
Receptor Height              : 0.0 m
Inversion Layer Height       : 300 m
Sample Time                  : 20.000 min
Breathing Rate               : 3.33E-04 m3/sec
Distance Coordinates         : All distances are on the Plume Centerline
Maximum Dose Distance        : 0.010 km
MAXIMUM  TED                 : 3.8 rem
Inner  Contour Dose          : 1.00E+02 rem
Middle Contour Dose          : 5.0 rem
Outer  Contour Dose          : 1.0 rem
Exceeds Inner  Dose Out To   : Not Exceeded
Exceeds Middle Dose Out To   : Not Exceeded
Exceeds Outer  Dose Out To   : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

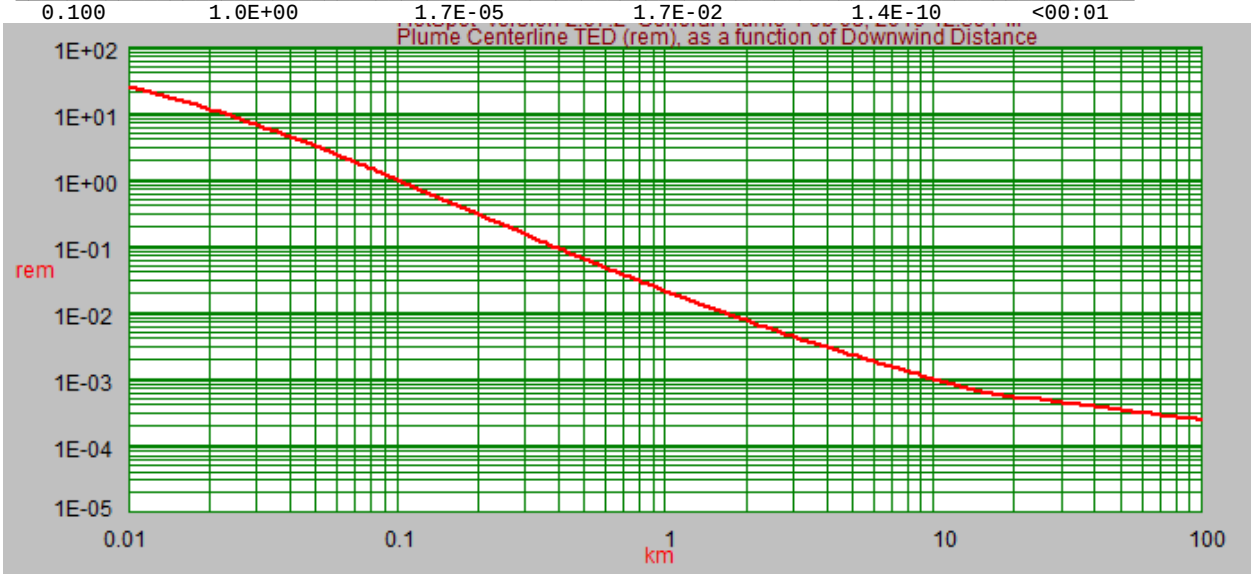
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.8E-05	1.8E-01	1.4E-09	<00:01



SAE Threshold – Adverse Meteorology E Stability 3 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:58 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 7.5100E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 7.51E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 3.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 24 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.036 km
Exceeds Outer  Dose Out To : 0.100 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.7E-05	1.7E-02	1.4E-10	<00:01

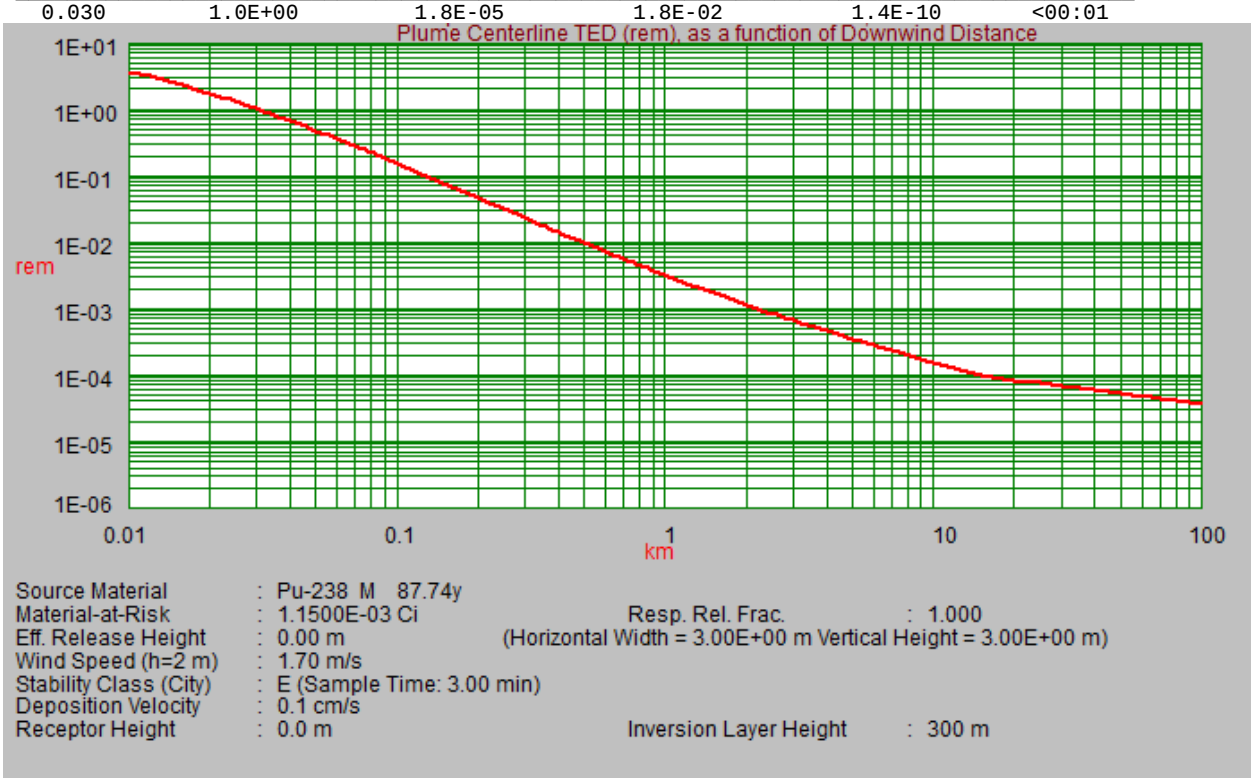


Source Material : Pu-238 M 87.74y
Material-at-Risk : 7.5100E-03 Ci Resp. Rel. Frac. : 1.000
Eff. Release Height : 0.00 m (Horizontal Width = 3.00E+00 m Vertical Height = 3.00E+00 m)
Wind Speed (h=2 m) : 1.70 m/s
Stability Class (City) : E (Sample Time: 3.00 min)
Deposition Velocity : 0.1 cm/s
Receptor Height : 0.0 m Inversion Layer Height : 300 m

Alert Threshold – Adverse Meteorology E Stability 3 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 12:59 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.1500E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.15E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 3.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 3.7 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

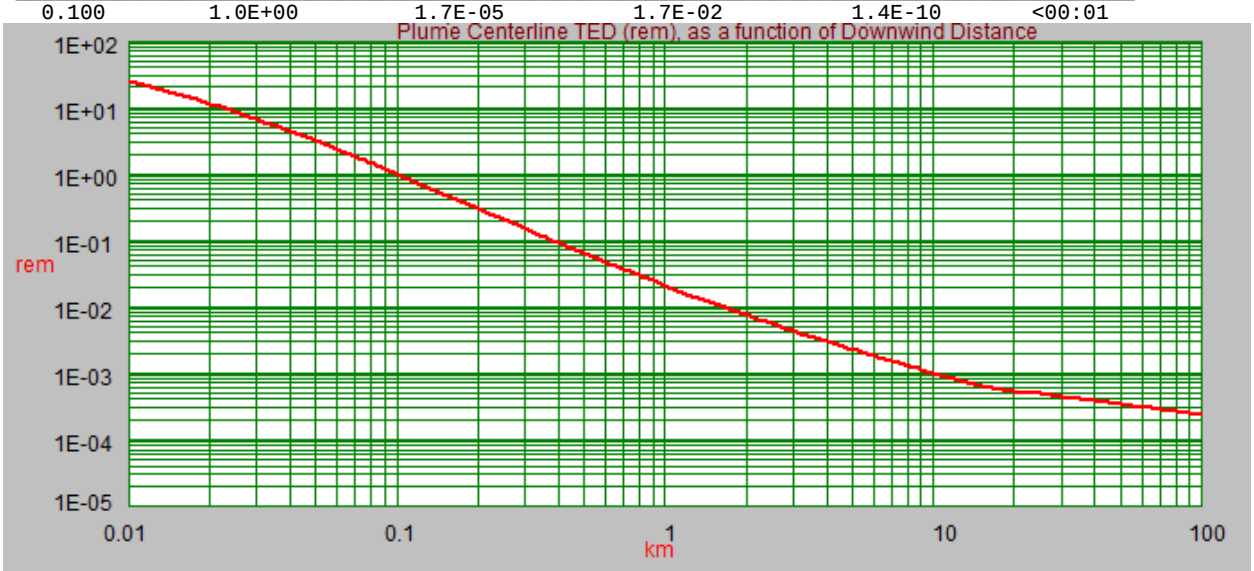
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.8E-05	1.8E-02	1.4E-10	<00:01



SAE Threshold – Adverse Meteorology E Stability 10 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 01:08 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 9.5500E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 9.55E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 24 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.036 km
Exceeds Outer  Dose Out To : 0.100 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.7E-05	1.7E-02	1.4E-10	<00:01

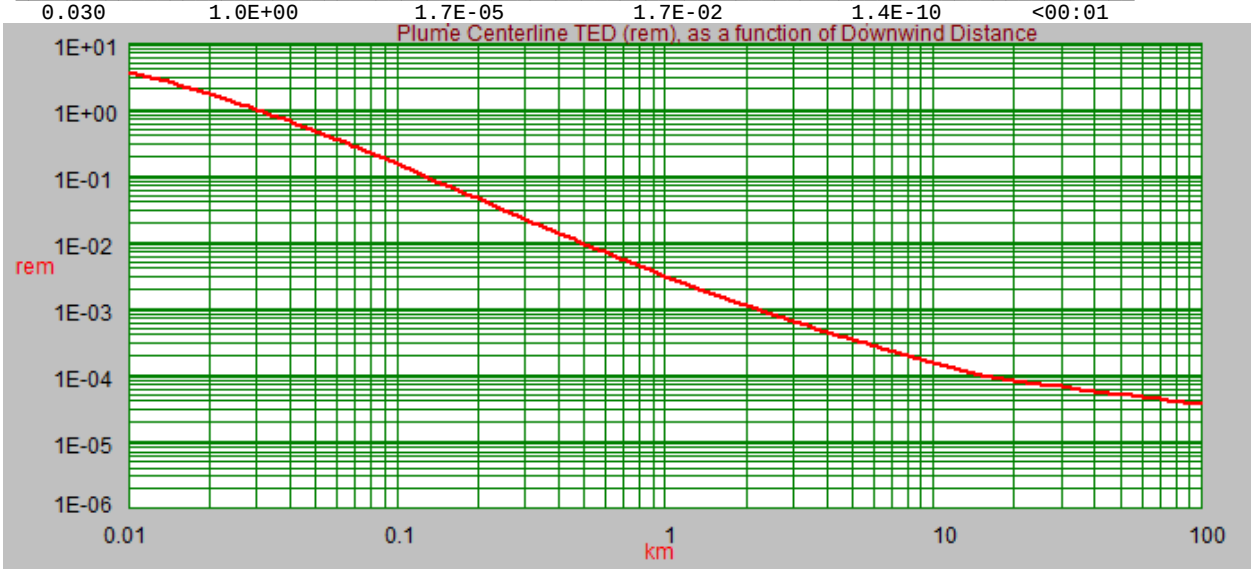


Source Material : Pu-238 M 87.74y
Material-at-Risk : 9.5500E-03 Ci Resp. Rel. Frac. : 1.000
Eff. Release Height : 0.00 m (Horizontal Width = 3.00E+00 m Vertical Height = 3.00E+00 m)
Wind Speed (h=2 m) : 1.70 m/s
Stability Class (City) : E (Sample Time: 10.00 min)
Deposition Velocity : 0.1 cm/s
Receptor Height : 0.0 m Inversion Layer Height : 300 m

Alert Threshold – Adverse Meteorology E Stability 10 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 08, 2016 01:10 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.4300E-03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.43E-03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 3.6 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.7E-05	1.7E-02	1.4E-10	<00:01



Source Material : Pu-238 M 87.74y
Material-at-Risk : 1.4300E-03 Ci Resp. Rel. Frac. : 1.000
Eff. Release Height : 0.00 m (Horizontal Width = 3.00E+00 m Vertical Height = 3.00E+00 m)
Wind Speed (h=2 m) : 1.70 m/s
Stability Class (City) : E (Sample Time: 10.00 min)
Deposition Velocity : 0.1 cm/s
Receptor Height : 0.0 m Inversion Layer Height : 300 m

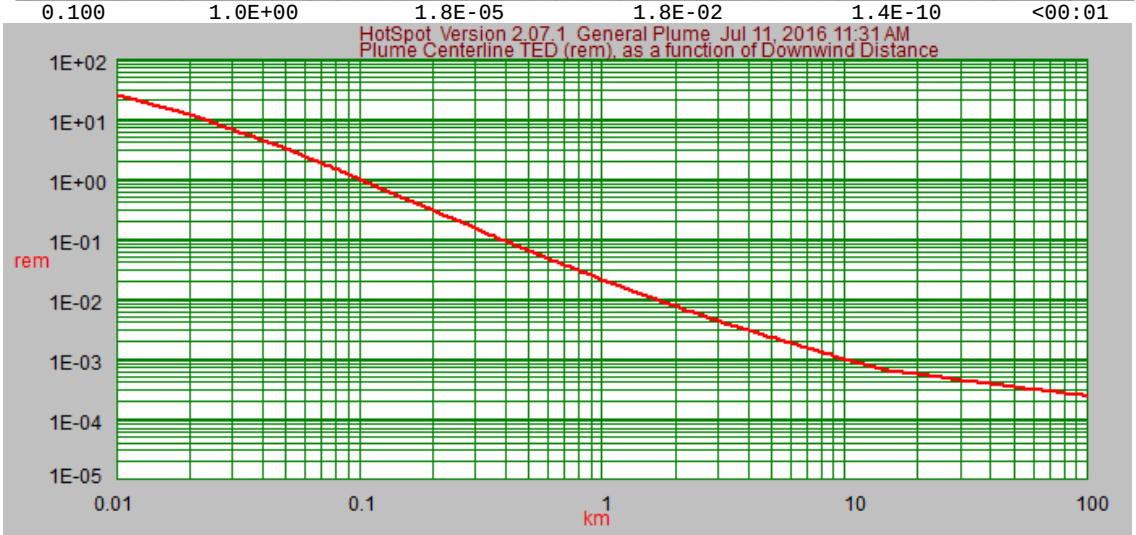
SAE Threshold – Adverse Meteorology E Stability 20 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Jul 12, 2016 12:59 AM

Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.1000E-02 Ci
Damage Ratio        (DR)   : 1.000
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.10E-02 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Distance Coordinates       : All distances are on the Plume Centerline
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00E+00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 20.000 min
Breathing Rate             : 3.33E-04 m3/sec
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 24 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.036 km
Exceeds Outer  Dose Out To : 0.100 km

FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

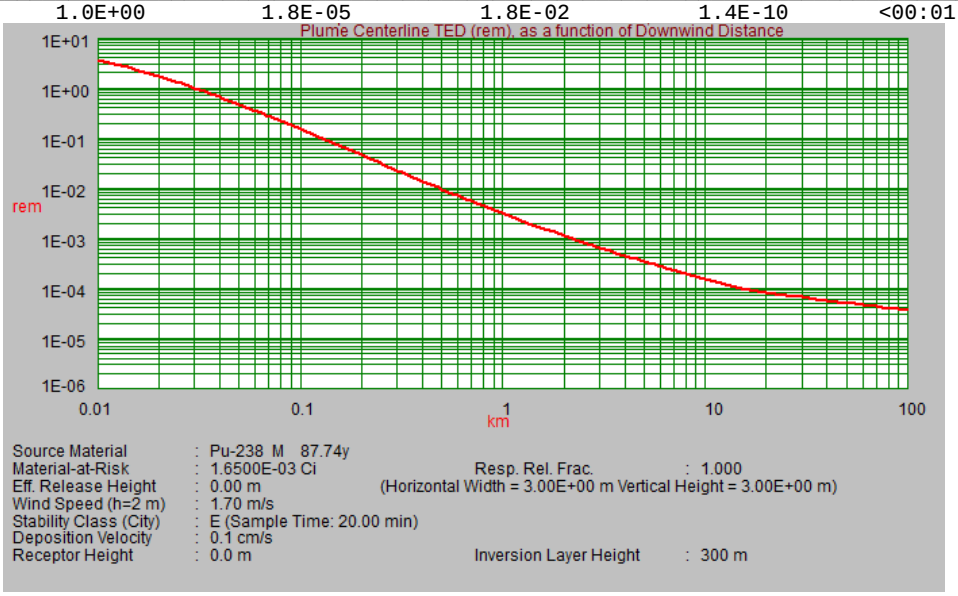
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.8E-05	1.8E-02	1.4E-10	<00:01



Alert Threshold – Adverse Meteorology E Stability 20 minute Ground Level – Filtered

```
HotSpot  Version 2.07.1  General Plume
Jul 12, 2016 12:06 PM
Source Material              : Pu-238  M    87.74y
Material-at-Risk   (MAR)     : 1.6500E-03 Ci
Damage Ratio        (DR)     : 1.00
Airborne Fraction  (ARF)     : 1.000
Respirable Fraction (RF)     : 1.000
Leakpath Factor    (LPF)     : 1.000
Respirable Source Term       : 1.65E-03 Ci
Non-respirable Source Term   : 0.00E+00 Ci
Vertical Height              : 3.00E+00 m
Horizontal Width             : 3.00E+00 m
Effective Release Height     : 0.00 m
Wind Speed (h=2 m)           : 1.70 m/s
Wind Speed (h=H-eff)         : 1.70 m/s
Stability Class (City)       : E
Respirable Dep. Vel.         : 0.10 cm/s
Non-respirable Dep. Vel.     : 8.00 cm/s
Receptor Height              : 0.0 m
Inversion Layer Height       : 300 m
Sample Time                  : 20.000 min
Breathing Rate               : 3.33E-04 m3/sec
Distance Coordinates         : All distances are on the Plume Centerline
Maximum Dose Distance        : 0.010 km
MAXIMUM  TED                 : 3.7 rem
Inner  Contour Dose          : 1.00E+02 rem
Middle Contour Dose          : 5.0 rem
Outer  Contour Dose          : 1.0 rem
Exceeds Inner  Dose Out To   : Not Exceeded
Exceeds Middle Dose Out To   : Not Exceeded
Exceeds Outer  Dose Out To   : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

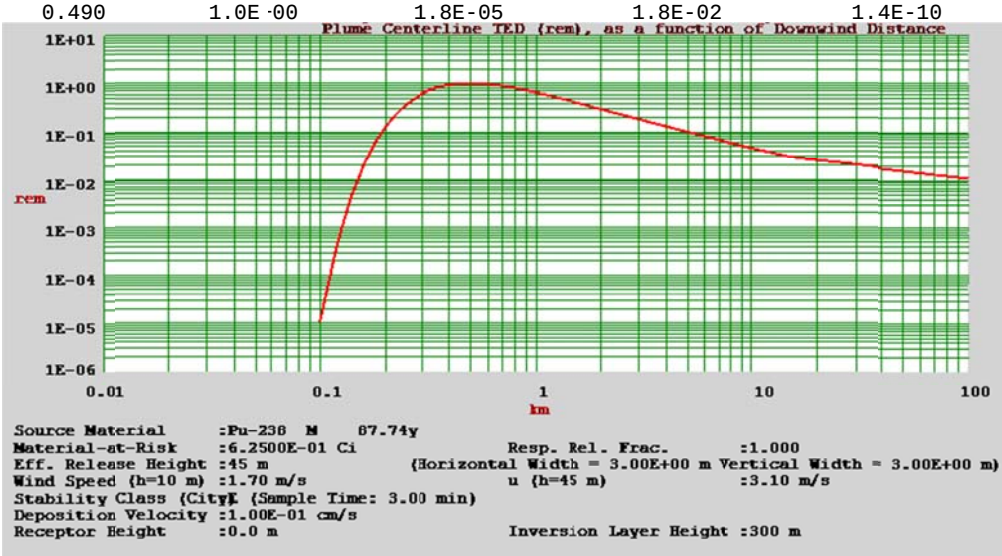
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.8E-05	1.8E-02	1.4E-10	<00:01



SAE Threshold – Adverse Meteorology E Stability 3 minute Elevated (45 m) - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 15, 2016 04:25 PM
Source Material              : Pu-238  M    87.74y
Material at-Risk    (MAR)    : 6.2500E-01 Ci
Damage Ratio        (DR)     : 1.000
Airborne Fraction   (ARF)    : 1.000
Respirable Fraction (RF)     : 1.000
Leakpath Factor     (LPF)    : 1.000
Respirable Source Term       : 6.25E-01 Ci
Non-respirable Source Term   : 0.00E+00 Ci
Vertical Width               : 3.00E+00 m
Horizontal Width             : 3.00E+00 m
Effective Release Height     : 45 m
Wind Speed (h=10 m)          : 1.70 m/s
Distance Coordinates         : All distances are on the Plume Centerline
Avg Wind Speed (h=H-Eff)     : 3.10 m/s
Stability Class (City)       : E
Respirable Dep. Vel.         : 0.10 cm/s
Non-respirable Dep. Vel.     : 8.00 cm/s
Receptor Height              : 0.0 m
Inversion Layer Height       : 300 m
Sample Time                  : 3.000 min
Breathing Rate               : 3.33E-04 m3/sec
Maximum Dose Distance        : 0.49 km
MAXIMUM  TED                 : 1.0 rem
Inner  Contour Dose          : 1.00E+02 rem
Middle Contour Dose          : 5.0 rem
Outer  Contour Dose          : 1.0 rem
Exceeds Inner  Dose Out To   : Not Exceeded
Exceeds Middle Dose Out To   : Not Exceeded
Exceeds Outer  Dose Out To   : 0.55 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	TED (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E-05	1.8E-10	1.8E-07	1.5E-15	<00:01
0.490	1.0E-00	1.8E-05	1.8E-02	1.4E-10	00:02



Alert Threshold – Adverse Meteorology E Stability 3 minute Elevated (45 m) – Filtered

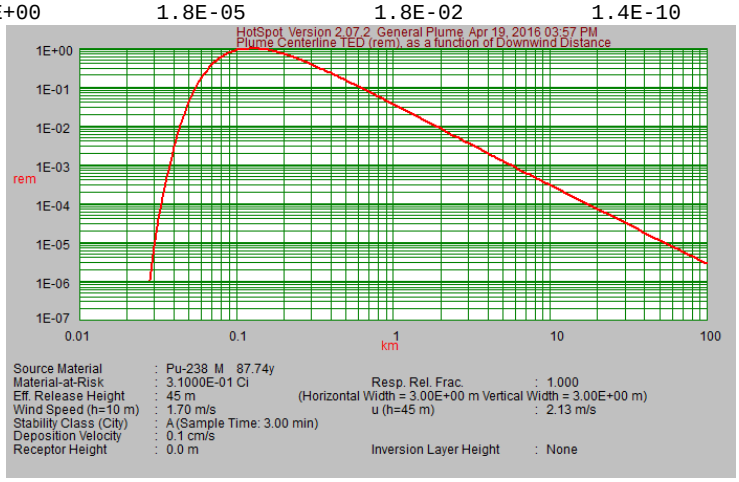
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology A Stability 3 minute Elevated (45 m) - Filtered

```
HotSpot  Version 2.07.2  General Plume
Apr 19, 2016 03:57 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 3.1000E-01 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 3.10E-01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 3.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 1.000 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
FGR-13 Dose Conversion Data - Total Effective Dose (TED)

      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	9.0E-01	1.6E-05	1.6E-02	1.3E-10	<00:01
0.120	1.0E+00	1.8E-05	1.8E-02	1.4E-10	<00:01

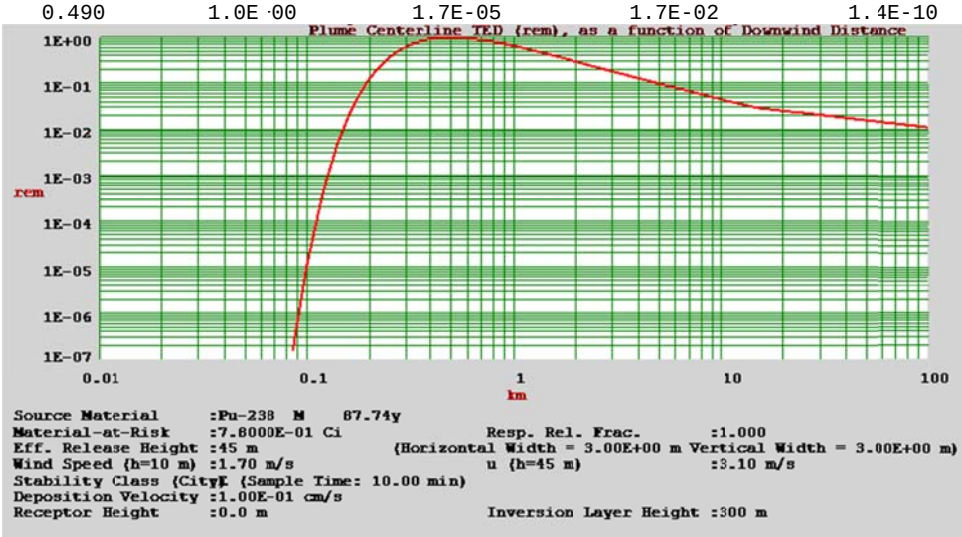


Alert Threshold – Adverse Meteorology A Stability 3 minute Elevated (45 m) – Filtered
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology E Stability 10 minute Elevated (45 m) – Filtered

```
HotSpot  Version 2.0.1  General Plume
Feb 15, 2016 05:06 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 7.8000E-01 Ci
Damage Ratio         (DR)  : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction  RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 7.80E-01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 3.10 m/s
Stability Class (Cit )     : E
Respirable Dep. Vel.       : 1.00E-01 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.49 km
MAXIMUM  TED               : 0.995 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E 05	1.8E-10	1.8E-07	1.4E-15	<00:01
0.490	1.0E 00	1.7E-05	1.7E-02	1.4E-10	00:02



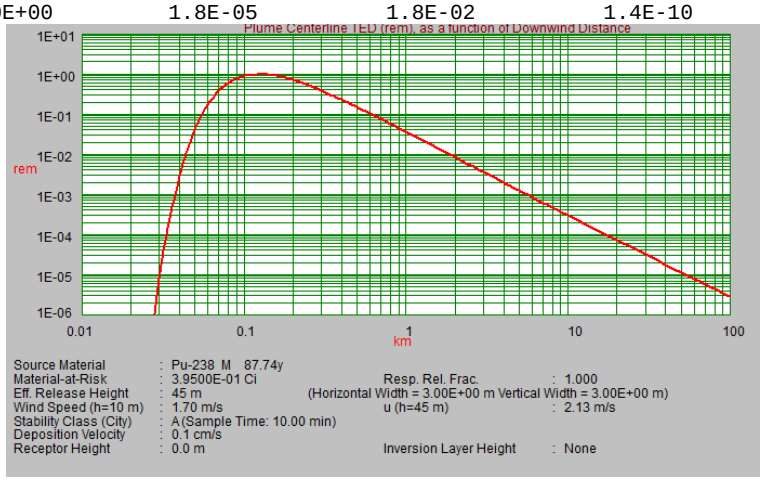
Alert Threshold – Adverse Meteorology E Stability 10 minute Elevated (45 m) – Filtered
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology A Stability 10 minute Elevated (45 m) – Filtered

```
HotSpot  Version 2.07.1  General Plume
Apr 19, 2016 02:30 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 3.9500E-01 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 3.95E-01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 1.0 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.13 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)

      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	9.0E-01	1.6E-05	1.6E-02	1.3E-10	<00:01
0.120	1.0E+00	1.8E-05	1.8E-02	1.4E-10	<00:01

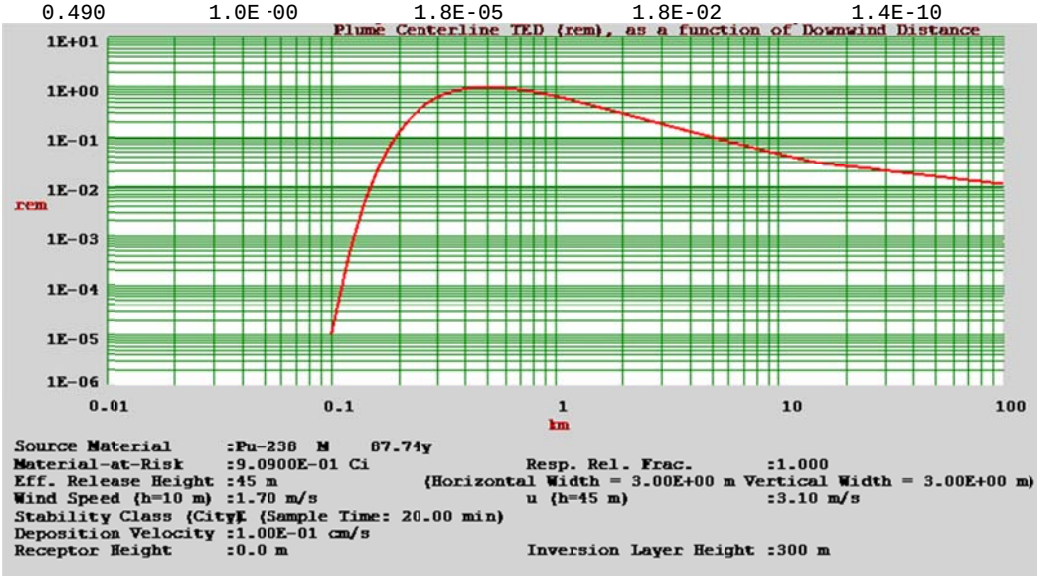


Alert Threshold – Adverse Meteorology A Stability 10 minute Elevated (45 m) – Filtered
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology E Stability 20 minute Elevated (45 m) – Filtered

```
HotSpot  Version 2.07.1 General Plume
Feb 15, 2016 05:18 PM
Source Material                 : Pu-238  M    87.74y
Material at-Risk    (MAR)       : 9.0900E-01 Ci
Damage Ratio        (DR)        : 1.00
Airborne Fraction   (ARF)       : 1.000
Respirable Fraction (RF)        : 1.000
Leakpath Factor     (LPF)       : 1.000
Respirable Source Term          : 9.09E-01 Ci
Non-respirable Source Term      : 0.00E+00 Ci
Vertical Width                  : 3.00E+00 m
Horizontal Width                : 3.00E+00 m
Effective Release Height        : 45 m
Wind Speed (h=10 m)             : 1.70 m/s
Wind Speed (h=H-eff)            : 3.10 m/s
Stability Class (Cities)        : E
Respirable Dep. Vel.            : 1.00E-01 cm/s
Non-respirable Dep. Vel.        : 8.00 cm/s
Receptor Height                 : 0.0 m
Inversion Layer Height          : 300 m
Sample Time                     : 20.000 min
Breathing Rate                  : 3.33E-04 m3/sec
Distance Coordinates            : All distances are on the Plume Centerline
Maximum Dose Distance           : 0.49 km
MAXIMUM  TED                    : 1.0 rem
Inner  Contour Dose             : 1.00E+02 rem
Middle Contour Dose             : 5.0 rem
Outer  Contour Dose             : 1.0 rem
Exceeds Inner  Dose Out To      : Not Exceeded
Exceeds Middle Dose Out To      : Not Exceeded
Exceeds Outer  Dose Out To      : 0.54 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	TED (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E-05	1.8E-10	1.8E-07	1.5E-15	<00:01
0.490	1.0E-00	1.8E-05	1.8E-02	1.4E-10	00:02



Alert Threshold – Adverse Meteorology E Stability 20 minute Elevated (45 m) – Filtered
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology A Stability 20 minute Elevated (45 m) – Filtered

```
HotSpot  Version 2.07.2  General Plume
Apr 19, 2016 02:36 PM

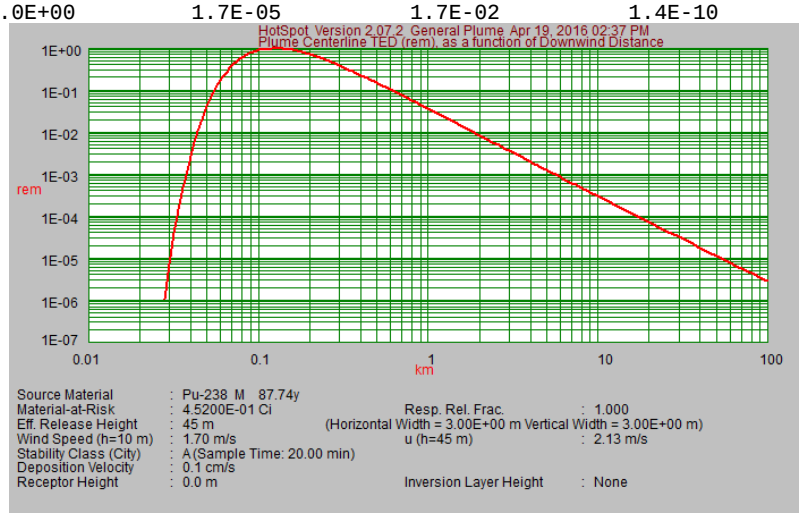
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 4.5200E-01 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 4.52E-01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 20.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline

Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 0.998 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded

FGR-13 Dose Conversion Data - Total Effective Dose (TED)

      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	9.0E-01	1.6E-05	1.6E-02	1.3E-10	<00:01
0.120	1.0E+00	1.7E-05	1.7E-02	1.4E-10	<00:01

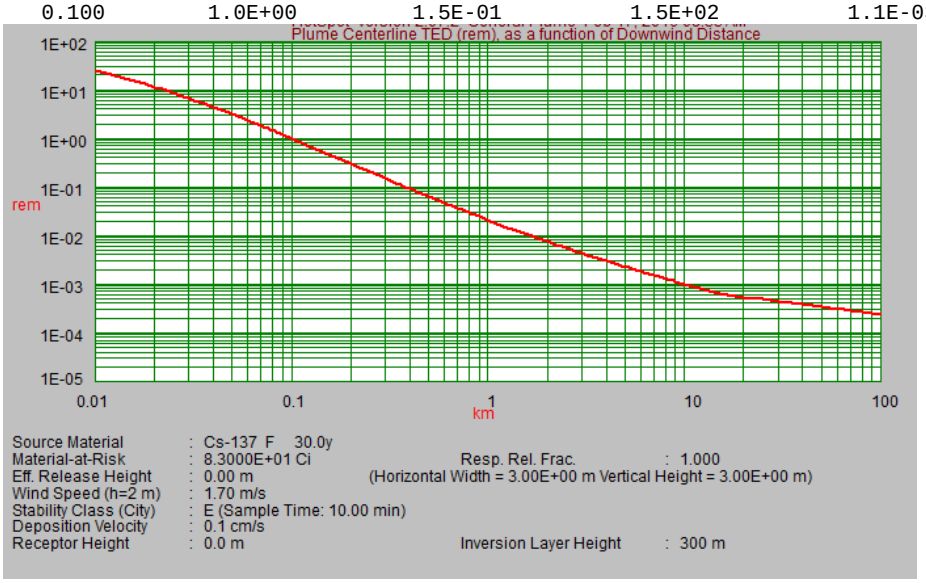


Alert Threshold – Adverse Meteorology A Stability 20 minute Elevated (45 m) – Filtered
The plume does not touch down between 30 m and 100 m; therefore, there is no threshold, and a Hotspot run is not presented.

SAE Threshold – Adverse Meteorology Cs-137 (F) Release E Adverse 10 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 17, 2016 08:53 AM
Source Material            : Cs-137  F     30.0y
Material-at-Risk   (MAR)   : 8.3000E+01 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 8.30E+01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 24 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : 0.036 km
Exceeds Outer  Dose Out To : 0.100 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

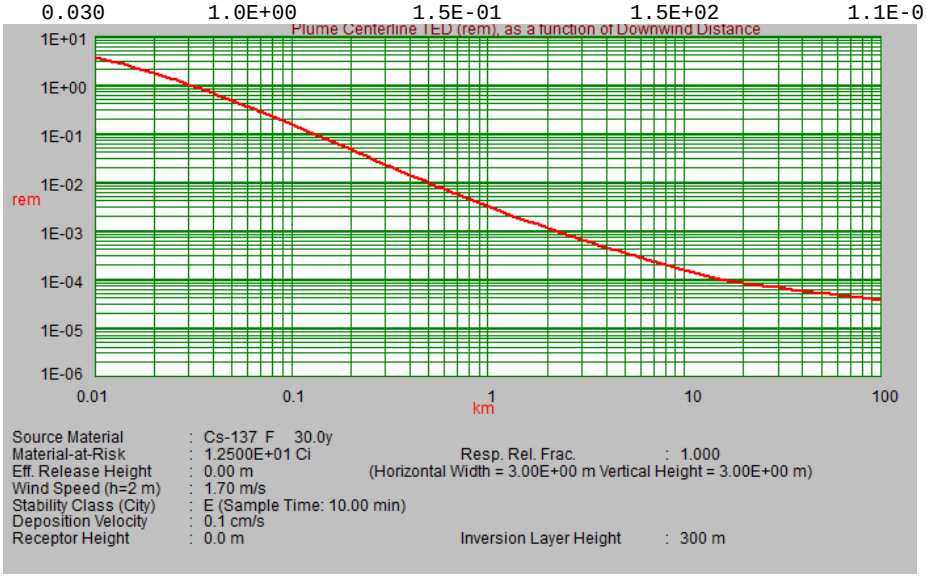
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E+00	1.5E-01	1.5E+02	1.1E-03	<00:01



Alert Threshold – Adverse Meteorology Cs-137 (F) Release E Stability 10 minute Ground Level - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 09, 2016 01:34 PM
Source Material            : Cs-137  F     30.0y
Material-at-Risk   (MAR)   : 1.2500E+01 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.25E+01 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 3.7 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.030 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

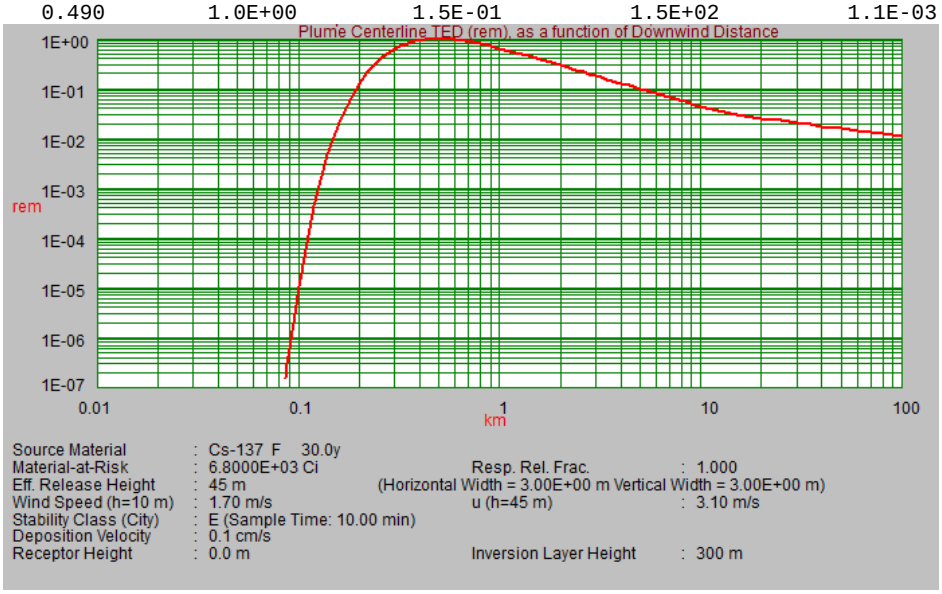
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	1.0E+00	1.5E-01	1.5E+02	1.1E-03	<00:01



SAE Threshold – Adverse Meteorology Cs-137 (F) Release E Stability 10 minute Elevated (45 m) - Filtered

```
HotSpot  Version 2.07.1  General Plume
Feb 17, 2016 10:08 AM
Source Material            : Cs-137  F     30.0y
Material-at-Risk   (MAR)   : 6.8000E+03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 6.80E+03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 3.10 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 0.10 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.49 km
MAXIMUM  TED               : 0.998 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : Not Exceeded
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Ground Roughness Correction Factor: 1.000
```

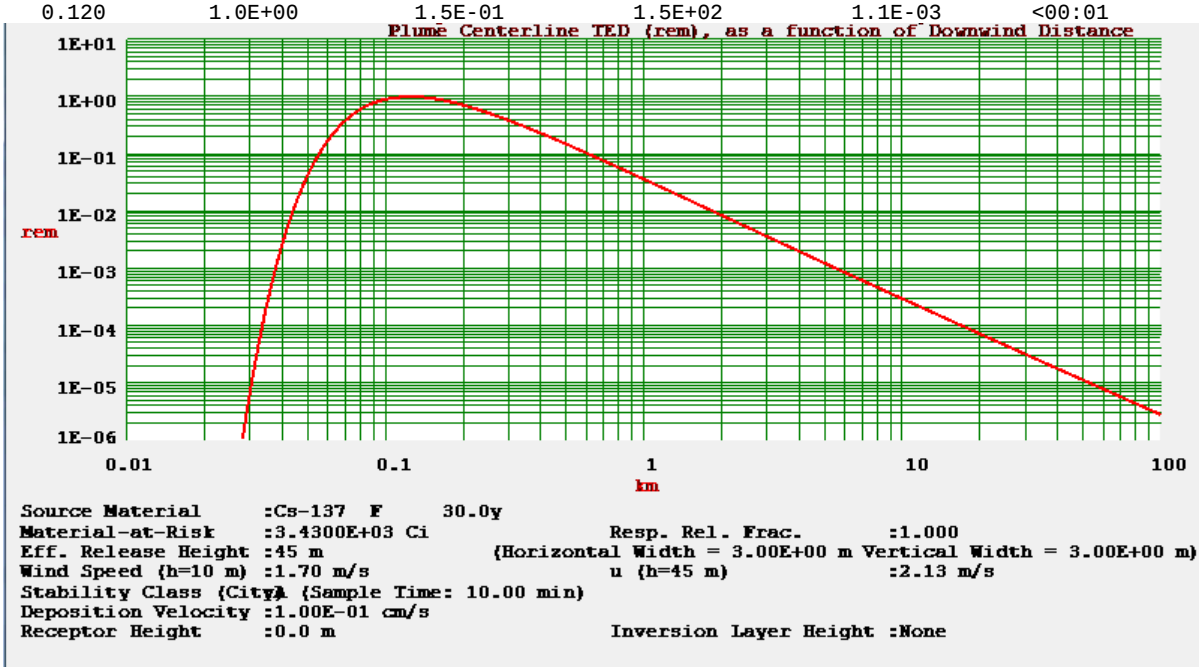
DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	1.0E-05	1.6E-06	1.6E-03	1.1E-08	<00:01
0.490	1.0E+00	1.5E-01	1.5E+02	1.1E-03	00:02



SAE Threshold – Adverse Meteorology Cs -137 (F) Release A Stability 10 minute Elevated (45 m) – Filtered

```
HotSpot  Version 2.07.1  General Plume
Jul 14, 2016 09:52 AM
Source Material            : Cs-137  F     30.0y
Material-at-Risk   (MAR)   : 3.4300E+03 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 3.43E+03 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Width             : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 45 m
Wind Speed (h=10 m)        : 1.70 m/s
Wind Speed (h=H-eff)       : 2.13 m/s
Stability Class (City)     : A
Respirable Dep. Vel.       : 1.00E-01 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : None
Sample Time                : 10.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.12 km
MAXIMUM  TED               : 1.0 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : Not Exceeded
Exceeds Middle Dose Out To : Not Exceeded
Exceeds Outer  Dose Out To : 0.13 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Plume Passage Inhalation and Submersion
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
      Initial Deposition and Dose Rate shown
      Ground Roughness Correction Factor: 1.000
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.100	9.0E-01	1.4E-01	1.4E+02	1.0E-03	<00:01
0.120	1.0E+00	1.5E-01	1.5E+02	1.1E-03	<00:01



ATTACHMENT B -

ALOHA OUTPUT AND ECKERT-DRAKE EVAPORATIVE MODELING FOR THRESHOLD DETERMINATION

ALOHA Output for an Alert Threshold – Ground level Release for Formic Acid

SITE DATA:
Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
Time: June 30, 2016 2359 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: FORMIC ACID
CAS Number: 64-18-6 Molecular Weight: 46.03 g/mol
ERPG-1: 3 ppm ERPG-2: 25 ppm ERPG-3: 250 ppm
IDLH: 30 ppm LEL: 120000 ppm UEL: 380000 ppm
Ambient Boiling Point: 100.0° C
Vapor Pressure at Ambient Temperature: 0.068 atm
Ambient Saturation Concentration: 69,150 ppm or 6.92%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1.7 meters/second from 270° true at 3 meters
Ground Roughness: urban or forest Cloud Cover: 1 tenths
Air Temperature: 29° C Stability Class: E
Inversion Height: 300 meters Relative Humidity: 50%

SOURCE STRENGTH:
Direct Source: 61 grams/min Source Height: 0
Release Duration: 15 minutes
Release Rate: 61 grams/min
Total Amount Released: 915 grams

THREAT ZONE: (GAUSSIAN SELECTED)
Model Run: Gaussian
Red : less than 10 meters(10.9 yards) --- (250 ppm = ERPG-3)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.
Orange: 30 meters --- (25 ppm = ERPG-2)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.
Yellow: 87 meters --- (3 ppm = ERPG-1)

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 30 meters Off Centerline: 0 meters
Max Concentration:
Outdoor: 24.3 ppm
Indoor: 2.58 ppm

ALOHA Output for a SAE Threshold – Ground level Release for Formic Acid

SITE DATA:
Location: AIKEN, SOUTH CAROLINA
Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
Time: June 30, 2016 2359 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: FORMIC ACID
CAS Number: 64-18-6 Molecular Weight: 46.03 g/mol
ERPG-1: 3 ppm ERPG-2: 25 ppm ERPG-3: 250 ppm
IDLH: 30 ppm LEL: 120000 ppm UEL: 380000 ppm
Ambient Boiling Point: 100.0° C
Vapor Pressure at Ambient Temperature: 0.068 atm
Ambient Saturation Concentration: 69,150 ppm or 6.92%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1.7 meters/second from 270° true at 3 meters
Ground Roughness: urban or forest Cloud Cover: 1 tenths
Air Temperature: 29° C Stability Class: E
Inversion Height: 300 meters Relative Humidity: 50%

SOURCE STRENGTH:
Direct Source: 660 grams/min Source Height: 0
Release Duration: 15 minutes
Release Rate: 660 grams/min
Total Amount Released: 9.90 kilograms

THREAT ZONE: (GAUSSIAN SELECTED)
Model Run: Gaussian
Red : 31 meters --- (250 ppm = ERPG-3)
Note: Threat zone was not drawn because effects of near-field patchiness
make dispersion predictions less reliable for short distances.
Orange: 100 meters --- (25 ppm = ERPG-2)
Yellow: 307 meters --- (3 ppm = ERPG-1)

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 100 meters Off Centerline: 0 meters
Max Concentration:
Outdoor: 24.9 ppm
Indoor: 2.63 ppm

422-S Trench and Sump

Eckert-Drake Evaporative Model

Parameter	Value	Dimensions		
mdot (Mass Transfer Rate)	**8.19E-05**	kg/s	4. 9E-03	kg/min
MW (Molecular Weight)	46.03	g/g-mole		
Vapor Pressure	37.2	mm Hg		
Rg (Gas Law Constant)	8.3144E-02	bar-m^3/kg-mol-K		
Temperature	29	C		
Volume of Spill	378.0	gal	Calculated volume of sump + trench	
d (Depth of Pool)	0.269	m	0.88	ft
A (Surface Area of Spill)	5.31	m^2	57	sq ft
hd (Mass Transfer Coeff)	1.69E-04	m/s		
D (Diffusion Coeff)	1.42E-05	m^2/s		
L (Pool Length)	19.8	m	*pool length is the total length of the trenches and sump, from the analysis method	
Re (Reynolds Number)	125053			
Sc (Schmidt Number)	1.12			
u (wind speed)	0.1	m/s	RMP uses 0.1 m/s for areas inside of a building. The trench area is semi-covered and the sump is covered; therefore 0.1 m/s is used	
rho (density of air)	1.2	kg/m^3		
mu (viscosity of air)	1.90E-05	kg/m-s		

Conditional

hd (if laminar)	1.69E-04	
hd (if mixed)	-3.19E-04	

Conversions

T (Absolute)	302.15	K
V (Volume)	1.43	m^3
dp ()	4.96E-02	bar
dp ()	4.96E+03	Pa
Evaporation Rate	5	g/min
2 hr evaporation	1	kg

422-S Dike Area – Alert Threshold

Parameter	Value	Dimensions	
mdot (Mass Transfer Rate)	9.39E-04	kg/s	Target = rate from Alert (Aloha) - rate from trench/sump
MW (Molecular Weight)	46.030	g/g-mole	Target = 61 g/min - 4.9 g/min = 56.1 g/min
Vapor Pressure	37.2	mm Hg	
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mole-K	
Temperature	29	°C	
Volume of Spill	32	gal	
d (Depth of Pool)	0.01	m	
A (Surface Area of Spill)	12.1	m^2	
hd (Mass Transfer Coeff)	8.53E-04	m/s	
D (Diffusion Coeff)	1.42E-05	m^2/s	
L (Pool Length)	3.9	m	
Re (Reynolds Number)	126600		
Sc (Schmidt Number)	1.09		
u (wind speed)	0.5	m/s	
rho (density of air)	1.225	kg/m^3	
mu (viscosity of air)	1.90E-05	kg/m-s	
Conditional			
hd (if laminar)	8.53E-04		
hd (if mixed)	-1.58E-03		
Conversions			
T (Absolute)	302.15	K	
V (Volume)	0.12	m^3	
dp ()	4.96E-02	bar	
Evaporation Rate	56.4	g/min	
2 hr evaporation	**7**	**kg**	

A spill volume of 32 gallons outside the trench/sump are will create an Alert. With the trench/sump having a volume of 378 gallons, the total amount released to reach an Alert is 410 gallons.

422-S Dike Area – SAE Threshold

Parameter	Value	Dimensions	
mdot (Mass Transfer Rate)	4.90E-03	kg/s	Target = rate from Alert (Aloha) - rate from trench/sump
MW (Molecular Weight)	46.030	g/g-mole	Target = 660 g/min - 4.9 g/min = 655 g/min
Vapor Pressure	37.2	mm Hg	
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mole-K	
Temperature	29	°C	
Volume of Spill	6500	gal	
d (Depth of Pool)	0.01	m	
A (Surface Area of Spill)	110.0	m^2	
hd (Mass Transfer Coeff)	4.90E-04	m/s	
D (Diffusion Coeff)	1.42E-05	m^2/s	
L (Pool Length)	11.8	m	
Re (Reynolds Number)	373722		
Sc (Schmidt Number)	1.12		
u (wind speed)	0.5	m/s	
rho (density of air)	1.225	kg/m^3	
mu (viscosity of air)	1.90E-05	kg/m-s	
Conditional			
hd (if laminar)	4.90E-04		
hd (if mixed)	2.38E-04		
Conversions			
T (Absolute)	302.15	K	
V (Volume)	24.60	m^3	
dp ()	4.96E+03	bar	
Evaporation Rate	294	g/min	
2 hr evaporation	**35**	**kg**	

The maximum evaporation rate for formic acid in a 110 m^2 surface area for the 422-S diked area from a spill is 294 g/min. It takes 660 g/min release rate to reach a SAE. Therefore, a SAE cannot be reached.

980-S Trench and Sump

Parameter	Value	Dimensions
mdot (Mass Transfer Rate)	1.26E-04	kg/s
MW (Molecular Weight)	46.030	g/g-mole
Vapor Pressure	37.2	mm Hg
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mole-K
Temperature	29	°C
Volume of Spill	194.4	gal
d (Depth of Pool)	0.304	m
A (Surface Area of Spill)	2.4	m^2
hd (Mass Transfer Coeff)	5.71E-04	m/s
D (Diffusion Coeff)	1.42E-05	m^2/s
L (Pool Length)	1.8	m
Re (Reynolds Number)	11319	
Sc (Schmidt Number)	1.09	
u (wind speed)	0.1	m/s
rho (density of air)	1.225	kg/m^3
mu (viscosity of air)	1.90E-05	kg/m-s
Conditional		
hd (if laminar)	5.71E-04	
hd (if mixed)	-6.72E-03	
Conversions		
T (Absolute)	302.15	K
V (Volume)	0.74	m^3
dp ()	4.96E-02	bar
Evaporation Rate	7.5	g/min
2 hr evaporation	**1**	**kg**

980-S Dike Area – Alert Threshold

Parameter	Value	Dimensions	
mdot (Mass Transfer Rate)	8.95E-04	kg/s	Target = rate from Alert (Aloha) - rate from trench/sump
MW (Molecular Weight)	46.030	g/g-mole	Target = 61 g/min - 7.5 g/min = 53.5 g/min
Vapor Pressure	37.2	mm Hg	
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mole-K	
Temperature	29	°C	
Volume of Spill	30	gal	
d (Depth of Pool)	0.01	m	
A (Surface Area of Spill)	11.4	m^2	
hd (Mass Transfer Coeff)	8.67E-04	m/s	
D (Diffusion Coeff)	1.42E-05	m^2/s	
L (Pool Length)	3.8	m	
Re (Reynolds Number)	122580		
Sc (Schmidt Number)	1.09		
u (wind speed)	0.5	m/s	
rho (density of air)	1.225	kg/m^3	
mu (viscosity of air)	1.90E-05	kg/m-s	
Conditional			
hd (if laminar)	8.67E-04		
hd (if mixed)	-1.68E-03		
Conversions			
T (Absolute)	302.15	K	
V (Volume)	0.11	m^3	
dp ()	4.96E-02	bar	
Evaporation Rate	53.7	g/min	
2 hr evaporation	**6**	**kg**	

A spill volume of 30 gallons outside the trench/sump are will create an Alert. With the trench/sump having a volume of 194 gallons, the total amount released to reach an Alert is 224 gallons.

980-S Dike Area – SAE Threshold

Parameter	Value	Dimensions	
mdot (Mass Transfer Rate)	2.78E-03	kg/s	Target = rate from Alert (Aloha) - rate from trench/sump Target = 660 g/min - 7.5 g/min = 652.5
MW (Molecular Weight)	46.030	g/g-mole	
Vapor Pressure	37.2	mm Hg	
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mole-K	
Temperature	29	°C	
Volume of Spill	3147	gal	
d (Depth of Pool)	0.01	m	
A (Surface Area of Spill)	51.5	m^2	
hd (Mass Transfer Coeff)	5.96E-04	m/s	
D (Diffusion Coeff)	1.42E-05	m^2/s	
L (Pool Length)	8.1	m	
Re (Reynolds Number)	261042		
Sc (Schmidt Number)	1.09		
u (wind speed)	0.5	m/s	
rho (density of air)	1.225	kg/m^3	
mu (viscosity of air)	1.90E-05	kg/m-s	
Conditional			
hd (if laminar)	5.94E-04		
hd (if mixed)	-1.33E-04		
Conversions			
T (Absolute)	302.15	K	
V (Volume)	11.91	m^3	
dp ()	4.96E-02	bar	
Evaporation Rate	166.9	g/min	
2 hr evaporation	**20**	**kg**	

The maximum evaporation rate for formic acid in a 51.5 m^2 surface area for the 422-S diked area from a spill is 166.9 g/min. It takes 660 g/min release rate to reach a SAE. Therefore, a SAE cannot be reached.

ATTACHMENT C - FACILITY EMAILS

980-S and 422-S dimensions

From: jeff ray@srs.gov [mailto:jeff ray@srs.gov]
Sent: Monday, November 20, 2006 8:19 PM
To: Davis, Wayne; wayne.davis@srs.gov; Shogren, Eric; richard.davis@srs.gov; Wallace, Jim; Burgess, Howard
Cc: s-david.burke@srs.gov
Subject: Fw: 980-S and 422-S dimensions
See sump and trench dimensions below.

----- Forwarded by Jeff Ray/WSRC/Srs on 11/20/2006 07:01 PM -----

Amanda Shafer/WSRC/Srs
11/20/2006 04:45 PM
To John Occhipinti/WSRC/Srs@Srs, Jeff Ray/WSRC/Srs@Srs, Pamelia Woodward/WSRC/Srs@Srs, John Neuville/BSRI/Srs@Srs
cc
Subject 980-S and 422-S dimensions
Dimensions for the sump and trenches for 980-S and 420-S
980-S
Sump: 2 ft by 2ft by 1ft = 4ft3 = 29.922 gal
Trench: 1ft by 1ft by 22ft = 22ft3 = 164.57 gal
Total volume: 194.49gal

Reference Documents
W762934
W762931
W757131
W763822

422-S
Sump: 2.5 ft by 2.5ft by 1ft = 6.25ft3 = 46.753 gal
Trench 1 (east to west): 1ft by 1ft by 37.667ft = 37.667ft3 = 281.79gal
Trench 2 (north to south): 0.5ft by 0.5ft by 26.42ft = 6.61ft3 = 49.41gal
Total volume: 377.95gal
At low level (28”alarm), the sump is at 8” in height in volume (31.169gal). 15.58gal remains available in sump.

Reference Documents
W762044---Note 12 for grating
W764020---Detail 3
W762051---Section F
W763820
W762931

Amanda Shafer
Washington Savannah River Company
DWPF Waste Acceptance
Building 704-27S Room 1

980 dimensions

From: katie-dara.dixon@srnl.doe.gov [mailto:katie-dara.dixon@srnl.doe.gov]
Sent: Thu 4/12/2007 12:02 PM
To: Burgess, Howard
Cc: Amanda.Shafer@srs.gov
Subject: Fw: 980 dimensions

Howard,
I found an error in the calculation. The new total is 554.5 ft2. We have updated the notebook (as mentioned below) accordingly. Please give myself or Amanda a call if you have any questions.

Dara
8-7157
----- Forwarded by Katie-Dara Dixon/SRNL/Srs on 04/12/2007 12:00 PM -----

Amanda Shafer/WSRC/Srs
04/03/2007 08:10 AM
To:Howard.burgess@wsms.com
Cc:Jeff Ray/WSRC/Srs@Srs, Katie-Dara Dixon/SRNL/Srs@Srs Subject
Re: 980 dimensionsLink
Howard,

The dimensions for OAWNT's dike is calculated in the following notebook information:
WSRC-NB-2007-00056, DWPF Chemical Process Engineering Systems-A. Shafer Laboratory Notebook Sheet 5
Date March 3, 2007: Signed April 3, 2007

I've asked Dara to be the verifier on my calculations.

Please let me know if there is anything else I can do to help.

Amanda Shafer
Washington Savannah River Company
DWPF Waste Acceptance
Building 704-27S Room 1
Aiken, SC 29808
(803) 208-7925
Pager: (803) 725-PAGE #19446

*This information is recorded in WSRC-NB-2007-00056, DWPF Chemical Process Engineering Systems-A. Shafer Laboratory Notebook, Sheet 5, Date March 3, 2007: Signed April 3, 2007.

ATTACHMENT D - HOTSPOT OUTPUT FOR THRESHOLD DETERMINATION FOR DIMETHYL MERCURY

Hotspot Output – 15 min Release, E Stability, Adverse Meteorology- 3x3 Source Geometry

```
HotSpot  Version 2.07.1  General Plume
Feb 11, 2016 02:46 PM
Source Material            : Pu-238  M    87.74y
Material-at-Risk   (MAR)   : 1.0000E+00 Ci
Damage Ratio        (DR)   : 1.00
Airborne Fraction  (ARF)   : 1.000
Respirable Fraction (RF)   : 1.000
Leakpath Factor    (LPF)   : 1.000
Respirable Source Term     : 1.00E+00 Ci
Non-respirable Source Term : 0.00E+00 Ci
Vertical Height            : 3.00E+00 m
Horizontal Width           : 3.00E+00 m
Effective Release Height   : 0.00 m
Wind Speed (h=2 m)         : 1.70 m/s
Wind Speed (h=H-eff)       : 1.70 m/s
Stability Class (City)     : E
Respirable Dep. Vel.       : 1.00 cm/s
Non-respirable Dep. Vel.   : 8.00 cm/s
Receptor Height            : 0.0 m
Inversion Layer Height     : 300 m
Sample Time                : 15.000 min
Breathing Rate             : 3.33E-04 m3/sec
Distance Coordinates       : All distances are on the Plume Centerline
Maximum Dose Distance      : 0.010 km
MAXIMUM  TED               : 2.34E+03 rem
Inner  Contour Dose        : 1.00E+02 rem
Middle Contour Dose        : 5.0 rem
Outer  Contour Dose        : 1.0 rem
Exceeds Inner  Dose Out To : 0.091 km
Exceeds Middle Dose Out To : 0.49 km
Exceeds Outer  Dose Out To : 1.3 km
FGR-13 Dose Conversion Data - Total Effective Dose (TED)
      Include Ground Shine (Weathering Correction Factor : None)
      Exposure Window:(Start: 0.00 days; Duration: 4.00 days)  [100% stay time].
```

DISTANCE km	T E D (rem)	RESPIRABLE TIME-INTEGRATED AIR CONCENTRATION (Ci-sec)/m3	GROUND SURFACE DEPOSITION (uCi/m2)	GROUND SHINE DOSE RATE (rem/hr)	ARRIVAL TIME (hour:min)
0.030	6.1E+02	**1.1E-02**	1.1E+02	8.6E-07	<00:01
0.100	8.5E+01	**1.5E-03**	1.5E+01	1.2E-07	<00:01

INTRODUCTION

The purpose of this calculation is to estimate source terms (STs) and downwind concentrations from process spills containing dimethyl mercury. The contaminant chemical concentrations are calculated at 30 m from the edge of the spill. Releases are considered under adverse meteorological conditions as directed by procedure Emergency Management Program Procedure (EMPP) 6Q-001 (Ref. 1).

INPUT DATA/ASSUMPTIONS

1. The accidents are modeled as ground level releases.
2. Meteorological conditions for 95% adverse and average conditions are (Ref. 2, 3):

	95 % Adverse	**Average**
Wind Speed	1.7 m/s	2.5 m/s
Stability Class	E	C
Ambient Temp.	29ºC	25ºC
Cloud Cover	10 %	80 %
Relative Humidity	50 %	50 %
Ground Roughness	Urban	Urban
Inversion Height	300 m	500 m

3. The maximum concentration of dimethyl mercury in the Concentration, Storage, and Transfer Facilities (CSTF) is 3 mg/L. This is a bounding value for the CSTF. It is representative of the bounding 3H Overheads condensate, which is the highest potential source of dimethyl mercury in the CSTF (Ref. 4). This value will be used to represent the composition of transfers from CSTF.
4. Protective Action Criteria (PAC) and the Threshold for Early Lethality (TEL) for dimethyl mercury is as follows (Ref. 5):

Chemical	**CAS Number**	**PAC-2**	**PAC-3 (TEL)**
Dimethyl Mercury	593-74-8	0.046 mg/m^3	2.3 mg/m^3

5. The threshold values for these chemicals are given in Appendix B, Calculation 5 as well as below:

Scenario Description	**X/Q (s/m^3)**	**PAC-2 Concentration (mg/m^3)**	**Limiting ST (mg/s)**
15 min – Adverse – Alert	1.1E-02	0.046	4.18E+00*
15-min – Adverse - SAE	1.5E-03	0.046	3.06E+01*

*ST- PAC-2/(X/Q)

6. Dimethyl Mercury:

   Dimethyl Mercury releases are postulated for areas of Defense Waste Processing Facility

(DWPF) that receive transfers of waste from CSTF; this includes the Actinide Removal Process (ARP, 512-S) and Low Point Pump Pit (LPPP, 511-S). Tank or transfer spills in either area would result in a spill to a cell and be transported outdoors by building ventilation. These scenarios are indoor release scenarios, so the ventilation systems facilitate the dispersion of the chemical to downwind receptors. The ventilation systems have interlocks such that if there were a high efficiency particulate air (HEPA) break through or failure, the ventilation fans interlock to the off position within seconds of activation. A spill from the LPPP Precipitate Pump Tank (PPT) to the PPT cell bounds all other spills in LPPP and ARP with a spill volume of 6466 gal (Ref. 6, Table 9.4-2). The PPT cell dimensions are 18 ft. x 18 ft.; the PPT vessel has a 12 ft diameter (Ref. 7). However, the vessel sits slightly elevated from the cell floor therefore the vessel area is not accounted for in calculating the surface area of the spill. The liquid spill "footprint" is therefore (18 x 18) ft^2 = 324 ft^2, or 30.1 m^2.

The Environmental Protection Agency's Risk Management Program approach to modeling releases inside buildings assumes the interior release is diluted over the available vapor space volume. This contaminated air then leaves the building according to the volumetric ventilation rate (Ref. 9).

ANALYSIS METHODS AND COMPUTATIONS

ST Evaluation

The evaporative release from a spill containing very dilute contaminants is estimated using a two-resistance mass transfer model (Ref. 10). The overall mass transfer coefficient is given by:

$$1/K_L = 1/k_w + RT/Hk_a \qquad \text{[Eq. 1]}$$

where, K_L – overall mass transfer coefficient (MTC)
k_w – water phase MTC
R – gas constant
T – temperature
H – Henry's constant
k_a – air phase MTC.

For substances like dimethyl mercury with a relatively large Henry's law constant, the rate of evaporation is controlled by the liquid phase coefficient (Ref. 10).

Therefore: $K_L \approx k_w$ [Eq. 2]

The mass flux across the phase boundary can then be given in terms of the bulk liquid concentration and the partial pressure of contaminant in the atmosphere (Ref. 10).

$$N = K_L (C_L - p/H) \qquad \text{[Eq. 3]}$$

where, N – mass flux
C_L – bulk liquid phase concentration
p – partial pressure
H – Henry's constant

The background atmospheric level of dimethyl mercury is conservatively assumed to be negligible.

Therefore: $N \approx K_L C_L$ [Eq. 4]

The water phase MTC is calculated using an experimentally determined correlation by Lunney, Springer, and Thibodeaux (Ref. 11).

$$k_w = 2.788E\text{-}06\ (D_{wi}/D_{we})^{2/3}$$ [Eq. 5]

where, k_w – liquid phase mass transfer coefficient, m/s
D_{wi} – contaminant diffusivity in water, m^2/s
D_{we} – diffusivity of ethyl ether in water, 0.85E-09 m^2/s @ 25°C (Ref. 11)

The equation is valid for "shallow" systems with a fetch to depth ratio (similar to diameter of pool to depth ratio) of greater than 14 and for wind speeds from 0 to 5 m/s determined at 10 m altitude.

The diffusivity of dimethyl mercury in water is estimated using the correlation of Wilke and Chang which is valid for dilute solutions of non-electrolytes (Ref. 12).

$$D_{wi} = [7.4E\text{-}08\ (\varphi\ M_w)^{0.5}\ T]/[\mu v_i^{0.6}]$$ [Eq. 6]

where, D_{wi} – contaminant diffusivity in water, cm^2/s
φ – association factor for solvent = 2.6 for water (Ref. 16)
M_w – molecular weight of solvent = 18.02 for water
T – temperature, K
μ – solution viscosity, centipoises
v_i – solute molar volume at the normal boiling point, $cm^3/gmol$

The molar volume of dimethyl mercury is estimated using the method of Schroeder (Ref. 13).

$$v_i = \Sigma\, n_i v_{bi} + \Sigma\, n_i^{extra}\, v_{bi}^{extra}$$ [Eq. 7]

where, v_i – solute molar volume at the normal boiling point, $cm^3/gmol$,
n_i – number of atoms of volume, v_{bi}
v_{bi} – atomic volume, $cm^3/gmol$
$n_i^{extra}\, v_{bi}^{extra}$ – volumes associated with bonding, not applicable for dimethyl mercury

Since all of the bonds in dimethyl mercury are single bonds, the above equation is simplified.

$$v_i = \Sigma\, n_i v_{bi}$$ [Eq. 8]

ST CALCULATIONS

LPPP (511-S) Tank Spill/Breach (**3-RD-1**)

The LPPP PPT vessel is ruptured from cell cover/equipment drop, etc., and contents are spilled to the floor.

Releases from the cell are transported outside via the LPPP Ventilation System, which provides HEPA filtration and ground level release. The 16.3 meter stack does not provide an elevated release point as the stack is only a meter or two higher than the roof of the building. The event is modeled as a 15 minute, ground level release.

ST – Dimethyl Mercury

The following calculations are performed to determine the evaporative mass flux from a spill of dimethyl mercury contaminated supernate.

Atomic Volume - Mercury

Inputs

Input	Value	Reference
Normal Boiling Point, NBP	356.58 °C	14, p. D-190
Density at NBP	12.755 g/cm^3	14, p. F-7
Atomic Weight - Hg	200.59	14, inside cover

Atomic Volume = Atomic Weight/Density
= 200.59 g/gmol / 12.755 g/cm^3
= 15.726 cm^3/gmol

Molar Volume

Inputs

Input	Value	Reference
Molecular Formula	C_2H_6Hg	
Atomic Vol – C, H	7 cm^3/gmol	13, p. 46
Atomic Vol - Hg	15.726 cm^3/gmol	Calculated

$v_i = \Sigma\, n_i v_{bi}$
= (2 carbons x 7) + (6 hydrogens x 7) + (1 mercury x 15.7)
= 71.7 cm^3/gmol

Diffusivity in Water – Dimethyl Mercury

Inputs

Input	Value	Reference
Association Factor, φ	2.6	16, p. 432
Molecular Weight Solvent, M_w	18.02	12, p. 37
Temperature, T	72°C/345 K	15
Solution Viscosity, μ	1 cP	7
Solute Molar Volume, v_i	71.7 cm^3/gmol	Calculated

$D_{wi} = [7.4E\text{-}08\ (\varphi\ M_w)^{0.5}\ T]/[\mu v_i^{0.6}]$
$= [7.4E\text{-}08\ (2.6 \times 18.02)^{0.5}\ (345\ K)]/[1.0 \times (71.7)^{0.6}]$
= 1.35E-05 cm^2/s
= (1.35E-05 cm^2/s) x (1 m/100 cm)^2
= 1.35E-09 m^2/s

Water Phase Mass Transfer Coefficient – Dimethyl Mercury in Water

Inputs

Input	Value	Reference
Diffusivity in Water – dimethyl mercury	1.35E-09 m^2/s	Calculated
Diffusivity in Water – ethyl ether	8.5E-10 m^2/s	11, p. 209

k_w = 2.788E-06 $(D_{wi}/D_{we})^{2/3}$
= 2.788E-06 $(1.35E\text{-}09/8.5E\text{-}10)^{2/3}$
= 3.79E-06 m/s

Evaporative Mass Flux – DMHg in Water

Inputs

Input	Value	Reference
Mass Transfer Coefficient	3.79E-06 m/s	Calculated
Liquid Concentration – dimethyl mercury	3 mg/L	Input/Assumption

N = K_L C_L
= 3.79E-06 m/s x 3 mg/L x (1000 L/1 m^3)
= 1.14E-02 mg/m^2-s

Pool Surface Area

Area = (18 x 18) ft^2 = 324 ft^2
Area = 324 ft^2 (9.29E-02 m^2/ft^2) = 3.01E+01 m^2

Source Term – Dimethyl Mercury
ST = N x A
= 1.14E-02 mg/m^2-s x 3.01E+01 m^2
= 3.42E-01 mg/s

The ST for dimethyl mercury is below the limiting ST determined in Appendix B, Calculation 5, prior to any mitigation from the building dilution factor and ventilation rate. Therefore, this release will not result in a classifiable operational emergency and no EAL is required. This event bounds a spill in the ARP (512-S).

RESULTS

The ST for dimethyl mercury in DWPF is less than the limiting STs that would result in exceeding PAC-2 at the 30 m receptor location. Therefore, none of the remaining chemical release scenarios would result in a classifiable, operational emergency and no EAL is required.

Limiting ST and Event-Based ST Comparison

RD	Chemical	ST	Limiting ST to reach PAC-2	Probable Event Class
3-RD-1	Dimethyl Mercury	3.42E-01 mg/s	4.18E+00 mg/s	None

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APPENDIX C - EPHA DEFINITIONS

Accident: A deviation from normal operations or activities associated with a hazard, which has the potential to result in an emergency.

Acute Exposure Guideline Levels (AEGLs) - threshold exposure limits for the general public that are applicable to emergency exposure periods ranging from 10 min to 8 h. It is believed that the recommended exposure levels are applicable to the general population including infants and children, and other individuals who may be susceptible. The three AEGLs have been defined as follows:

- **AEGL-1** is the airborne concentration (expressed as parts per million or milligrams per cubic meter [ppm or mg/m^3]) of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
- **AEGL-2** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape
- **AEGL-3** is the airborne concentration (expressed as ppm or mg/m^3) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

Alert: An Alert represents events in progress or having occurred that involves an actual or potential substantial reduction in the level of facility safety and protection. At SRS, an Alert has occurred if unplanned events result in hazardous material being released to the environment in concentrations that may result in exposures greater than the protective action criteria (PAC) at or beyond 30 meters from the source but not at or beyond the facility boundary.

Assess: The internal process, by which an organization evaluates its ability to comply with DOE and other applicable regulations, orders, plans, and procedures, conducted within a single, cognizant Program Office.

Breach: A fracture or penetration, undesirable opening of a tank, container, or line that results in the release of a hazardous material. The release of hazardous material must be of a magnitude to satisfy the EAL criteria to be considered a breach. Small leaks or seepage are not to be considered a breach.

Committed Effective Dose (CED): The sum of the committed effective doses over a fifty-year period to various organs or tissues in the body, each multiplied by the appropriate weighting factor. CED is applicable to exposure from internally deposited radionuclides.

Common Hazardous Material: The general public commonly uses the material. This includes any substance used for personal, family, or household purposes or is present in the same form and concentration as a product packaged for distribution and use by the general public (e.g., motor oil, gasoline, diesel fuel). Additionally, material screened, as per the criteria set forth in this procedure is common hazardous material.

Consequence: The result or effect (especially projected doses or dose rates) of a release of radioactive or hazardous materials to the environment.

Consequence Assessment: The evaluation and interpretation of radiological or other hazardous materials measurements and other information to provide a basis for decision-making.

Emergency Action Level (EAL): Specific, predetermined, observable criteria used to detect, recognize, and determine the emergency class of Operational Emergencies. An EAL can be an instrument reading; an equipment status indicator; a measurable parameter, onsite or offsite; a discrete, observable event; results of analyses; or another observed phenomenon that indicates entry into a particular emergency class.

Emergency Planning Zone (EPZ): A geographic area surrounding a specific DOE facility for which special planning and preparedness efforts are carried out to ensure that prompt and effective protective actions can be taken to reduce or minimize the impact to onsite personnel, public health and safety, and the environment in the event of an Operational Emergency.

Emergency Response Planning Guidelines (ERPGs) - a hazardous chemical exposure level developed for the general public. There are three (3) exposure levels of ERPGs approved by a committee of the American Industrial Hygiene Association (AIHA). These levels are as follows:

- **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-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 conditions that could impair their abilities to take protective action.
- **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.

Event: Any real-time occurrence or significant deviation from planned or expected behavior that could endanger or adversely affect people, property, or the environment.

Facility: Any equipment, structure, system, process, or activity that fulfills a specific purpose.

Facility Boundary: This boundary represents the receptor location that differentiates between an Alert and Site Area Emergency declaration.

General Emergency: A General Emergency represents events that are in progress or have occurred that involve actual or imminent catastrophic failure of facility safety systems with potential for loss of confinement integrity, catastrophic degradation of facility protection systems, or catastrophic failure in safety or protection systems threatening the integrity of a weapon or test device that could lead to substantial offsite impacts. Environmental releases of hazardous materials can reasonably be expected to exceed the appropriate protective action criteria at the site boundary.

Hazard: A process, condition, or asset which has the potential to adversely impact the health and safety of personnel, the public, the environment, or national security. Hazards are divided into three classes:

- Low - Hazards, which present minor onsite and negligible offsite impacts to people, the environment, or national security.
- Moderate - Hazards which represent considerable potential onsite impacts to the people or the environment, but at most only minor offsite impacts to people, the environment, or national security.
- High - Hazards with the potential for onsite and offsite impacts to large numbers of persons or with the potential for major impacts to the environment or national security.

Hazard Assessment: A Hazards Assessment identifies hazards significant enough to include in an emergency preparedness program and forms the technical basis for applicable emergency classification procedures.

Hazardous Materials: Any solid, liquid, or gaseous material that is toxic, flammable, radioactive, corrosive, chemically reactive, or unstable upon prolonged storage in quantities that could pose a threat to life, property, or the environment.

Material-at-Risk (MAR): The amount of hazardous material that is available to be acted on by a given physical stress. Multiply the MAR by the appropriate release fraction to determine the source term.

Maximum Fire A fire analyzed for the maximum consequence. The largest at risk hazardous material inventory is assumed to be involved and the worst fire situation is utilized.

Maximum Inventory: For a process, the maximum quantity of a hazardous material that a process produces during the process cycle. For storage tanks, the maximum inventory is equivalent to the physical capacity of the tank.

Offsite: The area beyond the boundaries of the site.

Onsite: The facility/site area over which DOE has access control authority.

Protective Action: Physical measures (such as evacuation or sheltering) taken to prevent potential health hazards, due to a release of hazardous materials to the environment, from adversely affecting the onsite or offsite population.

Protective Action Criteria (PAC): a radiological dose or toxic material concentration level that acts as a trigger, for the receptor point of interest, to declare an operational emergency and initiate the recommendation or issuance of protective actions to protect workers or the general public. The PAC that pertains to SRS onsite and offsite radiological and chemical exposure is as follows:

- For a radiological hazard, 1 rem Total Effective Dose Equivalent (TEDE) or 5 rem CEDE thyroid is used as the trigger for classification of operational emergencies and off-site protective action recommendations.
- For a chemical hazard, the limit is one of the following listed in order of preference: Acute Exposure Guideline Levels (AEGLs) promulgated by the EPA; Emergency Response Planning Guidelines (ERPGs) published by the American Industrial Hygiene Association; and Temporary Emergency Exposure Limits (TEELs) developed by DOE. For these criteria, the exposure level to be used as the trigger for classification of operational emergencies and off-site protective action recommendations represents no irreversible health effects, i.e. AEGL-2, ERPG-2, or TEEL-2.

Receptor Point: A defined point or distance from a release source, where the actual or projected threshold dose received from the release of hazardous material, results in exposures $\geq$ PACs. For the purpose of emergency classification, the receptor points are defined as 30 meters from the release, the facility boundary and the site boundary. These receptors establish the zones for classification of an operational emergency.

Release: An airborne effluent release to the environment as this pathway typically represents the most *time-urgent* situation. Releases to aquatic and ground pathways in most instances do not have the same time urgency as airborne releases. The hazard assessment considers releases to an aquatic or ground pathway having a time-urgent affect on the workers or the public (e.g., through a community water supply).

Release Fraction: The coefficient used to estimate the amount of a hazardous material (material at risk) suspended in air and made available for airborne transport under a specific set of induced physical stress. The release fraction is a combination of the fraction of the material released and the fraction of the material that is respirable.

Safety Analysis: Documented process to systematically identify the hazards of an operation; to describe and analyze the adequacy of measures taken to eliminate, control, or mitigate identified hazards; and to analyze and evaluate potential accidents and associated risks.

Safety Analysis Report (SAR): A documented process to systematically identify the hazards of a DOE operation; to describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards; and to analyze and evaluate potential accidents and their associated risks.

Segment: a demarcation used in hazards assessment where the system, section, building, etc., is not affected by the failure of other systems, sections, buildings, etc.

Site: The area over which DOE has access control authority. This includes any area that has been designated as a National Security Area.

Site Area Emergency (SAE): An SAE represents events that are in progress or have occurred involving actual or likely major failure(s) of facility safety or safeguard systems needed for the protection of onsite personnel, the public health and safety, the environment, or national security. Environmental releases of hazardous materials are expected to exceed the appropriate PAC at or beyond the facility boundary but not beyond the site boundary.

Site Boundary: In general, the perimeter of the DOE-owned and controlled land at SRS is the site boundary. Areas where the general public has uncontrolled access to areas of SRS are offsite for purposes of emergency classification unless it can be assured (e.g., procedures in place) that those areas can be evacuated and access control established within one hour of event declaration.

Source Term: The amount of respirable material released to the environment. Source term is equal to the amount of material at risk (MAR) multiplied by appropriate reduction factors.

Temporary Emergency Exposure Limits (TEELs) are intended for use until Emergency Response Planning Guidelines (ERPGs) are adopted for chemicals being evaluated. Therefore, with the exception of the recommended averaging time (15 minutes), TEELs 1, 2, and 3 have the same definitions as the equivalent ERPG.

- **TEEL-0:** The threshold concentration below which most people will experience no adverse health effects.
- **TEEL-1:** Same as ERPG-1
- **TEEL-2:** Same as ERPG-2
- **TEEL-3:** Same as ERPG-3

Total Effective Dose (TED) - The sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures). Deep dose equivalent to the whole body may be used as effective dose for external exposures. For accidents associated with most SRS facilities, the CED calculated by SRS dispersion models is equivalent to the TED.

Appendix D

Tech Support Room EAL Data for DWPF

DWPF EALS

		Maximum Distance to PAC (m)	
		Adverse Met	Average Met
1.0 Radioactive Release (Category 1)			
GE	None Identified	--	--
SAE	None Identified	--	--
Alert	None Identified	--	--
END OF CATEGORY 1			

		Maximum Distance to PAC (m)	
		Adverse Met	Average Met
2.0 Chemical Release (Category 2)			
GE	None Identified	--	--
SAE	None Identified	--	--
A-2.1	422-S Formic Acid Storage Tank Spill	66	29
A-2.2	980-S Organic Acid Waste Neutralization Tank Spill	49	19
END OF CATEGORY 2			

		Maximum Distance to PAC (m)	
		Adverse Met	Average Met
3.0 Other [Security] (CATEGORY 3)			
GE	None Identified	--	--
SAE	None Identified	--	--
A-3.1	Phase II, III, or IV Security Event Declaration	66	29
END OF CATEGORY 3			

CONSEQUENCE ASSESSMENT ASSUMPTIONS

1. General plume dispersion modeling parameters are as follows:
   - Reference wind input height 3 meters for ground level releases.
   - Ground-level release height is at 0 meters.
   - Dry deposition and city terrain options.
   - Since source term already has a release fraction (RF) applied, a value of 1 is input for modeling.
   - Filter % is 0 as it has been applied in the source term.
   - Chemical spills unless otherwise specified are modeled as 15 minute releases.

- Deposition velocity of 1 cm/s for unfiltered particulates and tritium oxide; 0.1 cm/s for HEPA filtered particulate releases.
- Receptor height is 0 m.

2. The Protective Action Criteria (PAC) for radiological releases is 1 rem TED.
3. PAC for formic acid:

Chemical	**PAC-2**	**PAC-3**	**Units**
Formic Acid (HCOOH)*	25	250	ppm

4. Stability classes and corresponding wind speeds used for appropriate release heights and meteorological conditions (95% adverse or average) are:

Meteorological Input Parameters

Release Height (m)	**Meteorological Conditions**	**Stability Class**	**Wind Speed (m/s)**	**Temperature °C**	**Inversion Layer (m)**	**Cloud Cover**	**Humidity %**
≤10	Average	C	2.5	25	500	80%	50
≤10	Adverse	E	1.7	29	300	10%	50
>10	Average	C	2.5	25	500	80%	50
>10	Adverse	A E	1.7 1.7	29 29	None 300	10% 10%	50

5. The stack height for the Zone 1 ventilation system from the top to the concrete foundation is 147 ft (45 m) to provide elevated release and preclude released radioactive materials from being drawn back into the Vitrification Building air inlets. An inspection port is provided at the bottom of the exhaust stack. All elevated releases are filtered releases.

A-2.1 422-S Formic Acid Storage Tank Spill (2-RD-1)

Spill of 90 wt% formic acid from the storage tank in Building 422-S.

Event indicated by:

Determination of a spill outside the 422-S trench/sump area by:

- Visual observation of formic acid overflowing the trench/sump area in 422-S.

OR

- Decreasing FAST #1 Level (LI6464) by 410 gallons

AND

- Organic Acid Sump LAH (LAH6430).

Maximum default source term: 294 g/min

Event should be modeled as a 15 minute, ground level, Gaussian release.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 66 m (0.04 miles)

This is the bounding postulated incident for a formic acid spill in Building 422-S. The unconfined spills outside of the diked areas are postulated to be from leaking pipes and would not approach the volume or surface area of the diked area. Rupture of a tanker carrying the acid would be covered under the transportation EPHA.

Failure of Primary Barrier — The primary barrier is the tank. Tank rupture will allow the liquid contents to fill the diked area.

Other Barriers/Mitigative Features — Formic acid tanks are enclosed by a berm; thus limiting the available evaporative spill area. A sump is provided in the dike to remove spills/leaks.

Range of Possible Releases — This release scenario is catastrophic failure of a Formic Acid Storage Tank in 422-S, spilling its entire contents of 6500 gallons of 90 wt% formic acid as an instantaneous spill but confined to the diked area. The effective surface area is 110 m^2. To model this percentage of solution, the Eckert-Drake Evaporative Model is used to determine a direct release source term (ST). This is used in the ALOHA model as a 15 minute, direct release from ground level.

Release Designation 2-RD-1

Rate of Release

Building	Release Rate Adverse Meteorology (g/min)	Release Rate Average Meteorology (g/min)
422-S	**294**	**408**

Consequences

Release Designation	Conc. at 30 meters	Conc. at Facility Boundary	Conc. at CTF Boundary	Conc. at WMA	Conc. at Site Boundary	Maximum Distance to PAC	Max Distance to TEL	Possible Emergency Classification
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(m)	(m)	
2-RD-1	1.17E+02	1.11E+01	4.44E-01	NA*	NA*	66	20	Alert

*According to ALOHA output, either not significant concentration at receptor point or it takes >1 hr to reach receptor point.

Thresholds

Ground Level Formic Acid Release	ST Threshold			MAR Threshold	
	Alert @ 30 m	SAE @ 100 m	SRF	Alert @ 30 m	SAE @ 100 m
	g/min	g/min		--	--
422-S	6.10E+01	6.60E+02	--	410 gal	NA**

**With reduced wind speeds at the surface of the spilled pool, the surface area of the dike is completely covered before the evaporation rate for an SAE is reached. Note: For 422-S, 660 gal will fill the trenches/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE. For 980-S, 330 gal will fill the trench/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE.

Release Maximum Source Term Input Determination for Diked Spill Area for 422-S (Adverse Met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	4.90E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	37.2	mm Hg
Rg (Gas Law Constant)	8.31E-02	bar-m^3/kg-mol-K
Temperature	29	°C
Volume of Spill	6,500	gal
d (depth of pool)		m
A (surface area of spill)	110	m^2
h_d (mass transfer coefficient)	4.90E-04	m/s
D (diffusion coefficient)	1.42E-05	m^2/s
L (pool length)	12	m
Re (Reynolds Number)	374,000	
Sc (Schmidt Number)	1.12	
u (wind speed)	0.5	m/s
ρ(density of air)	1.2	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	4.90E-04	
$h_{d,M}$ (if mixed)	2.38E-04	
Conversions		
T (absolute)	302.15	K
V (volume)	24.60	m^3
p_{bar}	4.96E-02	bar
p_{Pa}	4.96E+03	Pa
Evaporation Rate	294	g/min
2 hr Evaporation	35	kg

2-RD-1 422-S Formic Acid Storage Tank Spill Adverse Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 294 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 294 grams/min
   Total Amount Released: 4.41 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 20 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 66 meters --- (25 ppm = ERPG-2)
   Yellow: 199 meters --- (3 ppm = ERPG-1)


THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 117 ppm
      Indoor:  12.4 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 11.1 ppm
      Indoor:  1.17 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.444 ppm
      Indoor:  0.0467 ppm


At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because it is outside
of the 1 hour release time limit.
```

A-2.2 980-S Organic Acid Waste Neutralization Tank (OAWNT) Spill (6-RD-1)

Spill of 90 wt% formic acid from a storage tank in Building 980-S.

Event indicated by:

Determination of a spill outside the 980-S trench/sump area by:

- Visual observation of formic acid overflowing the trench/sump area in 980-S.

OR

- Decreasing tank level (OAWNT #1: LI9054; OAWNT #2: LI9084) by 224 gallons

AND

- Organic Acid Waste Sump LAH (LAH9058).

Maximum default source term: 167 g/min

Event should be modeled as a 15 minute, ground level, Gaussian release.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 49 m (0.03 miles)

This is the bounding postulated incident for a formic acid spill in Building 980-S. The unconfined spills outside of the diked areas are postulated to be from leaking pipes and would not approach the volume or surface area of the diked area. Rupture of a tanker carrying the acid would be covered under the Transportation EPHA.

Failure of Primary Barrier — The primary barrier is the tank. Tank rupture will allow the liquid contents to fill the diked area.

Other Barriers/Mitigative Features — The formic acid tanks are enclosed by a berm, thus limiting the available evaporative spill area. A sump is provided in the dike to remove spills/leaks.

Range of Possible Releases — This release scenario is a catastrophic failure of an Organic Acid Waste Neutralization Tank in 980-S, spilling its entire contents of 3,147 gallons of 90 wt% formic acid as an instantaneous spill but confined to the diked area. The effective surface area is 51.5 m^2. To model this percentage of solution, the Eckert-Drake Evaporative Model is used to determine a direct release source term. This is used in the ALOHA model as a direct release from ground level.

Release Designation 6-RD-1

Rate of Release

Building	Release Rate Adverse Meteorology (g/min)	Release Rate Average Meteorology (g/min)
980-S	**167**	**170**

Consequences

Release Designation	Conc. at 30 meters (ppm)	Conc. at Facility Boundary (ppm)	Conc. at CTF Boundary (ppm)	Conc. at WMA (ppm)	Conc. at Site Boundary (ppm)	Maximum Distance to PAC (m)	Max Distance to TEL (m)	Possible Emergency Classification
6-RD-1	6.65E+01	6.30E+00	2.52E-01	NA*	NA*	49	16	Alert

*According to ALOHA output, either not significant concentration at receptor point or it takes >1 hr to reach receptor point.

Thresholds

Ground Level Formic Acid Release	ST Threshold			MAR Threshold	
	Alert @ 30 m	SAE @ 100 m	SRF	Alert @ 30 m	SAE @ 100 m
	g/min	g/min		--	--
980-S	6.10E+01	6.60E+02	--	224 gal	NA**

**With reduced wind speeds at the surface of the spilled pool, the surface area of the dike is completely covered before the evaporation rate for an SAE is reached. Note: For 422-S, 660 gal will fill the trenches/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE. For 980-S, 330 gal will fill the trench/sump and cover the dike surface area, but this will not produce the rate of release necessary for a SAE.

Release maximum source term input determination for diked spill area for 980-S (adverse met):

Eckert-Drake Evaporative Model Parameter	Value	Dimensions
$\dot{m}$ (mass transfer rate)	2.78E-03	kg/s
M (Molecular Weight)	46.03	g/g-mole
Vapor Pressure	37.2	mm Hg
Rg (Gas Law Constant)	8.314E-02	bar-m^3/kg-mol-K
Temperature	29	°C
Volume of Spill	3,147	gal
d (depth of pool)		m
A (surface area of spill)	51.5	m^2
h_d (mass transfer coefficient)	5.94E-04	m/s
D (diffusion coefficient)	1.42E-05	m^2/s
L (pool length)	8.1	m
Re (Reynolds Number)	261042	
Sc (Schmidt Number)	1.09	
u (wind speed)	0.5	m/s
ρ(density of air)	1.2250	kg/m^3
μ (viscosity of air)	1.90E-05	kg/m-s
Conditional		
$h_{d,L}$ (if laminar)	5.94E-04	
$h_{d,M}$ (if mixed)	-1.33E-04	
Conversions		
T (absolute)	302.15	K
V (volume)	11.91	m^3
p_{bar}	4.96E-02	bar
p_{Pa}	4.96E+03	Pa
Evaporation Rate	166.9	g/min
2 hr Evaporation	20	kg

6-RD-1 980-S Organic Acid Waste Neutralization Tank Spill Adverse Direct Release

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 167 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 167 grams/min
   Total Amount Released: 2.51 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 16 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 49 meters --- (25 ppm = ERPG-2)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Yellow: 147 meters --- (3 ppm = ERPG-1)

 THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 66.5 ppm
      Indoor:  7.06 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 6.3 ppm
      Indoor:  0.666 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.252 ppm
      Indoor:  0.0265 ppm

At 9,400 m and 10,940 m:  Concentration/Dose pictures not drawn because there is no
significant concentration/dose at the point selected.
```

A-3.1 Phase II, III, or IV Security Event declaration for DWPF with the potential to release hazardous material.

This EAL is based upon the maximum amount of hazardous material that could be released in a worst-case malevolent act (7-RD-1) for DWPF as indicated by:

Event indicated by:

- PHASE II, III, or IV Security Declaration by Protective Force for the facility.

AND

- Involves the potential for a hazardous material release.

Maximum default source term: 294 g/min

Event should be modeled as a ground level release with release duration of 15 minutes.

Default Protective Action: *Remain Indoors*

Maximum distance to PAC: 66 m (0.04 miles)

For DWPF, the extreme malevolent act is assumed to involve the maximum event for the area. The extreme malevolent act is bounded by the postulated spill of the formic acid storage tank in Building 422-S (Cold Chemical Storage). This scenario has already been analyzed under release designation 2-RD-1. No other accident scenario (i.e., explosion, fire, loss of confinement, etc.) would result in significantly higher consequences for DWPF. Therefore, no further analysis of an extreme malevolent act scenario is required.

Release Designation 7-RD-1

		MAR Formic Acid	**SRF***	**ST g Formic Acid**
Malevolent Act	15 minute, Ground Level Release	6500 gal (2.95E+04 g)**	1.49E-01	4410***

*SRF is calculated by dividing the ST by the MAR and rounded
**1 gal = 0.0037854 m^3; 6500 gal x 0.0037854 m^3 = 24.6 m^3*1.2 kg/m^3 (density) = 2.95E+04 g
***294 g/min in 15 min = 4410 g

Consequences

Release Designation	Conc. at 30 m (ppm)	Conc. at Facility Boundary (ppm)	Conc. at CTF (ppm)	Conc. at WMA (ppm)	Conc. at Site Boundary (ppm)	Maximum Distance to PAC (m)	Max Distance to TEL (m)	Possible Event Class
7-RD-1	1.17E+02	1.11E+01	4.44E-01	NA*	NA*	66	20	Alert

*According to ALOHA output, either not significant concentration at receptor point or it takes >1 hr to reach receptor point.

Classifications Thresholds

Declarations for security events are based on conditions observed and are not based on inventory amount; therefore, no classification thresholds are developed for security events.

7-RD-1 Malevolent Act Adverse

```
SITE DATA:
   Location: AIKEN, SOUTH CAROLINA
   Building Air Exchanges Per Hour: 0.45 (unsheltered single storied)
   Time: June 30, 2016  2359 hours EDT (user specified)

 CHEMICAL DATA:
   Chemical Name: FORMIC ACID
   CAS Number: 64-18-6                    Molecular Weight: 46.03 g/mol
   ERPG-1: 3 ppm      ERPG-2: 25 ppm      ERPG-3: 250 ppm
   IDLH: 30 ppm       LEL: 120000 ppm     UEL: 380000 ppm
   Ambient Boiling Point: 100.0° C
   Vapor Pressure at Ambient Temperature: 0.068 atm
   Ambient Saturation Concentration: 69,150 ppm or 6.92%

 ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
   Wind: 1.7 meters/second from 270° true at 3 meters
   Ground Roughness: urban or forest      Cloud Cover: 1 tenths
   Air Temperature: 29° C                 Stability Class: E
   Inversion Height: 300 meters           Relative Humidity: 50%

 SOURCE STRENGTH:
   Direct Source: 294 grams/min           Source Height: 0
   Release Duration: 15 minutes
   Release Rate: 294 grams/min
   Total Amount Released: 4.41 kilograms

 THREAT ZONE: (GAUSSIAN SELECTED)
   Model Run: Gaussian
   Red   : 20 meters --- (250 ppm = ERPG-3)
   Note: Threat zone was not drawn because effects of near-field patchiness
      make dispersion predictions less reliable for short distances.
   Orange: 66 meters --- (25 ppm = ERPG-2)
   Yellow: 199 meters --- (3 ppm = ERPG-1)


THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 30 meters                    Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 117 ppm
      Indoor:  12.4 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 100 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 11.1 ppm
      Indoor:  1.17 ppm

THREAT AT POINT:
   Concentration Estimates at the point:
   Downwind: 570 meters                   Off Centerline: 0 meters
   Max Concentration:
      Outdoor: 0.444 ppm
      Indoor:  0.0467 ppm
```