D-Area Preliminary Hazards Analysis

by

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D-AREA PRELIMINARY HAZARDS ANALYSIS (U)

I. K. Paik

April 1998

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SAVANNAH RIVER SITE

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TABLE OF CONTENTS

TABLE OF CONTENTS.....	V
LIST OF TABLES.....	VI
LIST OF FIGURES	VII
EXECUTIVE SUMMARY	1
1.0 INTRODUCTION	2
1.1 D-AREA DESCRIPTION	2
1.2 420-D BUILDING	3
1.3 420-2D BUILDING	4
1.4 421-2D BUILDING	5
1.5 421-D BUILDING	5
1.6 421-4D BUILDING	5
1.7 772-D LABORATORY	5
1.8 421-6D BUILDING	6
1.9 B-12/B-25 STORAGE	6
2.0 INPUT DATA.....	7
2.1 RADIOLOGICAL HAZARD SOURCES.....	7
2.2 CHEMICAL HAZARD SOURCES	8
2.3 CRITICALITY HAZARD SOURCES.....	9
3.0 ASSUMPTIONS.....	10
4.0 ANALYSIS METHOD AND CALCULATIONS	12
4.1 METHOD	12
5.0 RESULTS AND DISCUSSION.....	20
5.1 HAZARD IDENTIFICATION.....	20
5.2 HAZARD EVALUATION.....	20
6.0 CONCLUSION.....	30
7.0 REFERENCES	31
APPENDIX A HAZARD IDENTIFICATION TABLE	57
APPENDIX B HAZARD EVALUATION TABLE.....	61

LIST OF TABLES

Table 1.	Radionuclide Inventory Other than Tritium in Heavy Water (Ref. 18)	34
Table 2.	D-Area Tritium Inventory (Ref. 19)	35
Table 3.	772-D Radionuclide Inventory	36
Table 4.	D-Area Fissile Material (Pu-239) Inventory	37
Table 5.	Frequency Qualitative Rating Levels (Ref. 1)	38
Table 6.	Event Consequence Levels (Ref. 1)	39
Table 7.	PHA Risk Matrix – Consequence versus Frequency (Ref. 1)	40
Table 8.	Dose to Onsite and Offsite Receptors due to 1 Curie of the Radioisotope Released (Ref. 26)	41
Table 9.	D-Area Heavy Water Dose Calculations	42
Table 10.	Onsite and Offsite Dose Contributions from the Radionuclides Inventory in 772-D	47
Table 11.	Moderator Processing Facility Radiological Inventory (Used to estimate radiological inventory in B-25 Box that contains the resin and filters.)	48
Table 12.	420-D Compressor Room Chemical Incompatibility Study	49
Table 13.	421-2D RBA Chemical Incompatibility Study	50
Table 14.	772-D Building, Room 118 Chemical Incompatibility Study	51
Table 15.	772-D Building, Room 118A Chemical Incompatibility Study	52
Table 16.	772-D Building, Room 121 Chemical Incompatibility Study	53

LIST OF FIGURES

Figure 1. Location of D-Area.....	54
Figure 2. Heavy Water Processing Facility (D-Area).....	55
Figure 3. Layout of Buildings 420-D, 420-2D, and 421-D	56

EXECUTIVE SUMMARY

A comprehensive review of hazards associated with the D-Area was performed to identify postulated event scenarios. To determine the risk of events, a Preliminary Hazards Analysis (PHA) was performed. The major hazards in D-Area are associated with the heavy water processed or stored in various buildings in D-Area.

The postulated natural and process events, their initiating event frequencies, the consequences, and the classification of the event scenario based upon the Department of Energy guidance for Basis for Interim Operation (DOE-STD-3011-94) (Ref. 1) are presented.

The only significant accident scenarios identified were from radionuclides (tritium from the heavy water) released from damaged drums or the heavy water processing units. The release possibility stems from the energetic events, such as earthquakes, fire, forklift accidents, and drum mishandling events potentially leaking the heavy water out of the drums.

None of the events resulted in consequence being higher than Low for the onsite evaluation point, maximum offsite individual or the environment based upon the conservative event scenarios. A few events resulted in unmitigated Medium consequences to the facility worker with an anticipated frequency, i.e., Scenario Class of I. This is based upon the assumption that the facility worker may not be able to recognize a leak of heavy water inside a building. However, the Radiation Monitoring System, which provides an alarm in case of a tritium leak inside the buildings, can adequately protect the facility worker.

There would be no significant impact from the heavy water being spilled into the groundwater or Savannah River. There is no significant concern from hazardous chemicals.

1.0 INTRODUCTION

The purpose of this PHA is to support the D-Area BIO by providing a qualitative (or semi-quantitative) assessment of event scenarios in D-Area. This assessment is accomplished by implementing the methodology for performing the hazard identification and hazard evaluation as described in Section 4.0. The analysis in the PHA is based upon the input and assumptions listed in Sections 2 and 3. This process results in a comprehensive evaluation as detailed in Section 5 and the appendices associated with this PHA.

1.1 D-AREA DESCRIPTION

D-Area at the Savannah River Site consists of four processes (i.e., facilities) that are used to purify the heavy water and remove chemical contaminants. The area also contains four drum storage buildings, one chemical storage building, and a Laboratory. The facilities that are used to accomplish the process of purifying and removing chemical contaminants from the heavy water consist of the Rework Unit (RW), DuPont Water (DW) Plant, Moderator Processing Facility (MPF), and Technical Purification Facility (TPF). RW, DW, and MPF are all housed in Building 420-D, and the TPF is housed in Building 421-2D. The buildings that are used to store heavy water in drums consist of 421-D, 421-2D, and 421-4D. Building 420-2D which is assumed to be a part of the RW, DW, and MPF facility of Building 420-D stores drums that are used to charge the processes and to remove heavy water from the processes in Building 420-D. These drums are also included as part of the inventory of heavy water for Building 420-D. 772-D Laboratory Facility contains the Water Quality Laboratory which was used to support reactor operations. Figure 1 shows the locations of the D-Area which is very close to the site boundary. Figure 2 shows the location of the buildings in the D-Area.

This PHA covers the following buildings in the D-Area:

- 420-D (Rework Unit, DuPont Water Plant, Moderator Processing Facility, and 420-2D for Heavy Water Drum Storage)
- 421-2D (Technical Purification Facility and Heavy Water Drum Storage)
- 421-D (Heavy Water Drum Storage)
- 421-4D (Heavy Water Drum Storage)
- 772-D (Laboratory Facility)
- 421-6D (Chemical Storage)

These buildings are primarily constructed of transite walls (except 421-4D which is constructed of metal siding) and roofs with steel frames which are not seismically qualified or hardened structures to withstand the forces of high winds or tornadoes. The flooring is concrete with curbing to prevent any minor spilled heavy water from exiting the building. Ramps are provided for personnel and equipment entering the building, and climate control consists of a general exhaust and steam heater system. The buildings are at an elevation of approximately 137 feet above sea level.

1.2 420-D BUILDING

The Distillation System in the 420-D Building contains two units, the Rework (RW) Unit and the DuPont Water (DW) Unit. Figure 3 shows the schematic layout of these units inside the 420-D Building. More detailed facility/system information can be found in Reference 5.

Rework Unit

The Rework Unit processes heavy water which has been used in the production reactors and contain tritium. The Rework Unit uses six distillation columns operated as a five-stage plant. Effluent released to the environment is primarily air containing small amounts of water and tritium oxide.

The main system in the Rework Unit is the Distillation System, which is located in and around the 420-D Building. The building contains one level divided into separate rooms used for each part of the system. The following rooms are in the 420-D Building and support the Distillation System:

- Heavy Water Control Room – contains various controls and instrumentation for operation of the Distillation System.
- Electrical Equipment Room – contains electrical distribution equipment for the Distillation System.
- Rework Pump Room – contains the various pumps, valves, and piping utilized by the Rework Unit portion of the Distillation System.

The Rework Unit is located separately in a diked area. No other processing is performed in this area. In the event of a loss of electrical power or process steam, the system will cease operation with no loss of integrity.

DuPont Water Unit

The DuPont Water Unit uses a separate but very similar process to concentrate deuterium oxide using three distillation towers. The DW Unit is limited to non-contaminated water. The pumps, piping, valves, tanks, and other miscellaneous equipment for the DW Plant portion of the Distillation System are located in the larger central area of the building. Per Reference 2, DW Unit inventory was omitted from the hazard assessment since it contains negligible radiological and chemical inventories.

The following major distillation equipment is located outside the 420-D Building.

- Distillation towers – 9 towers total- separate light and heavy water. Six are used for the RW Unit located on the east side of the 420-D Building and three are used for the DW Plant located on the west side of the 420-D Building
- Accumulators – 3 total - collect condensate from RW Unit and DW Plant
- Calandrias – 8 total – heat heavy water to a vapor
- Condensers – 8 total – condense heavy water vapor back to liquid.

Other Distillation Supporting Systems

The Distillation System is interconnected with various systems. These systems include:

- Cooling Water System – Provide cooling medium for condensation of the light water/heavy water vapor mixture in the Distillation Towers.
- Steam System – Source of heat (@ 55 psig) for the calandrias.
- Refrigeration System – To extract product entrained in the process exhaust vapors venting from the condensers.
- Feed and Storage System – Feeding water from the Distillation Towers to other feed points.
- Vacuum System – Provide vacuum in the Distillation Towers. (column head pressure of 60 to 100 mm of mercury absolute.
- Air System – Plant air and instrument air.
- Contaminated Waste Disposal System – Discharge condensate from the calandria steam traps and the jet tail pipe water into the process sewer. The cooling water from the condensers is also discharged to the process sewer which empties into Beaver Dam Creek and eventually into the Savannah River.
- Electrical System – 440 V feeder line from a transformer station on the south side of the 420-D Building. Power is distributed from the Electrical Control Room. Emergency diesel is available for lighting.

Moderator Processing Facility (MPF)

The MPF is designed to remove oil, particulate matter, and any ionic impurity (with the exception of mercury) that may increase conductivity of heavy water before it is sent to the Rework Unit to restore heavy water purity (Ref. 6). Mercury contaminated heavy water can not be charged to the MPF as mercury is highly corrosive to other metal, such as the stainless steel holding tank and other components in the MPF. The MPF receives degraded heavy water in 55-gallon drums. Any oil removed is collected in a 55-gallon waste oil drum.

The MPF is primarily located next to the Rework and DW Pump Rooms inside the 420-D Building with a small portion of the system located in 420-2D. The processing portion of the system is located inside the 420-D Building while the heavy water drums, the product drums, and associated charging station are located in 420-2D.

The major components in the MPF are:

- Feed Pump
- Transfer Pump
- Filters
- Resin Columns
- Receiving Tank (250 Gal.)
- Holding Tank (500 Gal.)
- Oil Decanter
- De-emulsifier
- Draw-off Pump
- De-deuterization Pump

1.3 420-2D BUILDING

420-2D Building (see Fig. 3) is located west of 420-D Building and it contains some part of MPF systems, such as the heavy water drums, the product drums, and associated charging stations to support the processes in 420-D Building.

1.4 421-2D BUILDING

421-2D Building contains the Technical Purification Facility (TPF), drum wash area, and drum storage area. Although the Drum Storage area is located in the same building as the TPF, the two areas are segregated by a barrier that contains a permanent opening to allow access into the Drum Storage area. Four drums are banded together and placed on a wooden pallet. The drums are stored in the building in stacks of up to three high. The hazardous waste from TPF is mixed with concrete and stored in 55-gallon drums. The building is primarily constructed of transite walls and roofs with steel frames. The flooring is concrete with curbing to prevent any spilled heavy water from exiting the building. Ramps or berms are provided for personnel and equipment entering the building, and climate control consists of a general exhaust and steam heater system.

Technical Purification Facility (TPF)

The Technical Purification Facility removes mercury from heavy water with greater than 0.01 ppm of mercury prior to it being processed through the RW or MPF. The TPF performs this function by re-circulating the heavy water through a resin column. In addition the resin also removes other heavy metals such as chromium and lead. The TPF consists of two pumps, two filters, and two 55-gal drums, located within an exhaust hood, one resin column, and a pre-filter cart located outside of the exhaust hood. The exhaust hood ventilates the facility to decrease the amount of tritium which escapes into the 421-2D Building. The tritium levels are monitored by a Kanne sample hose inside the hood exhaust. Small amounts of 50% sodium hydroxide solution or nitric acid are used to adjust pH. The TPF processes one 55-gal drum of heavy water at a time. There could be some 55-gallon drums in transit stored on the floor near TPF.

1.5 421-D BUILDING

421-D Building is located north of the 420-D Building (see Fig. 3). The drums are stored in the building in stacks of up to three high. The building used to store drums of heavy water are primarily constructed of transite walls and roofs with steel frames. The flooring is concrete with curbing to prevent any spilled heavy water from exiting the building. Ramps are provided for personnel and equipment entering the building, and climate control consists of a general exhaust and steam heater system.

This building stores drums of heavy water and contains the DW plant final product processing.

1.6 421-4D BUILDING

The drums are stored in the building in stacks of up to three high. The building used to store drums of heavy water are primarily constructed of metal siding walls and roofs with steel frames. The flooring is concrete with curbing to prevent any spilled heavy water from exiting the building. Ramps are provided for personnel and equipment entering the building, and climate control consists of a general exhaust and steam heater system.

1.7 772-D LABORATORY

772-D Laboratory Facility contains the Water Quality Laboratory, which was used to support reactor operations. The facility is a one-level, steel frame constructed building. The southern part of the building includes office space, a cafeteria, health protection

office, and restrooms. The Laboratory is located in northern part of the building. Radioactive and non-radioactive samples are handled in hoods or radionuclide benches approved for tritium handling. Radioactive waste is plumbed directly to waste drums from the hood drains.

1.8 421-6D BUILDING

Bulk process chemicals, resins, and empty clean drums are stored in Building 421-6D. The building is steel frame constructed with metal siding walls and roof. The flooring is concrete with curbing to prevent small spills from exiting the building. Ramps are provided for personnel and equipment entering the building. Climate control consists of a general exhaust and steam heater system.

1.9 B-12/B-25 STORAGE

The B-12 box is a 45-ft³, 12 gauge, carbon steel "Disposal/Storage Box" used for packaging, transport, and disposal of solid low-level radioactive waste. The B-25 box is a 90 ft³, 14 gauge, carbon steel "Low-Level Waste Burial Box" used for the disposal of solid low-level radioactive waste. The B-25 is loaded with spent MPF resins, TPF resins, filters and heavy water wet waste. Assuming the B-25 holds 5,000 pounds of resin and filters and a typical MPF resin changeout is approximately 10 ft³, a full B-25 of resin and filters waste may contain up to 3,500 Ci of tritium and a full B-25 of heavy-water-wet waste may contain 1000 Ci of tritium (Ref. 28). Reference 19 indicated that these boxes are loaded outside of Building 421-2D. The loaded B-25/B-12 boxes are stored outside Building 421-4D until shipment,

2.0 INPUT DATA

Input data to the PHA consists of the following items:

- Hazards Assessment Documents (Ref. 2 – 4)
- Event frequencies (Ref. 7 – 13)
- Existing Authorization Basis Documents (Ref. 14)
- Heavy Water Facility Chemical Inventory (Ref. 16)
- Updated Tritium Inventory (Ref. 19)
- B-25 Inventory (Ref. 28)

2.1 RADIOLOGICAL HAZARD SOURCES

It was assumed that the radionuclide concentrations other than tritium as shown on Table 1 provided in the HAD for 420-D and 421-2D Buildings (Ref. 2, 3, and 18) are still valid. Reference 19 provides most recent tritium inventories in the D-Area as shown in Table 2. Tritium concentration in each drum varies. The inventory information in Reference 19 is based upon the data in the Heavy Water Information Control System (HWIC). There are a total of 116 drums that HWIC lists as unsampled. For these drums a curie concentration of 11 Ci/liter was used. Reference 19 also stated that:

- Total curie content of highest half of drums: 1,396,929 Ci
- Mean curie concentration of all drums: 1.062 Ci/liter
- Average curie concentration of highest half of drums: 4.266 Ci/liter (5 Ci/liter is recommended.)

The number for curie concentration and thereby curie content are conservative because the curie concentration in HWIC is not reduced based on radioactive decay of tritium. Some of the measurements were performed in 1990. For the RW process, 11 Ci/liter is used for conservatism.

Each building is assumed to be at maximum capacity while still allowing forklift access. The category "Other" includes up to 3 trailers worth (64 drums) of transient drums (directly involved with some activity) at 11 Ci/liter temporarily stored in trailers or outside.

The total volume of the heavy water which can reside in RW and MPF is 28,950 gallons (including 550 gallons of heavy water in 420-2D Building). This is equivalent to 1,205,333 curies as indicated in Table 2. The maximum radionuclide inventory for the DW Plant is negligible per Ref. 2.

Reference 19 also indicated that all other nuclide source terms in the existing HADs (Ref. 2 – 3) are still conservative as compared to the radioisotope concentrations listed on Table 1 and shall remain the same.

Radionuclides which may be present in the Laboratory is from the heavy water that is tested in the Laboratory as shown on Table 3. No extra heavy water drums are stored in the Laboratory.

2.2 CHEMICAL HAZARD SOURCES

The current chemical inventories for the 400-D Heavy Water Facilities and the 772-D Water Quality Laboratory are provided in Reference 16. Reference 16 also performed a screening to determine if the maximum quantity stored in these buildings exceeds any of the following regulatory thresholds:

- CERCLA Reportable Quantity (RQ) per 40CFR302.4
- Threshold Planning Quantity (TPQ) per 40CFR355
- Threshold Quantities (TQ) per 29CFR1910.119

The results of the screening are listed below.

Regulatory Threshold	Chemical Exceeding Threshold
RQ	Potassium Permanganate (421-D & 421-6D)
TPQ	None
TQ	None

Asbestos in transite walls for the buildings in D-Area is considered to be a Standard Industrial type hazard, therefore, it is not considered in this PHA.

2.2.1 420-D Building

Per Reference 2, the mercury concentration in the heavy water is less than 0.01 ppm which is based upon the present administrative controls. No other hazardous non-radioactive impurities are present in any appreciable quantity. The reported 1.07 grams of mercury is well below the reportable quantity of 454 grams as stated in 40CFR302.4. Therefore, a chemical hazards analysis is not necessary for this building. There are a maximum of 8500 pounds of Freon 22 located outside of the 420-D Building that is used as the refrigerant for the Cooler and Freezer.

2.2.2 421-2D Building

Per Reference 3, a mercury concentration of 1 ppm was used for the TPF inventory based on historical data. A mercury concentration of 0.01 ppm was used for the Drum Storage inventory based upon the present administration controls. No other hazardous non-radioactive impurities are present in any appreciable quantity. The reported 0.47 grams of mercury in TPF and 1.83 grams in the Drum Storage are well below the reportable quantity of 454 grams as stated in 40CFR302.4. Therefore, a chemical hazards analysis is not necessary for this building.

2.2.3 421-D Building

Per reference 16, there is a maximum of 110 pounds of potassium permanganate, KMnO_4 , which exceeds the Reportable Quantity limit of 100 pounds per 40CFR302.4.

2.2.4 421-4D Building

No chemicals stored.

2.2.5 772-D Laboratory

Reference 16 also provides a list of hazardous chemicals stored in the Laboratory.

2.2.6 421-6D Building

Per reference 16, there is a maximum of 113 pounds of potassium permanganate, KMnO_4 , which exceeds the Reportable Quantity limit of 100 pounds per 40CFR302.4.

2.3 CRITICALITY HAZARD SOURCES

The fissile material of concern is plutonium-239, which is distributed in small amounts throughout the heavy water. There is no other fissile material stored in D-Area that can cause a criticality concern. Pu inventory is calculated using the Pu-239 concentration of 1.42×10^{-6} Ci/liter and the volume of heavy water stored or can be processed in the facility. The amount of plutonium present in the heavy water is given in Table 4 which gives an inventory of 15.9 grams of plutonium-239, far below the theoretical 450-gram criticality mass limit of Reference 25. Thus, criticality is not possible.

3.0 ASSUMPTIONS

The following assumptions were made for this hazards analysis:

1. The tritium inventory listed in Ref. 19 is valid and conservative. The B-25s boxes are controlled by the Waste Management Program and are assumed to a total less than 16,000 Ci. A B-25 box of resin and filter waste is assumed to total less than 3,500 Ci of tritium and a box of Process Water wet waste-stream is assumed to total less than 1,000 Ci of tritium (Ref. 28)
2. The radionuclide inventory in the 420-D DW Plant is negligible based upon the fact that the DW Plant only process uncontaminated heavy water.
3. The chemical inventory information in Reference 16 is valid.
4. A maximum concentration of 1 ppm of mercury was used for TPF inventory and 0.015 ppm for the remaining D-Area based on Reference 18.
5. For events involving releases from storage containers, the container was assumed to contain the maximum allowable quantity of radioactive material.
6. The radiological dose calculations are based on ground level release without any credit for mitigative design or administrative features other than inventory control and physical phenomena (Leak Path Factor is assumed 1).
7. Facility worker's ability to recognize fire or natural phenomena such as earthquake and to evacuate from the facility is credited in facility worker consequence estimate.
8. There are no explosive or potentially explosive materials in or around D-Area other than trucks that deliver the heavy water drums or forklifts that move heavy water drums.
9. Even though a railroad spur is located in the D-Area, service has been terminated.
10. For heavy water release, 2% airborne release in 2 hours was used for all weather conditions per Reference 20. A shorter release duration was not selected because the main release mode is evaporation. It is bounding for any other condition even including longer release duration due to plume meander. This is conservative compared to the release fraction of 0.1% recommended for liquid in Reference 15.
11. Pu-238, Pu-239, Cm-242, and Cm-244 have high dose conversion factors as shown in Table 8. For these nuclides which are insoluble heavy elements, an airborne release fraction of $1.8\text{E-}03$ is assumed per Reference 30. All other nuclides in heavy water are assumed to have an airborne release fraction of 1 which is very conservative.
12. It is assumed that a release concurrent with a fire may add 2% more to the above airborne release. This is also very conservative since water would extinguish the fire unless it is an oil/gasoline fire. Oil and gasoline will float on water while it burns, therefore, it may not be able to boil off water. Additional evaporation by thermal radiation is possible if the fire is significant in terms of temperature and size.
13. It is assumed that a maximum of 1/2 of the drums stored in the drum storage buildings would be damaged (i.e., a damage ratio of 1/2) and release their contents during a full building fire. This is very conservative since fire intensity and duration have to be sufficient enough to pressurize these drums and breach their integrity when there are not enough combustible materials in these storage buildings. In addition, the water released from the drums may extinguish the fire.
14. For accidents involving a forklift, it is assumed that no more than twelve drums would be damaged. The most likely forklift accidents would be to have a fork (or both forks, drum handlers) puncture one (or four) of the drum(s) or backing the forklift into a stack of drums, toppling up to twelve. For these drums, 11 Ci/liter is assumed.
15. For accidents involving vehicles other than forklifts, it is assumed that a maximum of 1/2 of the drums stored in the drum storage buildings (i.e., a damage ratio of 1/2)

would be damaged and release their content during a subsequent fire caused by fuel tanks.

16. It is assumed that all drums may be damaged during a freezing weather (i.e., a damage ratio of 1). This assumption is reasonable since the thermal inertia and heat capacity of each drum is not significant compared to a case of a large pool with the same mass of all the drums.
17. It is assumed that a maximum of 1/2 of the drums can be damaged due to straight winds or tornado (winds speeds in "Unlikely" frequency) by assuming that all drums stacked three high and one half of the drums stacked two high will be damaged (i.e., a damage ratio of 1/2).
18. It is assumed that a maximum of 1/2 of the drums can be damaged during an earthquake (even for an earthquake with an "Unlikely" frequency since the buildings are not seismically qualified) by assuming that all drums stacked three high and one half of the drums stacked two high will be damaged (i.e., a damage ratio of 1/2).
19. It is assumed that Respirable Fraction of heavy water particles or vapor containing tritium is one.
20. Since the material at risk in the Laboratory is negligible, release of all inventories is assumed for Onsite and Offsite receptors. The potential doses to these receptors are negligible as shown in Table 10.
21. It is assumed that the resins used in the Moderator Processing Facility (MPF) contains the maximum MPF radiological inventory except tritium as stated in the 420-D HAD (Reference 2) as shown in Table 11.
22. Site specific meteorological data were used.

4.0 ANALYSIS METHOD AND CALCULATIONS

4.1 METHOD

The PHA consists of two basic analytical activities: hazard identification and hazard evaluation. The BIO guidance document (Ref. 1) requires the PHA to comprehensively identify potential events, their initiators, and the dominant scenarios; estimate their frequencies and consequences; and present the results in a risk matrix. The PHA methodology performs gross estimates of consequences and frequencies (i.e., not detailed Safety Analysis Report [SAR] type analyses). Frequency and consequence levels are used in "binning" which focuses attention on those scenarios that are of greatest concern (i.e., highest risk). The results of these activities are used to develop the Safety Analysis section of the BIO.

4.1.1 Hazard Identification

Hazard Identification is a comprehensive, systematic process by which all known hazards (hazardous materials and energy) associated with the facility are identified, recorded, and screened by a team of individuals representing the stakeholder organizations.

To limit the scope of the following stages of safety analysis, screening is performed to eliminate material/energy types and quantities that are considered "common hazards." Common hazards are those that are commonly found in the home or work place and for which adequate guidelines or national consensus codes and standards are available and provide for safe design and operation of the facility containing those hazards. The exception to this screening is if the "common hazard" could result in the release of hazardous material that is not considered a "common hazard."

During the rigorous process of evaluating the facility system by system and identifying the hazards within each system, the systems that are either in the design or planned which could be expected to prevent the hazard from causing harm to the public, workers, or the environment or which could be expected to mitigate the consequences of the hazard to these three are evaluated. The identification of preventive and mitigative features for each hazard begins during Hazard Identification. These preventive and mitigative features identified at this stage of the safety documentation process are candidates for selection in the functional classification and accident analysis phases as credited SSCs providing a safety class or safety significant function.

Hazard Identification is divided into three steps; 1) division of the facility into "sections," 2) facility information gathering, and 3) screening for common hazards.

Division of the Facility

The facility is divided into "sections" to facilitate hazard identification and evaluation. These sections are individual unit operations, individual or grouped facility systems, specific function(s), and/or physical boundaries inside the facility. They are selected to ease hazard identification and evaluation and need not be used outside of the HA. The team should define a single general common hazard section that includes common cause events that could involve more than one facility section (e.g., building or facility fire and earthquake).

Facility Information Gathering

Facility information gathering includes both reviews of current design documentation and direct interactions with the designers responsible for the specific sections of the facility. The team performs information gathering to identify hazardous materials and energy sources that are currently known or which may be associated with each facility HA section. The team uses a hazards checklist or legend that lists generic facility hazards as a useful aid in conducting hazard identification. This checklist is based on the DOE Management Oversight Risk Tree (MORT) methodology (Ref. 21).

Thus, the team creates an inventory document listing all expected radiological and chemical hazards. These results are a key input to the process of Hazard Identification. Hazard Identification Tables are filled-out for each facility section. Generally facility walkdowns include both physical walkdowns and information (or paper) walkdowns. Information or paper walkdowns are the process of reviewing existing safety documentation, design/system drawings, procedures, etc. in the context of Hazard Identification. Information on facility hazards was gathered from the responsible design organizations.

An inventory and screening task, is completed prior to conducting the HA, and produces an inventory document listing all known radiological and chemical hazards. These results are a key input to the process of Hazard Identification. However, additional hazards may be identified as a result of chemical interactions. A chemical mixing study is completed as part of the final Hazard Evaluation process if the Hazards Identification determines that the potential for chemical mixing with the chemicals is expected.

Screening of Common Hazards

The third step in the Hazard Identification process is the screening of common hazards or standard industrial hazards. These are defined as hazards that are routinely encountered in general industry and construction, and for which national consensus codes and/or standards (e.g., OSHA and transportation safety) exist to guide safe design and operation. Standard industrial hazards and routinely accepted hazards are identified only to the degree that they are initiators and contributors to events that result in radiological and chemical hazards. The following characteristics are used to determine hazards that are standard industrial hazards and routinely accepted hazards:

- The hazard is routinely encountered first-hand by the general public in the home, home workshop, or public areas.
- Public consensus standards exist to control the hazard.
- No evidence exists that there are public or employee concerns about the hazard beyond normal prudence.
- The hazard is subject to Occupational Safety and Health Act (OSHA) regulations.

Practicing basic safety in the workplace and following applicable codes, standards, and operating practices provides protection against industrial hazards and routinely accepted hazards. Such hazards are formally and systematically treated by the following programmatic elements:

- WSRC Procedure Manual 8Q (Ref. 22) defines basic SRS sitewide safety policies and the associated minimum requirements. This procedure manual is augmented by detailed rules and procedures developed by departments and facilities for activities

within their areas of responsibility and requires compliance with DOE Orders and OSHA regulations, at a minimum, for industrial safety.

- Industrial safety involves the detection, mitigation, management, and prevention of workplace hazards to protect against accidental death, injury, property damage, or interruption of production. The operating philosophy for all facilities at the Savannah River Site (SRS) is that the safety and health of employees is the first and utmost priority. Policies are implemented at the facility level through facility-specific procedures.
- During the design phase of the facility or modifications to the facility, various design reviews contribute to industrial hazard identification.
- During facility operation, several programs ensure timely identification of industrial hazards. These programs include OSHA compliance reviews, routine safety audits and periodic safety inspections, incident investigations (formal reviews and assessments of any unsafe situation or incident), annual safety program reviews, monthly safety meetings, safety suggestion programs, lessons learned program, and the Quality Assurance program.

The HA team screens each identified hazard for each section based on material/energy types and quantities using the guidance and screening criteria provided in Ref. 23.

If the identified hazard does not meet the appropriate screening criteria for identification as a common hazard, then the hazard is not considered common and is carried forward to the Hazard Evaluation. Examples include events causing a release of hazardous material not covered as a standard hazard or hazards for which existing standard industry practices do not provide adequate protection for all conditions.

4.1.2 Hazard Evaluation

The Hazard Evaluation (HE) constitutes the primary focal point of the HA. Hazards are characterized in the context of actual facility operations and processes by considering feasible release mechanisms (or events), estimating initiating event frequency, estimating consequences of the unmitigated release, and identifying preventive features and mitigative features as contributors to defense-in-depth. The purpose of Hazard Evaluation is to ensure a comprehensive assessment of facility hazards and focus attention on those events that pose the greatest risk to the public, onsite workers, and the environment.

The scope of Hazard Evaluation includes:

- All aspects of facility process and modes of operation including startup, shutdown, production, and routine maintenance that is considered part of operations
- Natural phenomena (e.g. earthquakes, tornadoes, straight-line winds) and external events (e.g. aircraft and vehicular impact) are considered.
- The entire spectrum of possible events for a given hazard in terms of both frequency and consequence levels.
- Hazards addressed by other programs and regulations (e.g. PSM, OSHA, RCRA [10CFR835], DOT, and EPA) are included only if loss of control of the hazard will result in a release of radiological material or toxic material that are not covered.

The scope of Hazard Evaluation does not include:

- Willful acts, such as sabotage.

- Hazards routinely accepted by the public. (These are screened during the common hazard screening process prior to conducting the Hazard Evaluation.)

Using the results of Hazard Identification as a basis, the hazard analyst considers the hazardous material and energy sources in the context of facility section and/or whole facility operations to begin developing specific release events. Event categorization, identification of event cause(s), assignment of event frequency and consequence level, identification of mitigative and preventive features, screening for common hazardous events, and risk binning are tasks conducted by the hazard analyst during Hazard Evaluation.

Information related to Hazard Evaluation is collected and organized in "Hazard Evaluation Tables." These tables are a useful guide for performing Hazard Evaluation and they provide an effective format for documenting Hazard Evaluation results. The hazard analyst produces a separate Hazard Evaluation Table for each facility section.

Information in these tables is organized into the following categories:

- Event Number
- Event Category
- Postulated Event Description
- Causes
- Preventive Features (Design and Administrative)
- Initiating Event Frequency Level
- Method of Detection
- Mitigative Features (Design and Administrative)
- Unmitigated Consequence Level (Impact on Other Systems and Impact on Receptors)
- Scenario Class

Additional detail and pertinent methodology information regarding each of the Hazard Evaluation Table categories is provided in the following sections.

In the HE process, certain inherent assumptions are made that apply to the facility. The HE assumes that facility or section inventories are controlled such that the quantities of radionuclides and chemicals presented in Section 2 are not exceeded. The HE also assumes that facility access is controlled such that the population exposed to a given potential event is limited.

4.1.2.1 Event Number

Events are numbered to provide each with a sequential reference.

4.1.2.2 Event Category

Events are categorized according to the nature of the postulated release mechanism. A standard list of event categories, based on those given in Appendix E of DOE/TIC-11603 (Ref. 24), is used. They are as follows:

- E-1 Fire
- E-2 Explosion
- E-3 Loss of Containment/Confinement
- E-4 Direct Radiological/Chemical Exposure

- E-5 Nuclear Criticality
- E-6 External Hazards
- E-7 Natural Phenomena

Events are categorized according to the event description rather than the event cause. For example, a facility fire might be a postulated event that is caused by an earthquake or some other natural phenomena. This event would fall under category E-1 (Fire) rather than E-7 (Natural Phenomena).

4.1.2.3 Postulated Event Description

A brief description of a postulated event is given in this column of the Hazard Evaluation Tables. The event description clearly defines the nature of the event. It includes the type of event, hazardous material and/or energy released, its location or affected system(s), any interaction with other facility section(s), system(s), equipment, and any pertinent operating characteristics.

Using the Hazard Identification Tables as a basis, the HA Team develops event scenarios for each facility section wherever a potential exists for a release of hazardous energy and/or material. The scenarios cover the entire spectrum of possible events for a given hazard; from small consequence events, for which procedures or equipment may be acknowledged to provide adequate protection, to worst-case conditions.

4.1.2.4 Causes

A cause specifically states the failure, error, operational, and/or environmental condition that initiated the release event of the postulated event. Causes are synonymous with initiating events and therefore need to be clearly identified to support frequency evaluation. The Hazard Identification Tables are used as a guide in developing specific causes for release events.

4.1.2.5 Preventive Features

A preventive feature is any feature that could readily be expected to prevent the initiating event that causes the release of hazardous material to an unwanted location, thus reducing the frequency of the associated release event. The selection of such features is made without regard to any possible pedigree of the feature such as procurement level or functional classification. These might include engineered features (e.g. structures, systems, components, etc.), administrative controls (e.g. procedures, policies, programs, etc.), natural phenomena (e.g. ambient conditions, buoyancy, gravity, etc.), or inherent features (e.g. physical or chemical properties, location, elevation, etc.) operating individually or in combination. Preventive features are those that are generally assumed to be operable prior to an event and are not required to be operable during the event or post event. Note that features that prevent a release of the hazardous material, but do not prevent the initiating event are categorized as mitigative features.

Preventive features constitute a significant portion of Defense-in-Depth evaluation and they provide essential input to the Functional Classification task. Therefore, the identification effort captures essentially all of the possible features that could be counted on to prevent the initiating event that causes the release of the hazardous material to an unwanted location.

4.1.2.6 Initiating Event Frequency Level

Event frequency evaluation is a qualitative or quantitative process that involves assigning a frequency level to each initiating event in the Hazard Evaluation Tables. DOE-STD-3011-94 (Ref. 1) frequency levels and descriptions are summarized in Table 5. The HA team determines which qualitative frequency level is appropriate for a particular event. This determination is based on the event's root cause(s) and may be either qualitative or quantitative. Sources of frequency information include: generic initiator database (Ref. 7-10) and failure rate data (Ref. 11-12), and expert opinion including engineering judgment. The frequency level is recorded in the Hazard Evaluation Tables according to the lettering scheme in Table 5.

Uncertainties in frequency levels are accommodated by erring in the conservative direction from best-estimate values. Crediting a structure, system, component (SSC), or administrative control for its preventive properties is discouraged. Any preventive feature or assumption credited during consequence determination must be listed and highlighted in the Hazard Identification Tables for functional classification purposes.

4.1.2.7 Methods of Detection

Method of detection includes features that are designed to detect initiating events or subsequent event progression. These include alarms, monitors, indicators, and an operator's ability to recognize the events by visual observation or sound.

4.1.2.8 Mitigative Features

Mitigative features are any features that are readily expected to act to reduce the consequences associated with the release of hazardous material to an unwanted location for a particular event. The identification of such features is made without regard to any possible pedigree of the feature such as procurement level or functional classification. Mitigative features are those which are generally assumed to be operable during an event or post event, and are not required to be operating prior to the event initiation. Therefore, mitigative features must be capable of withstanding the environment of the event. These might include engineered features (e.g. structures, systems, components, etc.), administrative controls (e.g. procedures, policies, programs, etc.), natural phenomena (e.g. ambient conditions, buoyancy, gravity, etc.), or inherent features (e.g. physical or chemical properties, location, elevation, etc.) operating individually or in combination.

Mitigative features constitute a significant portion of Defense-in-Depth evaluation and they provide essential input to the Functional Classification task. Therefore, it is important that the identification effort capture essentially all of the possible features that could be counted on to reduce the consequences of a release of the hazardous material to an unwanted location.

4.1.2.9 Unmitigated Consequence Level

Event consequences are documented by specifying the impact on the receptors (described below) and the guideline used to assess the impact. Any potential impact of consequences on other systems is also documented in this column of the Hazard Evaluation Tables.

For HA purposes, consequences are defined as the dose or exposure at specified receptor locations based upon the unmitigated release of hazardous material. Consequences are a function of the type and characteristics of the hazard, the quantity released, the release

mechanism, relative location of the release, and any relevant material transport characteristics. Consequences are determined from: (1) simple source term calculations, (2) existing design documentation, and/or (3) qualitative or quantitative assessment. Unlike frequency levels, that cover two orders of magnitude, consequence levels sometimes span less than one order of magnitude. Thus, a more refined effort may be required by the HA team to determine the appropriate consequence level for a given event and receptor. Much like frequency evaluation, the HA team is encouraged to err in the conservative direction, especially for those events with consequences at the high end of a given level. Any other mitigative feature or assumption credited during consequence determination must be listed and highlighted in the Hazard Evaluation Tables.

Consequences are evaluated at various receptor locations to assess health and environmental effects of the postulated release. Tables 6 give the radiological and chemical consequence levels for the specified receptor locations. The following receptor locations are used to represent the populations of interest:

- Facility Worker (Facility) – An individual working inside one of the buildings in the D-Area
- Onsite Worker (Onsite) – An individual located 600 m away from the release point.
- Offsite Population (Offsite) – The maximally-exposed offsite individual located at the closest site boundary

When evaluating event consequences, credit may be taken for inventory controls limiting the amount of hazardous material in the facility, or facility section. Credit may also be taken for the ability of workers to react to obvious hazardous conditions and evacuate the scene of the accident. This of course invokes the assumptions that the workers are physically able to evacuate, and that an evacuation route is available during, or immediately following, the event. Crediting any other structure, system, component (SSC), or administrative control for its mitigative properties is discouraged. Any mitigative feature or assumption credited during consequence determination must be listed and highlighted in the Hazard Evaluation Tables for functional classification purposes. Other mitigative SSCs or administrative controls are listed in the Hazard Evaluation Tables for consideration during the functional classification process.

4.1.2.10 Scenario Class Level

The final step in the hazard evaluation process is to determine the scenario class for the postulated event. The determination of the scenario class prioritizes event scenarios for review or further analysis. The scenario classes are defined by the BIO guidance document (Ref. 1) as follows:

- Scenario Class I: Major
- Scenario Class II: Serious
- Scenario Class III: Marginal
- Scenario Class IV: Negligible

Scenario classes are identified based on the BIO guidance document. Scenario classes are associated with sectors of the risk matrix in a manner that prioritizes event scenarios for review or further analysis primarily in terms of the risk that they present. Scenario classes are identified and distinguished based on consequences to the offsite individual, onsite (600 meters) worker, and facility worker using the BIO guidance document. The scenario class for each postulated event is determined by locating the event on a risk

matrix based on the consequence level and frequency level of the event. The risk matrix, as defined by the BIO guidance document, is provided in Table 7.

5.0 RESULTS AND DISCUSSION

As discussed in Section 3.0, the PHA consists of two basic analytical activities: hazard identification and hazard evaluation. This section provides an in-depth discussion of the work performed to ensure completeness and compliance with the methodology presented in Section 4.0 and the BIO guidance document (Ref. 1).

5.1 HAZARD IDENTIFICATION

For this PHA, hazard identification consisted of developing a list of hazardous energy and material sources. Hazard identification activities include:

- In accordance with the BIO guidance document (Ref. 1), applicable safety documentation was reviewed and evaluated to identify the hazardous energy sources and hazardous material sources associated with the D-Area.
- Discussions with D-Area personnel were held, and information was incorporated into this evaluation in addition to the information gathered during the walkdown by the hazard analyst. This process was followed by facility reviews to ensure the accuracy and completeness of the hazard identification.

The results of these activities are documented in Appendix A, Table A-1, which identifies the hazardous energy sources and hazardous material sources applicable to the D-Area and its related outside facilities.

Division of Facility

The second step to ensure completeness of the identification of hazards is to provide details of the location of the hazardous energy sources and hazardous material. For purposes of PHA scenario development, the process is assessed using the following 5 Sections or segments per Ref. 15:

- 420-D (Rework Unit, DuPont Water Plant, Moderator Processing Facility, and 420-2D for Heavy Water Drum Storage)
- 421-2D (Technical Purification Facility and Heavy Water Drum Storage)
- 421-D (Heavy Water Drum Storage)
- 421-4D (Heavy Water Drum Storage)
- 772-D (Laboratory Facility)
- 420-6D (Chemical Storage)

These tables are then used to provide detailed locations of hazardous energy sources and hazardous material sources within D-Area during the hazard evaluation phase of the PHA.

5.2 HAZARD EVALUATION

The hazard evaluation was performed in accordance with the methodology provided in Section 4.1.2. This comprehensive evaluation identified events associated with

hazardous material and energy sources identified in the D-Area. The results of these activities are documented in Appendix B, Tables B-1 through B-5 (Hazard Evaluation Tables), which provide postulated events associated with the hazard sources and provide an evaluation of each event in terms of frequency and consequence. These tables which were developed in accordance with the methodology provided in Section 4.1.2 is the focal point of this PHA.

For each of these events, frequencies were estimated using the References 7 through 13, natural phenomena frequency data, or engineering judgement.

To determine the consequence level of each event, a qualitative (or semi-quantitative) assessment was performed. This assessment estimates potential radiological and hazardous chemical dose based on the amount of hazardous material released and subsequently become airborne. Potential radiological releases were estimated by determining Material-at-Risk, Damage Ratio, Leak Path Factor, Airborne Release Fraction and Respirable Fraction. As indicated in Section 3, a leak path factor of 1 and a respirable fraction of 1 were assumed to be bounding.

The scenario class for each postulated event is determined by locating the event on a risk matrix based on the consequence level and frequency level of the event. Table 7 provides the risk matrix, as defined by the PHA guidelines. Scenario classes are associated with sectors of the risk matrix in a manner that prioritizes event scenarios for review or further analysis primarily in terms of the risk that they present, with the consideration that scenarios in the low consequence sectors should represent no more than a marginal concern regardless of the frequency. Scenario classes are identified and distinguished based on consequences offsite, onsite, and to the facility worker using the PHA guidelines. The purpose of the hazard evaluation is to identify those significant events that require further evaluation for determination of risk acceptance. The events are identified based on their associated scenario classes as determined in accordance with Section 4.1.2.10.

The following sections provide a summary of events identified in Tables B-1 through B-4. Since the potential consequences due to the events postulated in the Laboratory (see Table B-5 in Appendix B) are insignificant for all receptors, an event summary for the 772-D Building is not provided in the following section.

The event scenario spectrum is divided into two main subgroups: naturally occurring phenomena and process phenomena. Each subgroup is then subdivided into actual event scenarios. The discussion for each of the following scenarios, along with estimates of their frequencies and consequences, are presented in this section.

The natural phenomena scenarios include the following:

- Straight Winds/Tornado
- Floods
- Earthquake
- Lightning
- Freezing Temperature
- Heavy snow and ice-induced building failure

The process phenomena include the following:

- Fire
- Explosion
- Loss of confinement/containment
- Direct exposure
- External event

5.2.1 Natural Phenomena

Source term calculations for the release from the RW Unit, B-12/B-25 Box, and aqueous release are presented below.

Heavy Water Release from RW Unit in 420-D Building

The RW Unit uses distillation process to purify heavy water. It has 6 distillation columns, 5 calandrias, and 5 condensers. The distillation columns employ a column pressure of 60 to 100 mm of mercury (absolute). Since some of the heavy water in the unit is in vapor phase and the systems are interconnected, release mechanism assumed for the event associated with the RW Unit is different from those assumed for drums. It is assumed that 100 % of RW inventory would be released for the events postulated in this hazards analysis, i.e., a damage ratio of 1. Furthermore, a higher airborne release fraction is assumed relative to the release from drums, mainly because the existence of heavy water vapor in the RW Unit. The airborne release fraction is estimated as follows:

1. Mass of heavy water in vapor phase is estimated based upon the volume of distillation column. This estimate is conservative since the volume occupied by water and internal structures was not reduced from the volume of distillation columns based on the outside dimensions.
2. Space for vapor in calandrias and condensers is much smaller than that in the distillation columns, however, it is assumed that the volume of vapor space in calandrias and condensers is the same as that of the distillation columns.
3. At 100 mm of absolute mercury (3.94 inches of Hg or 1.934 psia), the specific volume of heavy water vapor at saturation temperature of 128.5 deg F is 154 ft³/lb (Ref. 29). The operating temperature of the distillation column is lower than the saturation temperature, thus, this is conservative to use the specific volume of heavy water vapor at saturation temperature because this will produce a higher vapor concentration.
4. 11 Ci/liter is used conservatively even though more light water is in vapor phase than heavy water.
5. Heavy water density of 1.11 g/cc was used.

The total curie content in heavy water vapor inside the distillation columns is very insignificant (309 Ci as shown on the table below) relative to the potential curie content of 1,182,434 Ci of tritium in the RW Unit per Reference 19. This is about 0.026 % of the total tritium content in the RW Unit. Including the vapor in other parts of the RW Unit, the total tritium in vapor phase is assumed to be 0.052%.

Since heavy water in the RW Unit is heated, the airborne release fraction for the heavy water released in both vapor and liquid phases from the RW Unit is assumed to be 10% in a 2 hour duration. This is very conservative since it is physically improbable to evaporate additional 9.948% of heavy water in 2 hours from a standing pool of water.

Airborne release fractions of other radioisotopes in the heavy water is very negligible since those are not volatile or can not be easily airborne.

Thus, for this hazards evaluation, 10% airborne release fraction is used with a damage ratio of one for any type of release from the RW Unit even for the events that may accompany a fire or an explosion.

Distillation Column	4R	7R	30R	50R	70R	90R	Total
Diameter - ft	6	7.5	5	4	4	4	N/A
Height - ft	92	80	78	78	78	78	N/A
Volume - cu ft	2,600	3,533	1,531	980	980	980	10,602
Volume - liter	73,630	1,00,040	43,351	27,745	27,745	27,745	300,255
Mass of Heavy Water in Vapor Phase (lb)	16.9	22.9	9.9	6.4	6.4	6.4	69
Mass of Heavy Water in Vapor Phase (g)	7,658	10,406	4,509	2,887	2,887	2,887	31,228
Volume of Vapor when saturated (liter)	6.9	9.4	4.1	2.6	2.6	2.6	28
Curies	76	103	45	29	29	29	309

Release from B-25/B-12 Boxes

Resins and filters are taken out from the Moderator Processing Facility (MPF) and placed in a B-25 Box. Therefore, theoretically, these resin filters can not have more radionuclides than what is in the MPF. Maximum radiological inventory in MPF (Reference 2) is shown in Table 11. A fire in the B-25 Box may be anticipated and it can release all the radionuclide contents into the air. As shown in Table 11, a fire with a single resin can release $9.62\text{E-}03$ rem and $1.72\text{E-}02$ rem to Onsite and Offsite receptors, respectively, which are in the "Low" range. Therefore, this event is in Scenario Class III. Since this is the worst case scenario and the consequence is low, consequences from events caused by other initiating events (such as natural phenomena) are not specifically identified in the hazards evaluation table. In addition, these boxes are placed outside, impact on facility worker was not considered.

Surface/Ground Water Release

Many events postulated in this hazards evaluation involve release of heavy water to the ground. The aqueous doses from liquid spills from D-Area were presented in References 26 and 33. It was assumed that heavy water would be introduced instantaneously into the Savannah River. The entire contents of the spill from D-Area are assumed to reach the river. The dose-release factors (Rem/Ci) for the nuclides in the heavy water to the maximally exposed offsite individual who may consume water from the Savannah River are presented in Table 9 as "Aqueous DCFs". It is also postulated that the most significant spill is a spill of heavy water from all of the Process Capacity (i.e., inventory from 420-D) and half of the drum contents during an earthquake scenario. Thus, the 50-year Committed Effective Dose Equivalent to the impacted receptor from the aqueous release is 42 mrem, which is in the "Low" range. Therefore, the effects of aqueous release to offsite receptors during the various events are not covered per event basis in this hazards evaluation. Only exception to this is a natural phenomena event caused by freezing temperature where all drums and process systems may leak due to freezing and

thawing process. For this case the leak would be very slow. Current aqueous release dose calculation method is not affected by release rate. Thus, the 50-year Committed Effective Dose Equivalent to the impacted receptor from the aqueous release caused by freezing is 68 mrem, which is in the "Low" range.

In-Facility Worker Dose Calculation

The facility worker effective dose equivalent (EDE) rate, i.e., dose rate, from a postulated spill of contaminated heavy water was analyzed in Reference 32. The rate is 0.98 rem per minute which is based upon very conservative assumptions. In this hazards evaluation, facility worker consequence is assumed "Medium" based on the potential unmitigated consequence, i.e., the facility worker may not be able to recognize a slow leak and keep working an 8 hour shift. However, it is important to note that the ability of the facility workers to recognize obvious abnormal events such as fire or earthquake and to evacuate from the facility should be credited, thus, reducing the consequence from "Medium" to "Low".

Furthermore, the Radiation Monitoring System, which provides an alarm in case of a tritium leak inside the Buildings, adequately protects the facility workers who would have "Low" mitigated consequence.

5.2.1.1 Winds/Tornado

The D-Area buildings, primarily constructed of transite walls and roofs with steel frames, are not seismically qualified or hardened structures that can withstand the forces of high winds or tornadoes. Since these buildings and the heavy water processing units located outside were not designed to meet the DOE Natural Phenomena Performance Category 2, it is assumed that drums and the Distillation Towers would be damaged by tornadoes or straight winds with the frequency of occurrence in the "Unlikely" or "Extremely Unlikely" range. It is assumed that the total inventory from the RW (10% becomes airborne) and 1/2 of the drums (2% becomes airborne) would be released (See Event Number DA-19, DB-15, DC-12, and DD-11). Consequences for all these events are estimated to be "Low" for all three receptors. Scenario Classes for these events are all III.

The frequency of missiles striking during a tornado is assumed to be an order of magnitude less than the occurrence of the tornado itself, with damaging strikes even less likely (See Event Number, DA-20, DB-16, DC-13, and DD-12). Tornado induced missiles have been postulated to damage the drums, a separate type of accident quite apart from the wind damage. The missiles have the ability to actually penetrate the drums and small thickness of steel and concrete. However, only a very small number of drums would be impacted. Consequences for all these events are estimated to be "Low" for Offsite and Onsite receptors. However, Facility Worker consequence could be "Medium" if heavy water release is not recognized. Scenario Classes for these events are III or IV.

5.2.1.2 Floods

The D Area facilities are approximately 137 feet above mean sea level (msl). The maximum historical flow of the Savannah River of 360,000 cubic feet per second (cfs) corresponds to an approximate elevation of 118 feet above the msl at the Vogtle Electric Generation Plant (VEGP) directly across the river from the SRS. The probable maximum flood (PMF) for the Savannah River where Upper Three Runs Creek enters the river is approximately 1,001,000 cfs. This information is based upon Appendix B to the Nuclear Regulatory Commission Regulatory Guide 1.59 at the VEGP opposite the SRS, and

precludes consideration of the domino-type failure of upstream dams. The calculated PMF water level is 138.5 feet. The water level for the Savannah River was conservatively determined by the US Army Corp. of Engineers' HEC-2 computer program. The inclusion of a domino type failure of the dams that are up river from the Savannah River Site would lead to a peak flood elevation at VEGP of 141 feet above msl (Ref. 31).

Because D-Area is below the PMF level, it is assumed that flooding is in the "Unlikely" frequency range. However, since it is only 1.5 feet below the PMF level, none of the drums would be completely immersed in water. Also, most of heavy water is stored in sealed systems (stainless steel drums) it is very unlikely that the heavy water would be mixed with floods. As indicated in Section 5.2, the impact due to surface water release to the Savannah River is estimated to be in the "Low" consequence range for all three receptors. Scenario Classes for all flooding events are III.

5.2.1.3 Earthquake

It is assumed that the buildings in the D-Area would be damaged during an earthquake with intensity in the "Unlikely" frequency range. (See Event Number DA-22, DB-18, DC-15, and DD-14) The earthquake can cause drum movement and possibly drum rupture by drums vibrating off pallets. Pallets of drums will normally be stacked up to three high. All drums on the third level and 1/2 the drums on the second level are conservatively assumed to fail during the earthquake. For the Rework Unit, all inventories are assumed to be released and 10% of the inventories would be airborne in 2 hours.

It is also assumed that for the atmospheric release, the pool is subject to a conservative airborne release fraction of 2% in two hours. In case of an earthquake with a subsequent fire, a 4% airborne release fraction is assumed. As shown on Table 9, the Offsite and Onsite consequences due to a release from each building is "Low", i.e., less than 0.1 rem. For all these events, consequences are estimated to be "Low" for all three receptors and the Scenario Classes are all III.

5.2.1.4 Lightning

Lightning striking the facilities, such as the 420-D Building, is assumed to be in the "Anticipated" frequency range and has the potential for significant safety threats. In addition, it can cause an overload of electrical systems along with multiple fire ignitions. Lightning has also been known to spall concrete and create the potential of falling debris in areas of the building that are not heavily reinforced. Since the Distillation Towers can be struck by lightning, it was assumed that the total RW inventory would be released and 10% would become airborne. The consequence is bounded by that of the full building fire. For other storage buildings, damage would be limited to a few drums. Since there is a possibility that the Facility Worker may not be able to recognize the leak, consequence for the Facility Worker could be Medium and with the anticipated frequency, Scenario Class for the Facility Worker could be I. However, proper placement of Kanne monitors will reduce the facility worker's exposure to tritium. For this event, consequences are estimated to be "Low" for the onsite and offsite receptors and the Scenario Classes for all events are III.

5.2.1.5 Freezing Temperatures

With a heating system in the heavy water storage areas, the air temperature inside the buildings will stay above the freezing point of heavy water (3.8 deg C, 38.8 deg F). If the

heating system fails during cold weather, the heavy water may freeze and the drums could rupture; and when the heavy water melted, a radionuclide release would occur. (See Event Number DA-18, DB-14, DC-11, and DD-10). Because of the metal frame type construction of the buildings, there may not be adequate thermal inertia stored in the buildings to allow taking compensatory measures to prevent the heavy water from freezing upon loss of heating. This event is assumed to be in the "Anticipated" frequency range. It is assumed that the total inventory from the RW (2 % becomes airborne) and from all of the drums (2% becomes airborne) would be released. During a period with temperature lower than the freezing point of heavy water, an inspection of the heating system is recommended. Since there is a possibility that the Facility Worker may not be able to recognize the leak, consequence for the Facility Worker could be Medium and with the anticipated frequency, Scenario Class for the Facility Worker could be I. However, proper placement of Kanne monitors will reduce the facility worker's exposure to tritium.

5.2.1.6 Heavy Snow and Ice-Induced Building Failure

Due to the warm climate at the SRS, large accumulations of snow and ice (which could potentially collapse the roof) are quite rare (It is assumed to be in the "Unlikely" frequency range). It is also conservatively assumed that about 1/2 of the drums (2% becomes airborne) would be damaged due to building collapse. The consequence is bounded by that of earthquake.

5.2.2 **Process Phenomena**

5.2.2.1 Fire

All Buildings

Incipient fires can be put out with a hand held fire extinguisher and are limited to the room of origin. Process related fires or equipment fires are in this range. The frequency of the incipient fires is assumed to be in the "Anticipated" range. In addition, in the event of a fire, the extent of the fire will be small and localized due to the small amount of combustible materials. Thus, it is postulated that these small incipient fires would not be able to release heavy water that is contained in the primary containers, either in heavy water processing systems or in drums. Therefore, no release is postulated for these events.

The bounding fire is a full building fire, which is assumed to be in the "Unlikely" frequency range. Facility personnel must fail to detect the fire before it has progressed beyond the incipient stage and the automatic fire suppression systems, if there are any, must fail to control the fire to the room of origin.

420-D/420-2D Buildings

The danger of a full building fire is the possibility of breaching the primary heavy water containment. (Event Number DA-2 in Appendix B, Table B-1) Release of the heavy water would be in the forms of vapor and liquid from the RW and MPF. In addition to natural evaporation of spilled heavy water, which would be contained in the containment dike, there could be some additional evaporation due to fire. However, the intensity of the full building fire is limited since no combustible materials are permitted in or around these buildings except as permitted by the Transient Combustibles Control Program, operator procedures and training. In addition, due to the limited amount of combustible materials, the extent of the fire will be small and localized.

It is assumed that the complete heavy water inventory of RW and MPF would be released due to the full building fire and 10 % of the total inventory would become airborne in 2 hours. This high airborne release fraction was assumed to account for the facts that some of the heavy water is in vapor phase or near boiling point in the Distillation Towers and the Calandrias. However, 10% airborne release fraction is still conservative since the vapor inside the Distillation Towers will quickly condense when the Distillation Towers lose their vacuum.

The consequences due to the full building fire are estimated to be "Low" for Offsite (about 0.065rem) and Onsite (0.045 rem) receptors as shown in Table 9. The reason that the Offsite Receptor has a higher consequence than the Onsite Receptor is due to two reasons: (1) vapor plume rise and (2) proximity of the site boundary. The consequences for the Facility Worker are also estimated to be low.

421-D, 421-2D, and 421-4D Building

The probability of having a full building fires in these storage buildings (Event Numbers DB-2, DC-2, and DD-2 in Appendix B) is assumed to be in the "Unlikely" frequency range due to very low combustible loading. The intensity of the full building fires is limited since no combustible materials are permitted in or around these buildings except as permitted by the Transient Combustibles Control Program, operator procedures and training. However, there is one exception in Buildings 421-D and 421-6D, which store potassium permanganate in 5-gallon cans. Potassium Permanganate is in crystal form and is used to oxidize organic impurities in heavy water. It is not combustible but is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition.

It would be very difficult to release heavy water from the drums if there are not enough combustible materials to sustain a fire. In addition, any water that is released from the drums would extinguish the fire unless it is an oil/gasoline fire. Since oil and gasoline will float on water while they burn, the fire would not be able to boil water. However, it may be able to evaporate more water by thermal radiation if the fire is significant in terms of temperature and size. Based on this, it was assumed that about 1/2 of the drums lose their integrity and release heavy water to the floor where it is assumed that the heavy water is released from the building. It is also assumed that for the atmospheric release, the pool is subject to a conservative airborne release fraction of 4%.

From the total curie inventory value for each building shown on Table 2 and the Tritium Unit Dose value in Table 8, the consequences due to the full building fires are estimated to be "Low" for the Offsite and Onsite receptors. The Facility Worker will get the similar dose as indicated for the 420-D Building.

B-25 Storage

In B-12/B-25 storage areas, it is possible that electrical sparks or sparks from vehicles or vehicle fires could ignite waste in B-12 and B-25 boxes, causing a fire, but it is expected that these would not spread past the boxes. It is assumed that a fire in a B-25 is in the "Anticipated" frequency range.

The probability of a fire is limited because combustible materials are controlled in or around D-Area facilities. Combustible materials are only as permitted by the Transient Combustible Control Program required by Section 6.0. In addition, in the event of a fire due to the small amount of combustible materials, the extent of the fire is small and

localized. For this event, consequences are estimated to be "Low" for on-site and offsite receptors. Since these boxes are located outside, impact to the facility worker who are inside a building is not considered.

5.2.2.2 Explosion

Vehicles will be used periodically in the D-Area adding the possibility of explosions that could damage the heavy water processing units or drums and release radionuclides. For example, the delivery trucks and forklifts have fuel tanks and batteries. An explosion could cause a pressure wave strong enough to move the drums or generate missiles that can damage the heavy water processing units or drums. Compressed nitrogen gas bottles stored in the Compressor Room in Building 420-D can generate missiles that could damage the systems in the Compressor Room. However, potential damage that can be caused by the compressed gas bottle is limited. Batteries used in the forklift can explode, however, potential damage is limited. It is assumed that the power house is too distant from the heavy water facilities to cause any fire or other effect if the power house exploded.

This type of event is assumed to be in the "Anticipated" frequency range, except for vehicle explosions which are considered to be in the "Unlikely" frequency range. However, the damage that can be caused by the explosion is very limited.

Vehicles running into the buildings and the subsequent fire or explosion can cause significant damage. (See Event Number DA-13, DB-10, DC-7, and DD-6) An event where a vehicle runs into the RW and causes a gasoline fire/explosion is postulated in Event DA-13. It is assumed that total RW and MPF inventory is released and 10% of the inventory would become airborne as in the full building fire. Consequences are still "Low" for all three receptors.

For other buildings, it is conservatively assumed that 1/2 of the total building inventory would be released and 4% would become airborne as in the full building fires for 421-D, 421-2D, and 421-4D Buildings. Consequences are "Low" for all three receptors.

5.2.2.3 Loss of Containment/Confinement

Because forklift operations occur frequently in the building, the possibility of a forklift accident damaging a large number of drums and releasing some quantities of radionuclides is assumed to be in the "Anticipated" frequency range. It is postulated that no more than twelve drums would be damaged. The most likely forklift accidents would be to have a fork (or both forks) puncture one (or two) of the drum(s) or backing the forklift into a stack of drums, toppling up to twelve.

Another type of lift is used in the area that uses a pair of grabbers to hold 4 drums at a time on the side of the drums. Since it does not use forks to lift up drums there is lower frequency of poking and puncturing the drums. However, if too much force is exerted while drums are grabbed, drums can be crushed. The frequency of human errors such as these is assumed to be in the "Anticipated" frequency range. However, the number of drums damaged by these types of mishaps is not enough to be a major concern to the offsite receptor.

A forklift could back into the drums with sufficient force to move or potentially topple a stack of drums. Moving or toppling the drums could damage at most twelve drums. The damage is unlikely since the drums are normally banded together. In addition, only drums on second or third stack could be expected to fail if they fell.

If a drum were punctured by the forks or toppled and failed releasing the contents, it is conservatively assumed to spill its entire contents. The consequences of up to 12 drums releasing its entire contents can be estimated by using Table 8.

There could be other types of containment failure in the "Anticipated" frequency range, such as a leak or catastrophic failure of mechanical systems (considered "Unlikely") in the RW, leaks due to corrosion, drum handling error, etc. which can release heavy water. Since there is a possibility that the Facility Worker may not be able to recognize the leak, consequence for the Facility Worker could be Medium and with the anticipated frequency, Scenario Class for the Facility Worker could be I. Radiation monitoring is installed in the processing and storage areas will reduce the facility worker's exposure to tritium. The full building fires, which cause "Low" consequences, bound all these events.

5.2.2.4 Direct Exposure

Direct exposure events are in the "Anticipated" frequency range. Due to the low concentration of tritium in the heavy water, the dose received from a direct contact of heavy water would not cause a serious injury to the Facility Workers even though tritiated water can be absorbed through skin. Radiation monitoring is installed in the processing and storage areas and the areas where drums are handled to warn the Facility Workers.

5.2.2.5 External Events

Aircraft Hazard

Because the expected frequency of an airplane crash into the D-Area is below $1 \times 10^{-6}/\text{yr}$, this event is considered to be in the "Beyond Extremely Unlikely" frequency range.

Vehicle Collision into Buildings

See Section 5.2.2.2.

5.2.3 Hazardous Chemical Release Consequences

As identified in Section 2.2, there are no significant quantities of hazardous chemicals in the D-Area Heavy Water Facilities except Potassium Permanganate (KMnO_4) in Buildings 421-D and 421-6D, which exceed the CERCLA Reportable Quantity (RQ) per 40CFR302.4. Potassium Permanganate is stored in crystal form and is used to oxidize organic impurities in heavy water. It is not combustible but is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition (Ref. 27). It is harmful if swallowed and it can cause severe skin irritation. Since it is in a crystal form with a density of 2.7 g/cc and stored in a 5-gallon can, it can not easily become airborne and transportable. Thus, it is concluded that Potassium Permanganate can cause "Low" consequences to the facility workers whose skin may have contacted with the chemical.

A chemical incompatibility study has been performed to identify hazardous conditions that may be created due to potential mixing of two chemicals located in the same room. The study is presented in Tables 12 – 16. The chemical stored in bulk includes some incompatible acids, caustics, and oxidizers. Compliance with RDP 14.01, Spent Fuel Storage Chemical Management Program, operating procedures and Material Safety Data Sheets prevents the mixing of incompatible chemicals.

6.0 CONCLUSION

A comprehensive review of hazards associated with these areas was performed to identify postulated accident scenarios. To determine the risk of accidents, a Preliminary Hazards Analysis (PHA) was performed. The only significant accident scenarios identified were from radionuclide (tritium from the heavy water) released from damaged drums or the heavy water processing units. The release possibility stems from the energetic events, such as earthquakes, fire, forklift accidents, and drum mishandling events potentially leaking the heavy water out of the drums. None of the events resulted in consequence higher than Low for the onsite evaluation point, maximum offsite individual or the environment based upon the conservative event scenarios. A few events resulted in unmitigated medium consequences to facility worker with an anticipated frequency, i.e., Scenario Class of I. This is based upon the assumption that the Facility Worker may not be able to recognize a leak of heavy water in a building. However, the Radiation Monitoring System, which provides an alarm in case of a tritium leak inside the Buildings, protects the Facility Worker.

There would be no significant impact from the heavy water being spilled into the groundwater or Savannah River. There is no significant concern from hazardous chemicals.

Appendix B identifies the postulated natural and process events, resultant hazard event frequencies, the consequences, and the classification of the accident scenario based upon Reference 1.

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Table 1. Radionuclide Inventory Other than Tritium in Heavy Water (Ref. 18)

Radionuclide	Ci/Gallon	Ci/liter
Cs-137	6.14E-07	1.62E-07
Sm-151	1.15E-08	3.04E-09
I-129	1.08E-13	2.85E-14
Nb-94	1.11E-13	2.93E-14
Sr-90	9.60E-07	2.54E-07
Pu-238	1.29E-05	3.41E-06
Pu-239	5.38E-06	1.42E-06
Cm-242	2.15E-06	5.68E-07
Cm-244	1.06E-06	2.80E-07

Table 2. D-Area Tritium Inventory (Ref. 19)

Building	Drum/Process Capacity	Total (Curies)
420-D	28,400 gallons	1,182,434
420-2D	550 gallons	22,899
421-D	1,567 drums	1,631,051
421-2D	694 drums	722,368
421-4D	883 drums	919,093
772-D	N/A	16,000
Other	192 drums	439,666

(It was assumed that there are 55 gallons of heavy water in each drum.)

Table 3. 772-D Radionuclide Inventory

Radionuclide	Inventory (Curies)
Ba-140	5.31E-02
Ce-141	4.50E-03
Ce-143	3.41E-02
Co-58	1.85E-04
Co-60	8.78E-04
Cr-51	7.07E-03
Fe-59	2.89E-04
H-3	1.44E+04
I-131	3.68E-03
Na-24	5.82E+00
Nb-95	4.38E-03
Np-239	7.68E-01
P-32	8.03E-03
Pu-239	1.31E-06
S-35	6.73E-03
Sr-91	2.54E-01
Sr-92	2.54E-01
Zr-95	4.38E-03

Table 4. D-Area Fissile Material (Pu-239) Inventory

Location	Activity (Curies)	Mass * (Grams)
421-D	0.47	7.5
421-2D	0.21	3.3
421-4D	0.26	4.2
Other	0.06	0.9
Total	1.00	15.9

Curie amount was converted to gram amount using the specific activity of Pu-239, 6.21E-02 Ci/g.

Table 5. Frequency Qualitative Rating Levels (Ref. 1)

Code	Description	Estimated Annual Frequency of Occurrence
A	Anticipated: Incidents that may occur several times during the lifetime of the facility.	$F > 10^{-2}$
U	Unlikely: Events that are not anticipated to occur during the lifetime of the facility.	$10^{-2} \geq F > 10^{-4}$
EU	Extremely Unlikely: Events that will probably not occur during the life cycle of the facility. This class includes the design basis accidents.	$10^{-4} \geq F > 10^{-6}$
BEU	Beyond Extremely Unlikely: All other events.	$10^{-6} \geq F$

Table 6. Event Consequence Levels (Ref. 1)

Consequence Level	Type	Offsite	Onsite (600 meters)	Facility Worker
High	Radiological	> 5 rem at site boundary	>25 rem at 600 meters	Potential for prompt death
	Chemical	>ERPG-2 at site boundary	>ERPG-3 at 600 meters	Potential for prompt death
Medium	Radiological	> 0.1 rem at site boundary	>0.5 rem at 600 meters	Potential for serious injury
	Chemical	Not applicable	Not applicable	Potential for serious injury
Low	Radiological	< Medium	< Medium	< Medium
	Chemical	< High	< High	< Medium

Table 7. PHA Risk Matrix – Consequence versus Frequency (Ref. 1)

Frequency Level	Consequence Level		
	Low	Medium	High
Anticipated	III	I	I
Unlikely	III	II	I
Extremely Unlikely	IV	III	II

For the purposes of this PHA, all events that are determined to have a frequency level of “beyond extremely unlikely” will be assigned a consequence level and scenario class of “N/A”.

Table 8. Dose to Onsite and Offsite Receptors due to 1 Curie of the Radioisotope Released (Ref. 26)

Radionuclide	Onsite Dose (Rem/Ci) (Unit curie released in 2 hour duration)	Offsite Dose (Rem/Ci) (Unit curie released in 2 hour duration)
H-3	3.66E-07	5.24E-07
Cs-137	1.28E-04	2.01E-04
Sm-151	1.03E-04	1.99E-04
I-129	6.83E-04	1.00E-03
Nb-94	1.41E-03	2.75E-03
Sr-90	8.27E-04	1.41E-03
Pu-238	1.02E+00	1.99E+00
Pu-239	1.19E+00	1.99E+00
Cm-242	6.83E-02	1.00E-01
Cm-244	9.74E-01	1.54E+00
Ba-140	1.42E-05	2.92E-05
Ce-141	3.63E-05	5.07E-05
Ce-143	1.34E-05	2.03E-05
Co-58	4.92E-05	9.27E-05
Co-60	8.24E-04	1.24E-03
Cr-51	1.47E-06	2.92E-06
Fe-59	5.83E-05	1.00E-04
I-131	1.28E-04	2.01E-04
Na-24	1.42E-05	2.16E-05
Nb-95	2.93E-05	5.02E-05
Np-239	9.79E-06	1.99E-05
P-32	2.34E-05	3.18E-05
S-35	1.14E-06	1.99E-06
Sr-91	5.78E-06	9.76E-06
Sr-92	3.85E-06	6.84E-06
Zr-95	6.84E-05	1.01E-04

(Isotopes in bold letters are contained in heavy water.)

The reason that the Offsite Receptor has a higher dose than the Onsite Receptor is due to two reasons: (1) Vapor plume rise and (2) Proximity of the site boundary.

Table 9. D-Area Heavy Water Dose Calculations

Building 420-D

Volume of Heavy Water =

109576 liter

28950 gallons

Radionuclide	Ci/liter	DCF(rem/Ci) Onsite	DCF(rem/Ci) Offsite	Ci Content Ci	DR	ARF	Dose (Rem) Onsite	Dose (Rem) Offsite	DCF(rem/Ci) Aqueous	Aqu. Dose (Rem)
H-3	11	3.66E-07	5.24E-07	1.21E+06	1.0	0.10	4.41E-02	6.32E-02	1.30E-08	1.57E-02
Cs-137	1.62E-07	1.28E-04	2.01E-04	1.78E-02	1.0	1.00	2.27E-06	3.57E-06	1.00E-05	1.78E-07
Sm-151	3.04E-09	1.03E-04	1.99E-04	3.33E-04	1.0	1.00	3.43E-08	6.63E-08	7.10E-08	2.37E-11
I-129	2.85E-14	6.83E-04	1.00E-03	3.12E-09	1.0	1.00	2.13E-12	3.12E-12	5.90E-05	1.84E-13
Nb-94	2.93E-14	1.41E-03	2.75E-03	3.21E-09	1.0	1.00	4.53E-12	8.83E-12	1.10E-06	3.53E-15
Sr-90	2.54E-07	8.27E-04	1.41E-03	2.78E-02	1.0	1.00	2.30E-05	3.92E-05	2.70E-05	7.51E-07
Pu-238	3.41E-06	1.02E+00	1.99E+00	3.74E-01	1.0	1.80E-03	6.86E-04	1.34E-03	8.00E-04	2.99E-04
Pu-239	1.42E-06	1.19E+00	1.99E+00	1.56E-01	1.0	1.80E-03	3.33E-04	5.57E-04	9.00E-04	1.40E-04
Cm-242	5.68E-07	6.83E-02	1.00E-01	6.22E-02	1.0	1.80E-03	7.65E-06	1.12E-05	2.30E-05	1.43E-06
Cm-244	2.80E-07	9.74E-01	1.54E+00	3.07E-02	1.0	1.80E-03	5.38E-05	8.50E-05	4.80E-04	1.47E-05
Total	N/A	N/A	N/A	N/A	N/A	N/A	4.52E-02	6.52E-02	N/A	1.61E-02

ARF for Pu is taken from Table 3-2, Page 3-14 of Reference 30 for ARF during heating of pools of plutonium nitrate solution. Since Cm is also a heavy metal, the same ARF as Pu is assumed.

ARF for other nuclides except Tritium, Pu and Cm are assumed to be 1 to be conservative.

Dose (Offsite) = Ci Content * DR * ARF * Offsite DCF

Aqueous dose = Ci Content * DR * Aqueous DCF

Table 9. D-Area Heavy Water Dose Calculations (Continued)

Building 421-D Volume of Heavy Water = 326211 liter 86185 gallons 1567 drums

Radionuclide	Ci/liter	DCF(rem/Ci) Onsite	DCF(rem/Ci) Offsite	Ci Content Ci	DR	ARF	Dose (Rem) Onsite	Dose (Rem) Offsite	DCF(rem/Ci) Aqueous	Aqu. Dose (Rem)
H-3	5	3.66E-07	5.24E-07	1.63E+06	0.50	0.02	5.97E-03	8.55E-03	1.30E-08	1.06E-02
Cs-137	1.62E-07	1.28E-04	2.01E-04	5.28E-02	0.50	1.00	3.38E-06	5.31E-06	1.00E-05	2.64E-07
Sm-151	3.04E-09	1.03E-04	1.99E-04	9.92E-04	0.50	1.00	5.11E-08	9.87E-08	7.10E-08	3.52E-11
I-129	2.85E-14	6.83E-04	1.00E-03	9.30E-09	0.50	1.00	3.17E-12	4.65E-12	5.90E-05	2.74E-13
Nb-94	2.93E-14	1.41E-03	2.75E-03	9.56E-09	0.50	1.00	6.74E-12	1.31E-11	1.10E-06	5.26E-15
Sr-90	2.54E-07	8.27E-04	1.41E-03	8.29E-02	0.50	1.00	3.43E-05	5.84E-05	2.70E-05	1.12E-06
Pu-238	3.41E-06	1.02E+00	1.99E+00	1.11E+00	0.50	1.80E-03	1.02E-03	1.99E-03	8.00E-04	4.45E-04
Pu-239	1.42E-06	1.19E+00	1.99E+00	4.63E-01	0.50	1.80E-03	4.96E-04	8.30E-04	9.00E-04	2.08E-04
Cm-242	5.68E-07	6.83E-02	1.00E-01	1.85E-01	0.50	1.80E-03	1.14E-05	1.67E-05	2.30E-05	2.13E-06
Cm-244	2.80E-07	9.74E-01	1.54E+00	9.13E-02	0.50	1.80E-03	8.01E-05	1.27E-04	4.80E-04	2.19E-05
Total	N/A	N/A	N/A	N/A	N/A	N/A	7.62E-03	1.16E-02	N/A	1.13E-02

ARF for Pu is taken from Table 3-2, Page 3-14 of Reference 30 for ARF during heating of pools of plutonium nitrate solution. Since Cm is also a heavy metal, the same ARF as Pu is assumed.

ARF for other nuclides except Tritium, Pu and Cm are assumed to be 1 to be conservative.

Dose (Offsite) = Ci Content * DR * ARF * Offsite DCF

Aqueous dose = Ci Content * DR * Aqueous DCF

Table 9. D-Area Heavy Water Dose Calculations (Continued)

Building 421-2D Volume of Heavy Water = 144474 liter 38170 gallons 694 drums

Radionuclide	Ci/liter	DCF(rem/Ci) Onsite	DCF(rem/Ci) Offsite	Ci Content Ci	DR	ARF	Dose (Rem) Onsite	Dose (Rem) Offsite	DCF(rem/Ci) Aqueous	Aqu. Dose (Rem)
H-3	5	3.66E-07	5.24E-07	7.22E+05	0.50	0.02	2.64E-03	3.79E-03	1.30E-08	4.70E-03
Cs-137	1.62E-07	1.28E-04	2.01E-04	2.34E-02	0.50	1.00	1.50E-06	2.35E-06	1.00E-05	1.17E-07
Sm-151	3.04E-09	1.03E-04	1.99E-04	4.39E-04	0.50	1.00	2.26E-08	4.37E-08	7.10E-08	1.56E-11
I-129	2.85E-14	6.83E-04	1.00E-03	4.12E-09	0.50	1.00	1.41E-12	2.06E-12	5.90E-05	1.21E-13
Nb-94	2.93E-14	1.41E-03	2.75E-03	4.23E-09	0.50	1.00	2.98E-12	5.82E-12	1.10E-06	2.33E-15
Sr-90	2.54E-07	8.27E-04	1.41E-03	3.67E-02	0.50	1.00	1.52E-05	2.59E-05	2.70E-05	4.95E-07
Pu-238	3.41E-06	1.02E+00	1.99E+00	4.93E-01	0.50	1.80E-03	4.52E-04	8.82E-04	8.00E-04	1.97E-04
Pu-239	1.42E-06	1.19E+00	1.99E+00	2.05E-01	0.50	1.80E-03	2.20E-04	3.67E-04	9.00E-04	9.23E-05
Cm-242	5.68E-07	6.83E-02	1.00E-01	8.21E-02	0.50	1.80E-03	5.04E-06	7.39E-06	2.30E-05	9.44E-07
Cm-244	2.80E-07	9.74E-01	1.54E+00	4.05E-02	0.50	1.80E-03	3.55E-05	5.61E-05	4.80E-04	9.71E-06
Total	N/A	N/A	N/A	N/A	N/A	N/A	3.37E-03	5.13E-03	N/A	5.00E-03

ARF for Pu is taken from Table 3-2, Page 3-14 of Reference 30 for ARF during heating of pools of plutonium nitrate solution. Since Cm is also a heavy metal, the same ARF as Pu is assumed.

ARF for other nuclides except Tritium, Pu and Cm are assumed to be 1 to be conservative.

Dose (Offsite) = Ci Content * DR * ARF * Offsite DCF

Aqueous dose = Ci Content * DR * Aqueous DCF

Table 9. D-Area Heavy Water Dose Calculations (Continued)

Building 421-4D Volume of Heavy Water = 183819 liter 48565 gallons 883 drums

Radionuclide	Ci/liter	DCF(rem/Ci) Onsite	DCF(rem/Ci) Offsite	Ci Content Ci	DR	ARF	Dose (Rem) Onsite	Dose (Rem) Offsite	DCF(rem/Ci) Aqueous	Aqu. Dose (Rem)
H-3	5	3.66E-07	5.24E-07	9.19E+05	0.50	0.02	3.36E-03	4.82E-03	1.30E-08	5.97E-03
Cs-137	1.62E-07	1.28E-04	2.01E-04	2.98E-02	0.50	1.00	1.91E-06	2.99E-06	1.00E-05	1.49E-07
Sm-151	3.04E-09	1.03E-04	1.99E-04	5.59E-04	0.50	1.00	2.88E-08	5.56E-08	7.10E-08	1.98E-11
I-129	2.85E-14	6.83E-04	1.00E-03	5.24E-09	0.50	1.00	1.79E-12	2.62E-12	5.90E-05	1.55E-13
Nb-94	2.93E-14	1.41E-03	2.75E-03	5.39E-09	0.50	1.00	3.80E-12	7.41E-12	1.10E-06	2.96E-15
Sr-90	2.54E-07	8.27E-04	1.41E-03	4.67E-02	0.50	1.00	1.93E-05	3.29E-05	2.70E-05	6.30E-07
Pu-238	3.41E-06	1.02E+00	1.99E+00	6.27E-01	0.50	1.80E-03	5.75E-04	1.12E-03	8.00E-04	2.51E-04
Pu-239	1.42E-06	1.19E+00	1.99E+00	2.61E-01	0.50	1.80E-03	2.80E-04	4.67E-04	9.00E-04	1.17E-04
Cm-242	5.68E-07	6.83E-02	1.00E-01	1.04E-01	0.50	1.80E-03	6.42E-06	9.40E-06	2.30E-05	1.20E-06
Cm-244	2.80E-07	9.74E-01	1.54E+00	5.15E-02	0.50	1.80E-03	4.51E-05	7.13E-05	4.80E-04	1.24E-05
Total	N/A	N/A	N/A	N/A	N/A	N/A	4.29E-03	6.52E-03	N/A	6.36E-03

ARF for Pu is taken from Table 3-2, Page 3-14 of Reference 30 for ARF during heating of pools of plutonium nitrate solution. Since Cm is also a heavy metal, the same ARF as Pu is assumed.

ARF for other nuclides except Tritium, Pu and Cm are assumed to be 1 to be conservative.

Dose (Offsite) = Ci Content * DR * ARF * Offsite DCF

Aqueous dose = Ci Content * DR * Aqueous DCF

Table 9. D-Area Heavy Water Dose Calculations (Continued)

Other (192 Drums) Volume of Heavy Water = 39970 liter 10560 gallons 192 drums

Radionuclide	Ci/liter	DCF(rem/Ci) Onsite	DCF(rem/Ci) Offsite	Ci Content Ci	DR	ARF	Dose (Rem) Onsite	Dose (Rem) Offsite	DCF(rem/Ci) Aqueous	Aqu. Dose (Rem)
H-3	11	3.66E-07	5.24E-07	4.40E+05	0.50	0.02	1.61E-03	2.30E-03	1.30E-08	2.86E-03
Cs-137	1.62E-07	1.28E-04	2.01E-04	6.48E-03	0.50	1.00	4.14E-07	6.51E-07	1.00E-05	3.24E-08
Sm-151	3.04E-09	1.03E-04	1.99E-04	1.22E-04	0.50	1.00	6.26E-09	1.21E-08	7.10E-08	4.31E-12
I-129	2.85E-14	6.83E-04	1.00E-03	1.14E-09	0.50	1.00	3.89E-13	5.70E-13	5.90E-05	3.36E-14
Nb-94	2.93E-14	1.41E-03	2.75E-03	1.17E-09	0.50	1.00	8.26E-13	1.61E-12	1.10E-06	6.44E-16
Sr-90	2.54E-07	8.27E-04	1.41E-03	1.02E-02	0.50	1.00	4.20E-06	7.16E-06	2.70E-05	1.37E-07
Pu-238	3.41E-06	1.02E+00	1.99E+00	1.36E-01	0.50	1.80E-03	1.25E-04	2.44E-04	8.00E-04	5.45E-05
Pu-239	1.42E-06	1.19E+00	1.99E+00	5.68E-02	0.50	1.80E-03	6.08E-05	1.02E-04	9.00E-04	2.55E-05
Cm-242	5.68E-07	6.83E-02	1.00E-01	2.27E-02	0.50	1.80E-03	1.40E-06	2.04E-06	2.30E-05	2.61E-07
Cm-244	2.80E-07	9.74E-01	1.54E+00	1.12E-02	0.50	1.80E-03	9.81E-06	1.55E-05	4.80E-04	2.69E-06
Total	N/A	N/A	N/A	N/A	N/A	N/A	1.81E-03	2.68E-03	N/A	2.94E-03

ARF for Pu is taken from Table 3-2, Page 3-14 of Reference 30 for ARF during heating of pools of plutonium nitrate solution. Since Cm is also a heavy metal, the same ARF as Pu is assumed.

ARF for other nuclides except Tritium, Pu and Cm are assumed to be 1 to be conservative.

Dose (Offsite) = Ci Content * DR * ARF * Offsite DCF

Aqueous dose = Ci Content * DR * Aqueous DCF

Table 10. Onsite and Offsite Dose Contributions from the Radionuclides Inventory in 772-D

Radionuclide	Onsite Unit Dose (rem/Ci)	Offsite Unit Dose (rem/Ci)	Inventory (Ci)	Onsite Dose (rem)	Offsite Dose (rem)
H-3	2.41E-07	3.15E-07	1.44E+04	3.47E-03	4.54E-03
Ba-140	1.42E-05	2.92E-05	5.31E-02	7.54E-07	1.55E-06
Ce-141	3.63E-05	5.07E-05	4.50E-03	1.63E-07	2.28E-07
Ce-143	1.34E-05	2.03E-05	3.41E-02	4.57E-07	6.92E-07
Co-58	4.92E-05	9.27E-05	1.85E-04	9.10E-09	1.71E-08
Co-60	8.24E-04	1.24E-03	8.78E-04	7.23E-07	1.09E-06
Cr-51	1.47E-06	2.92E-06	7.07E-03	1.04E-08	2.06E-08
Fe-59	5.83E-05	1.00E-04	2.89E-04	1.68E-08	2.89E-08
I-131	1.28E-04	2.01E-04	3.68E-03	4.71E-07	7.40E-07
Na-24	1.42E-05	2.16E-05	5.82E+00	8.26E-05	1.26E-04
Nb-95	2.93E-05	5.02E-05	4.38E-03	1.28E-07	2.20E-07
Np-239	9.79E-06	1.99E-05	7.68E-01	7.52E-06	1.53E-05
P-32	2.34E-05	3.18E-05	8.03E-03	1.88E-07	2.55E-07
Pu-239	1.19E+00	1.99E+00	1.31E-06	1.56E-06	2.61E-06
S-35	1.14E-06	1.99E-06	6.73E-03	7.67E-09	1.34E-08
Sr-91	5.78E-06	9.76E-06	2.54E-01	1.47E-06	2.48E-06
Sr-92	3.85E-06	6.84E-06	2.54E-01	9.78E-07	1.74E-06
Zr-95	6.84E-05	1.01E-04	4.38E-03	3.00E-07	4.42E-07
Total	N/A	N/A	N/A	3.57E-03	4.69E-03

Table 11. Moderator Processing Facility Radiological Inventory (Used to estimate radiological inventory in B-25 Box that contains the resin and filters.)

Impurity	Total Curies	DCF ⁺ (Onsite) (Rem/Ci)	DCF (Offsite) (Rem/Ci)	Dose (Onsite) (Rem)	Dose (Offsite) (Rem)
H-3*	3.50E+03	3.66E-07	5.24E-07	1.28E-03	1.83E-03
Cs-137	2.46E-04	1.28E-04	2.01E-04	3.15E-08	4.94E-08
Sm-151	4.60E-06	1.03E-04	1.99E-04	4.74E-10	9.15E-10
I-129	4.32E-11	6.83E-04	1.00E-03	2.95E-14	4.32E-14
Nb-94	4.44E-11	1.41E-03	2.75E-03	6.26E-14	1.22E-13
Sr-90	3.80E-04	8.27E-04	1.41E-03	3.14E-07	5.36E-07
Pu-238	5.20E-03	1.02E+00	1.99E+00	5.30E-03	1.03E-02
Pu-239	2.15E-03	1.19E+00	1.99E+00	2.56E-03	4.28E-03
Cm-242	8.60E-04	6.83E-02	1.00E-01	5.87E-05	8.60E-05
Cm-244	4.30E-04	9.74E-01	1.54E+00	4.19E-04	6.62E-04
Total	N/A	N/A	N/A	9.62E-03	1.72E-02

Note: + DCF- Dose Conversion Factor

* The maximum tritium content in B-25 box, 3,500 Ci is specified in Reference 28.
Damage Ratio and ARF are assumed to be 1.

Table 12. 420-D Compressor Room Chemical Incompatibility Study

Chemical	Chemical				
		FREON 22	Duoseal Vacuum Pump Oil	Fel-Pro C-100 Antiseize Compound	Fel-Pro C5-A High Temp. Antiseize Compound Bulk
					Methanol
FREON 22				X	X
Duoseal Vacuum Pump Oil					
Fel-Pro C-100 Antiseize Compound					X
Fel-Pro C5-A High Temp. Antiseize Compound Bulk					X
Methanol					

Note: X indicates that there is a chemical incompatibility exists between two chemicals.
 (Some of the common chemicals were screened out from the study.)

Table 13. 421-2D RBA Chemical Incompatibility Study

Chemical	Chemical	Savogran Supersrip Paint & Varnish Remover	GSA Mil-A-907E Anti-Seize Lubricant	HD-927	Lectron 13 Aerosol	Nitric Acid	Sodium Hydroxide Solutions 0.02N - 1N	Sodium Phosphate Tribasic Dodecahydrate
Savogran Supersrip Paint & Varnish Remover					X	X	X	X
GSA Mil-A-907E Anti-Seize Lubricant								
HD-927								
Lectron 13 Aerosol							X	X
Nitric Acid							X	X
Sodium Hydroxide Solutions 0.02N - 1N								
Sodium Phosphate Tribasic Dodecahydrate								

Note: X indicates that there is a chemical incompatibility exists between two chemicals.

(Some of the common chemicals were screened out from the study.)

Table 14. 772-D Building, Room 118 Chemical Incompatibility Study

Chemical	Chemical	Alconox	Conductivity Standard - 10 micromhos/ cm	Custom Plasma Standard-Multi-Element Solution	Ecolite(+)	Hydrochloric Acid	Hydroxylamine Hydrochloride	Nitric Acid	Oxalic Acid Dihydrate	Potassium Chloride	Potassium Persulfate	Silicon Carbide	Sodium Bicarbonate	Sodium Chloride	Sodium Hydroxide	Sodium Nitrate	Sodium Nitrite	Sulfuric Acid
Alconox						X	X	X	X							X	X	X
Conductivity Standard- 10 micromhos/ cm																		
Custom Plasma Standard-Multi-Element Solution																		
Ecolite(+)								X			X					X	X	
Hydrochloric Acid											X	X	X		X	X	X	X
Hydroxylamine Hydrochloride								X			X		X		X	X	X	X
Nitric Acid											X		X	X	X	X	X	X
Oxalic Acid Dihydrate											X		X		X	X	X	X
Potassium Chloride																		
Potassium Persulfate													X	X	X	X	X	X
Silicon Carbide															X	X	X	X
Sodium Bicarbonate																		X
Sodium Chloride																X	X	X
Sodium Hydroxide. 50%																		X
Sodium Nitrate																		X
Sodium Nitrite																		X
Sulfuric Acid																		

Note: X indicates that there is a chemical incompatibility exists between two chemicals.

(Some of the common chemicals were screened out from the study.)

Table 15. 772-D Building, Room 118A Chemical Incompatibility Study

Chemical	Chemical					
		Deuterium Oxide	Glycerin	Triethylene glycol		
Deuterium Oxide						
Glycerin						
Triethylene glycol						

Note: X indicates that there is a chemical incompatibility exists between two chemicals.
 (Some of the common chemicals were screened out from the study.)

Table 16. 772-D Building, Room 121 Chemical Incompatibility Study

Chemical	Chemical	Deuterium Oxide	Flon S-316 Halocarbon	Nitric Acid	Oxalic Acid Dihydrate	Potassium Permanganate Solution 0.1N	Tributyl Phosphate
Deuterium Oxide							X
Flon S-316 Halocarbon				X			
Nitric Acid					X		
Oxalic Acid Dihydrate						X	
Potassium Permanganate Solution 0.1N							X
Tributyl Phosphate							

Note: X indicates that there is a chemical incompatibility exists between two chemicals per MSDS.

(Some of the common chemicals were screened out from the study.)

Figure 1. Location of D-Area

Figure 2. Heavy Water Processing Facility (D-Area)

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APPENDIX A HAZARD IDENTIFICATION TABLE

Table A-1. D-Area Hazard Identification Table
Hazard Energy Sources, Materials, and Their Locations
(1 of 3)

Location (identifier for system, sub-system, or operational feature in this facility section)	Hazard Energy Sources and Materials																							
	Electrical												Thermal						Friction					
	Battery Banks (BB)												Bunsen Burner, Hot Plate (BR)											
	Cable Runs (CB)												Electrical Equipment (EE)											
	Diesel Units (DU)												Furnaces (FR)											
	Electrical Equipment (EE)												Heaters (HT)											
	Hot Plates (HP)												Steam Lines (SL)											
	Heaters (HT)												High Heat Source (HH)											
	High Voltage (HV)												Welding Torch (WT)											
	Locomotive, electrical (LE)												Exothermic Reactions (ER)											
	Motors (MT)												Other											
	Pumps (PM)												Belts (BL)											
	Power Tools (PT)												Bearings ((BR)											
	Switchgear (SG)												Fans (FN)											
	Service outlets, fittings (SO)												Gears (GE)											
	Transformers (TF)												Motors (MT)											
	Transmission Lines (TL)												Power Tools (PT)											
	Underground Wiring (UW)												Other											
	Wiring (WR)																							
	Other																							
420-D/RU				X	X					X	X										X	X		
420-D/DW				X	X					X	X									X	X			
420-D/MPF				X	X					X	X									X	X			
420-2D (Drum Storage)				X	X					X	X											X	X	
421-2D (TPF and Drum Storage)				X						X	X									X	X			
421-D (Drum Storage)																								
421-4D (Drum Storage)																								
772-D (Laboratory)				X	X					X	X									X	X			
421-6D				X						X														

X = Refers to the hazards considered applicable

FOOTNOTES:

- 1) 55 psig steam supply system that provides heat to the Calandrias and heat tracing for Distillation system located outside.
- 2) Refrigerant
- 12) Battery charger for the batteries for drum handlers/fork lifts

- X = Refers to the hazards considered applicable
- FOOTNOTES:
 - * SC = SPONTANEOUS COMBUSTION
 - 3) Oil collected
 - 4) Vacuum
 - 5) Flammables in steel cabinet
 - 6) Nitrogen compressed gas bottles in compressor Room

Table A-1. D-Area Hazard Identification Table
Hazard Energy Sources, Materials, and Their Locations
(3 of 3)

Location (identifier for system, sub-system, or operational feature in this facility section)	Hazard Energy Sources and Materials																																	
	Radioactive Material (RM)	Fissile Material (FM)	Non-Ionizing Radiation (NI)	Ionizing Rad.			Hazardous Materials							Natural Phenomena							Vehicles in Motion													
				Accelerator Beam (AB)	Radiography Equipment (RE)	Radioactive Materials (RM)	Radioactive Sources (RS)	Other	Alkali Metals (AM)	Asphyxiants (AS)	Biologicals (BI)	Carcinogens (CA)	Oxidizers (OX)	Corrosives (CO)	Toxics (TX)	Other	Earthquake (EQ)	Flood (FD)	Lightning (LT)	Rain (RN)	Snow (SN)	Freezing Weather (FW)	Straight Wind (SW)	Tornado (TO)	Other	Airplane (AP)	Helicopter (HL)	Train (TN)	Truck/Car (TR)	Forklift/lift Truck (FK)	Crane/Hoist (CR)	Other - Remote Handling Equipment (RH)		
420-D/RU	X	8				X				9		12						X	X	X	X	X	X	X	X	X	X	X	X	X				
420-D/DW	X	8				X				9		12						X	X	X	X	X	X	X	X	X	X	X	X	X	X			
420-D/MPF	X					X						13						X	X	X	X	X	X	X	X	X	X	X	X	X	X			
420-2D (Drum Storage)	X					X						13						X	X	X	X	X	X	X	X	X	X	X	X	X	X			
421-2D (TPF and Drum Storage)	X					X						13		10	7			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
421-D (Drum Storage)	X					X						13	11		11			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
421-4D (Drum Storage)	X					X												X	X	X	X	X	X	X	X	X	X	X	X	X	X			
772-D (Laboratory)	X					X			X	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
421-6D	X					X						13	11		11			X	X	X	X	X	X	X	X	X	X	X	X	X	X			

X = Refers to the hazards considered applicable

FOOTNOTES:

7) Mercury collected in resin columns.

8) Trace amount of Pu-239

9) Refrigerant (Freon 22)

10) nitric acid for pH control

11) Potassium Permanganate

13) Asbestos in transite wall (Standard Industrial Hazard)

APPENDIX B HAZARD EVALUATION TABLE

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (1 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative		Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-1	E-1	A small fire in RW Area caused by ignition of combustible material - The building and the systems located outside have very low combustible loading, fire would be small, localized, and contained. (No hazardous material release is assumed.)	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation	Building Design	Combustible material control program	A	Smoke or fire alarm, building drains and sump, containment dike around the systems that are exposed to the environment	Evacuation, emergency plan for recovery, workers trained in use of hand extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (No release of D2O for small fires.)	III III III
DA-2	E-1	Release of all D2O from RW due to a full building fire in RW Area caused by ignition of combustible material - The building and the systems located outside have very low combustible loading.	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation	Building Design	Combustible material control program	U	Smoke or fire alarm, building drains and sump, containment dike around the systems that are exposed to the environment, Kanne monitor inside the building	Evacuation, emergency plan for recovery, workers trained in use of hand extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III
DA-3	E-2	Release of D2O vapor from RW due to missiles generated from compressed gas bottles used in 420-D Compressor Room damaging the Cooler and Freezer systems (very small amount of vapor)	Equipment failure, operator error	None	SOP's (Maintenance & surveillance)	A	Kanne monitor inside the building	Shutdown of the operation	Environmental Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DA-4	E-3	Release of D2O vapor to atmosphere due to loss of refrigeration (very small amount)	Condenser failure, Cooler and Freezer failure, operator error	System or equipment design	SOP's (Maintenance & surveillance)	A	Kanne monitor inside the building	Shutdown of the operation	Environmental contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III

Event Categories

- E-1 - Fire
- E-2 - Explosion
- E-3 - Loss of Containment/Confinement
- E-4 - Direct Radiological/Chemical Exposure
- E-5 - Nuclear Criticality
- E-6 - External Hazards
- E-7 - Natural Phenomena

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (2 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-5	E-3	Release of all D2O from RW and MPF due to leak from the system (If leak is not detected then all D2O can be released.)	Loss of material integrity, missiles from rotating equipment	System or equipment design	SOPs (Maintenance & surveillance)	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, berms, sump, containment dike	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Med (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.)	III III I
DA-6	E-3	Release of all D2O from RW and MPF due to catastrophic failure of the system	Loss of material integrity, missiles from rotating equipment	System or equipment design	SOPs (Maintenance & surveillance)	U	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, containment dike	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III
DA-7	E-3	Release of D2O from drums or tanks in 420-2D due to loss of container integrity - Assuming a max of 550 gal (22,899 Ci) - The building is too small to store more than a few drums.	Mechanical failure, equipment failure, corrosion, drum handling error	Drum or tank design	SOPs	A	Visual, Kanne monitor	Kanne monitor inside the building, Building floor drain, berms, sump, containment dike	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Med (Worker does not recognize the leak.)	III III I
DA-8	E-3	Release of D2O from the systems/drums located inside or near 420-2D by forklift or truck running into them (Max. of 550 gal or 22,899 Ci of D2O)	Operator Error, Procedural Violation, Equipment Failure	None	Procedures, Worker training	A	Audible, Visual	Kanne monitor inside the building, Containment dike	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Low (Facility worker recognizes the event and the leak.)	III III III
DA-9	E-3	Release of radionuclides trapped in resin columns during resin replacement	Operator Error, Procedural Violation, Equipment Failure	Wet resin reduces airborne	Procedures, Worker training	A	Visual	Kanne monitor inside the building, PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers, resin replacement program	Contamination of the MPF area	Offsite - Low Onsite - Low Facility Worker - Low (Materials trapped in the resin can not be easily airborne)	III III III

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (3 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-10	E-3	Release of D2O due to dropping or mishandling of drums	Operator Error, Equipment Failure	Drums are banded together	SOP's	A	Visual	Kanne monitor inside the building, Containment ramps, Building sump	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite- Low Facility Worker - Low (Facility worker recognizes the event and the leak.)	III III III
DA-11	E-3	Release of D2O due to loss of ventilation system while heavy water is pumped in a hut	Operator Error, Equipment Failure, loss of power	None	SOP's	A	Ventilation System Alarm, Kanne Monitor	Kanne monitor inside the building	Evacuation	Contamination, Shutdown of the operation	Offsite - Low Onsite- Low Facility Worker - Low (Evaporation rate is very low)	III III III
DA-12	E-4	Direct skin contact with D2O due to spill or leak from equipment	Operator Error, Procedural Violation, Equipment Failure	Drum and pump station design	Procedures, Worker training	A	Visual, Kanne Monitor	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination of the MPF area	Offsite - Low Onsite- Low Facility Worker - Low	III III III
DA-13	E-2 E-6	Release of all D2O from RW due to an external fire or explosion near 420-D Building causing system damage and leading to leak of water or steam	Fuel tank fire/explosion of delivery or utility trucks/ tractor, Fuel storage tank for emergency diesel	Standard Vehicle Design	Explosive Restrictions and Combustible Loading	U	Visual, Audible, Kanne monitor inside the building	Very low combustible loading on the systems located outside of the building, building drains and sump, containment dike around the systems exposed to the environment	Evacuation, emergency plan for recovery, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite- Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III
DA-14	E-6	Release of total D2O inventory due to a large aircraft crashing into the building	External event - Aircraft crash	Not under pathways for landing and take-off for a large commercial airport, Small footprint of the building	None	BEU	Visual, Audible	Building floor drain, berms, sump, containment dike	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (4 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-15	E-6	Release of total D2O inventory due to small aircraft/helicopter crashing into the building	External event – small aircraft/helicopter crash	Small footprint of the building	Helicopter flight restriction over structures	BEU	Visual, Audible	Building floor drain, berms, sump, containment dike	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DA-16	E-6	Release of all D2O from the systems located outside caused by forklift or truck running into them	Operator Error, Procedural Violation, Equipment Failure	None	Procedures, Worker training, Containment dike work as a bump or barrier for the systems located outside.	A	Audible, Visual	Distillation towers located outside are placed on top of concrete pedestal, Containment dike	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite- Low Facility Worker – Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III
DA-17	E-6	Release of D2O due to loss of exhaust system caused by loss of power	External Event – Loss of Offsite Power	None	SOPs	A	Ventilation System Alarm, Visual	Kanne monitor inside the building	Evacuation	Contamination, Shutdown of the operation	Offsite - Low Onsite- Low Facility Worker – Low (Evaporation rate is very low)	III III III
DA-18	E-7	Release of D2O from components due to leak caused by freezing and thawing	Mechanical failure, equipment failure, NPH - freezing weather	Heat tracing with steam	Freeze Protection procedures	A	Visual	Kanne monitor inside the building, Building floor drain, sump, containment dike	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite- Low Facility Worker – Med (Damage ratio of 1 is assumed, ARF and dose estimate for Offsite and Onsite receptors.) Facility worker may not be able to recognize the event.	III III I
DA-19	E-7	Release of all D2O due to Straight Wind/Tornado causes distillation towers to fail	Natural Phenomena - Straight Wind/Tornado	None	None	U	Audible, Visual	Containment dike	Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination, Shutdown of the operation	Offsite - Low Onsite- Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Distillation Towers located outside.	III III III

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (5 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-20	E-7	Release of D2O due to missile impelled by tornado or high winds into 420-D Building or systems located outside	Natural Phenomena - Missile generated by high wind or tornado	None	None	EU	Audible, Visual	Containment dike	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Med (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event.	IV IV III
DA-21	E-7	Release of all D2O due to Heavy rains flooding 420-D/420-2D Buildings	Natural Phenomena - Flooding	D-Area is 137 ft above sea level	None	U	Audible, Visual	Sealed system	Evacuation, Emergency Plans (WSRC 6Q Manual series), IIP is required before work starts, trained workers.	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.)	III III III
DA-22	E-7	Release of all D2O due to earthquake causes non-seismically qualified systems to fail in 420-D/420-2D Buildings	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Kanne monitor inside the building	Evacuation, Spill procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, release to ground water	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III
DA-23	E-7	Release of all D2O due to earthquake with a subsequent fire causes non-seismically qualified systems to fail in 420-D/420-2D Buildings	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, release to ground water	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III

Table B-1. 420-D/420-2D Building Hazard Evaluation Table (6 of 6)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DA-24	E-7	Release of all D2O due to damage caused by Lightning strikes on 420-D Building	Natural phenomena - Lightning	Lightning arrestor	Low Combustible Loading	A	Visual	Kanne monitor inside the building	Emergency plan for recovery, fire department and emergency team response	Evacuation and shutdown of D-Area	Offsite - Low Onsite - Low Facility Worker - Med (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker may not be able to recognize the event.	III III I
DA-25	E-7	Release of all D2O due to 420-D/420-2D Building collapse by heavy snow, hail, or ice storms resulting in system damage	Natural phenomena - heavy snow	420-D Building Design, Equipment design	None	U	Audible, visual, Temp, Weather Forecast	Steel frame building	Procedures, Emergency Plans (WSRC 6Q Manual series)	Evacuation and shutdown of D-Area, Environment contamination	Offsite - Low Onsite - Low Facility Worker - Low (See Table 9 for ARF and dose estimate for Offsite and Onsite receptors.) Facility worker recognizes the event and evacuates.	III III III

Table B-2. 421-2D Building Hazard Evaluation Table (1 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initial-Ing Event Freq. Level	Method of Detection	Mitigative Features		Impact on Other Systems	Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative		Impact on Receptors		
DB-1	E-1	Release of D20 from TPF due to a small fire in TPF Area caused by ignition of combustible material (One drum at a time is processed). Because of very low combustible loading, fire would be small, localized, and contained and would not be able to breach the integrity of transient drums.	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation, Nitric acid contact with organic material	None	Combustible material control program	A	Snell, Visual, smoke alarm, Kane monitor inside the building	Smoke or fire alarm, building drains and sump, Containment workers trained in use of hand fire extinguishers, fire department and emergency team response	Evacuation, emergency plan for recovery, workers trained	Shutdown of the facility	Contamination, Shutdown of the facility	Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either pressurize and breach drum integrity to release D2O. It is assumed that the fires can only impact one open drum.)	III III III
DB-2	E-1	Release of D20 from 421-2D due to a large fire in the building caused by ignition of combustible material. (It was assumed that 1/2 of the inventory is released from the drums.)	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation, Nitric acid contact with organic material	None	Combustible material control program	U	Snell, Visual, smoke alarm, Kane monitor inside the building	Smoke or fire alarm, building drains and sump, Containment workers trained in use of hand fire extinguishers, fire department and emergency team response	Evacuation, emergency plan for recovery, workers trained	Shutdown of the facility	Contamination, Shutdown of the facility	Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either pressurize and breach drum integrity to release D2O. 1/2 of the drums is assumed to release the inventory, 4% of the released will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III
DB-3	E-3	Release of D20 to atmosphere due to failure of dampers or Driftle tube in the Exhaust Hood System for TPF (very small amount)	Mechanical failure, Driftle tube failure, loss of power	System or equipment design	SOPs (Maintenance & surveillance)	A	Process Vapor Tritium Monitoring System	Building exhaust system	Shutdown of the operation	Environmental contamination, spread in the TPF area.	Onsite - Low Facility Worker - Low	III III III	III

Event Categories

E-1 - Fire

E-2 - Explosion

E-3 - Loss of Containment/Confinement

E-4 - Direct Radiological/Chemical Exposure

E-5 - Nuclear Criticality

E-6 - External Hazards

E-7 - Natural Phenomena

Table B-2. 421-2D Building Hazard Evaluation Table (2 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initialing	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DB-4	E-3	Release of D2O from TPF due to leak from the TPF system (If leak is not detected then a Max. of 55 gal in TPF may be released)	Loss of material integrity, leak from seals	System or equipment design	SOPs (Maintenance & surveillance)	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, Containment ramps, sump	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the operation	Offsite - Low Onsite- Low Facility Worker - Med Facility worker may not be able to recognize the event.	III III F
DB-5	E-3	Release of D2O from transient drums stored on the floor of TPF	Loss of material integrity, corrosion, drum handling error	System or equipment design	SOPs (Maintenance & surveillance)	A	Visual	Kanne monitor inside the building, Building floor drain, sump, Containment ramps, Building exhaust	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite- Low Facility Worker - Med (Drums do not stay in the TPF area long but can be assumed that conservatively a few drums leak.) Facility worker may not be able to recognize the event.	III III I
DB-6	E-3	Release of D2O from drums stored in 421-2D by damage caused by forklift (assumed 12 drums damaged, for 3 stacks of 4 drums banded together.)	Operator Error, Procedural Violation, Equipment Failure, dropping	None	Procedures, Worker training	A	Audible, Visual, Kanne monitor inside the building	Kanne monitor inside the building, Drum design and construction, Building floor drain, sump, Containment ramps	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination, Shutdown of the facility	Offsite - Low Onsite- Low Facility Worker - Low (12 drums * 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker recognizes the event /leak and evacuates	III III III
DB-7	E-3	Release of mercury trapped in resin column during resin replacement	Operator Error, Procedural Violation, Equipment Failure	None	Procedures, Worker training	A	Visual	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination of the TPF area	Offsite - Low Onsite- Low Facility Worker - Low (Chemical toxicity, minute mercury collected in the resin columns.)	III III III
DB-8	E-4	Direct skin contact with D2O due to spill or leak from equipment	Operator Error, Procedural Violation, Equipment Failure	None	Procedures, Worker training	A	Visual, Kanne monitor inside the building	PPE, Kanne monitor inside the building	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination of the TPF area	Offsite - Low Onsite- Low Facility Worker - Low	III III III

Table B-2. 421-2D Building Hazard Evaluation Table (3 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DB-9	E-4	Direct contact with phosphoric acid that is used to wash drums	Operator Error, Procedural Violation, Equipment Failure	PPE	Procedures, Worker training	A	Visual	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination of the drum wash area	Offsite - Low Onsite - Low Facility Worker - Low (Chemical toxicity)	III III III
DB-10	E-2 E-6	Release of D20 from 421-2D due to Tractor/Truck run into the building with fuel tank fire/explosion damaging drums stored in the building (It is assumed that a max. of 1/2 of the drums damaged.)	External Event - fire/Explosion - Fuel tank fire/explosion of delivery or utility trucks, Lift truck battery explosion	Standard Vehicle Design	Combustible Loading, Vehicle traffic restriction	U	Visual, Audible, Kanne monitor inside the building	Kanne monitor inside the building, Drum design and construction, Building drains and sump	Evacuation, emergency plan for recovery, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (High from explosion) (It is assumed that 1/2 of the inventory will be released in 2 hours and conservatively 4% will be airborne due to fire.) Facility worker recognizes the event/ leak and evacuates.	III III III
DB-11	E-6	Release of total D2O inventory due to a large aircraft crashing into the building	External event - Aircraft crash	Not under pathways for landing and take-off for a large commercial airport, Small footprint of the building	None	BEU	Visual, Audible	Drum design and construction, Building floor drain, sump, containment dike	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DB-12	E-6	Release of total D2O inventory due to small aircraft/helicopter crashing into the building	External event - small aircraft/ helicopter crash	Small footprint of the building	Helicopter flight restriction over structures	BEU	Visual, Audible	Drum design and construction, Building floor drain, sump, containment dike	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DB-13	E-6	Release of D2O into the building due to loss of building exhaust system caused by loss of power (Natural evaporation from open drums only)	External Event - Loss of Offsite Power	None	SOPs	A	Visual, Kanne monitor inside the building	None	Evacuation	Contamination, Shutdown of the operation	Offsite - Low Onsite - Low Facility Worker - Low Facility worker recognizes the event and evacuates.	III III III

Table B-2. 421-2D Building Hazard Evaluation Table (4 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DB-14	E-7	Release of D2O from drums due to leak caused by freezing and thawing (It is assumed that all of the drums will fail and leak.)	Natural Phenomena - Freezing	Drum design and construction	Freeze Protection procedures	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, Containment ramps	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Med (It is assumed that all of the drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to a cold weather.) Facility worker may not recognize the leak.	III III I
DB-15	E-7	Release of D2O due to Straight Wind/Tornado damages the building and the stored drums (It is assumed that max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, damaged.)	Natural Phenomena - Straight Wind/Tornado	None	None	U	Audible, Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump	Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel.	Contamination, Shutdown of the facility, Environment contamination	Offsite - Low Onsite - Low Facility Worker - Low (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to a cold weather.) Facility worker recognizes the event and evacuates.	III III III
DB-16	E-7	Release of D2O due to missile impelled by tornado or high winds into 421-2D Building damaging drums (Max. of 12 drums)	Natural Phenomena - Missile generated by high wind or tornado	None	None	EU	Audible, Visual, Kanne monitor inside the building,	Kanne monitor inside the building, Building floor drain, sump, Containment ramps	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination	Offsite - Low Onsite - Low Facility Worker - Med (12 drums * 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker may not be able to recognize the event.	IV IV III
DB-17	E-7	Release of D2O due to Heavy rains flooding 421-2D Building (Only impact open drums which may be only one for TPF.)	Natural Phenomena - Flooding	D-Area is 137 ft above sea level	None	U	Audible, Visual	Sealed system	Procedures, Emergency Plans (WSRC 6Q Manual series), HP is required before work starts, trained workers	Evacuation and shutdown of D-Area	Offsite - Low Onsite - Low Facility Worker - Low	III III III

Table B-2. 421-2D Building Hazard Evaluation Table (5 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DB-18	E-7	Release of D2O due to earthquake causes non-seismically qualified systems to fail in 421-2D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Building floor drain, sump, Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite- Low Facility Worker - Low (High due to earthquake) (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III
DB-19	E-7	Release of D2O due to earthquake with a subsequent fire causes non-seismically qualified systems to fail in 421-2D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Building floor drain, sump, Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground water release	Offsite - Low Onsite- Low Facility Worker - Low (High due to earthquake) (It is assumed that 1/2 of the drums will fail and 4% will be airborne in 2 hours to account for potential boil-off of water due to fire.) Facility worker recognizes the event and evacuates.	III III III
DB-20	E-7	Release of D2O due to damage caused by lightning strikes on 421-2D Building (There are three trailers with 64 transient drums each with 11 C/L stored outside)	Natural phenomena - Lightning	Lightning arrestor	Low Combustible Loading	A	Visual, Kanne monitor inside the building	Drum design and construction,	Emergency plan for recovery, fire department and emergency team response	Contamination	Offsite - Low Onsite- Low Facility Worker - Low	III III III
DB-21	E-7	421-2D Building is damaged by heavy snow, hail, or ice storms resulting in drum damage (It is assumed that a max. of 1/2 of the drums is damaged.)	Natural phenomena - heavy snow	421-2D Building Design, Drum design and construction	None	U	Audible, visual, Temp, Weather Forecast, Kanne monitor inside the building	Drum design and construction, Steel frame building	Procedures, Emergency Plans (WSRC 6Q Manual series)	Contamination, Shutdown of the facility, Environment contamination	Offsite - Low Onsite- Low Facility Worker - Low (1/2 of the drums is assumed to be released and 2% will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III

Table B-3. 421-D Building Hazard Evaluation Table (1 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DC-1	E-1	Release of D2O from 421-D due to a small fire caused by ignition of combustible material (One drum at a time is processed) Because of very low combustible loading, fire would be small, localized, and contained and would not be able to breach the integrity of drums.	Electrical equipment, Welding spark, electrical short, potassium permanganate contact with organic material, unknown ignition source, worker error, improper maintenance operation	None	Combustible material control program	A	Smell, Visual, smoke alarm, Kanne monitor inside the building	Smoke or fire alarm, building drains and sump, berms, Drum design and construction	Evacuation, Emergency plan for recovery, workers trained in use of hand fire extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either boil off or breach drum integrity to release D2O.)	III III III
DC-2	E-1	Release of D2O from 421-D due to a large fire in the building caused by ignition of combustible material. (It was assumed that 1/2 of the inventory is released from the drums.)	Electrical equipment, Welding spark, electrical short, potassium permanganate contact with organic material, unknown ignition source, worker error, improper maintenance operation	None	Combustible material control program	U	Smell, Visual, smoke alarm, Kanne monitor inside the building	Smoke or fire alarm, building drains and sump, berms, Drum design and construction	Evacuation, Emergency plan for recovery, workers trained in use of hand fire extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either pressurize and breach drum integrity to release D2O. 1/2 of the drums is assumed to release the inventory. 4% of the released will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III
DC-3	E-3	Release of D2O from leaky drums stored in 421-D Building	Loss of material integrity, corrosion, drum handling error	Drum design and construction	SOPs (Maintenance & surveillance)	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, berms	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Med (Only a few may leak simultaneously) Facility worker may not be able to recognize the leak.	III III I

Event Categories

E-1 - Fire

E-2 - Explosion

E-3 - Loss of Containment/Confinement

E-4 - Direct Radiological/Chemical Exposure

E-5 - Nuclear Criticality

E-6 - External Hazards

E-7 - Natural Phenomena

Table B-3. 421-D Building Hazard Evaluation Table (2 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DC-4	E-3	Release of D2O from drums stored in 421-D by damage caused by forklift (It was assumed that 12 drums damaged, for 3 stacks of 4 drums banded together.)	Operator Error, Procedural Violation, Equipment Failure, dropping	Drum design and construction	Procedures, Worker training	A	Audible, Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, berms	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low (12 drums * 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker recognizes the event and evacuates.	III III III
DC-5	E-4	Direct skin contact with D2O due to spill or leak from equipment	Operator Error, Procedural Violation, Equipment Failure	Drum design and construction	Procedures, Worker training	A	Visual, Kanne monitor inside the building	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DC-6	E-4	Direct skin contact with Potassium Permanganate	Operator error	PPE, Stored in crystal form	Procedures, Worker training	A	Visual, Sense	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	None	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DC-7	E-2 E-6	Release of D2O from 421-D due to Tractor/Truck run into the building with fuel tank fire/explosion damaging drums stored in the building (It is assumed that a max. of 1/2 of the drums damaged.)	External Event - Fire/Explosion - Fuel tank fire/explosion of delivery or utility trucks, Lift truck battery explosion	Standard Vehicle Design	Combustible Loading, Vehicle traffic restriction	U	Visual, Audible, Kanne monitor inside the building	Drum design and construction, Building drains and sump, Kanne monitor inside the building	Evacuation, emergency plan for recovery, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (It is assumed that 1/2 of the inventory will be released in 2 hours and conservatively 4% will be airborne due to fire.) Facility worker recognizes the event and evacuates.	III III III
DC-8	E-6	Release of total D2O inventory due to a large aircraft crashing into the building	External event - Aircraft crash	Not under pathways for landing and take-off for a large commercial airport, Small footprint of the building		BEU	Visual, Audible	Building floor drain, berms, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A

Table B-3. 421-D Building Hazard Evaluation Table (3 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DC-9	E-6	Release of total D2O inventory due to small aircraft/helicopter crashing into the building	External event – small aircraft/helicopter crash	Small footprint of the building	Helicopter flight restriction over structures	BEU	Visual, Audible	Building floor drain, berms, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DC-10	E-6	No impact	External Event – Loss of Offsite Power			A				N/A	N/A	N/A
DC-11	E-7	Release of D2O from drums due to leak caused by freezing and thawing (It is assumed that all drums will fail and leak.)	Natural Phenomena – Freezing	Drum design and construction	Freeze Protection procedures	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Drum design and construction, Building floor drain, berms, sump	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite- Low Facility Worker - Med (It is assumed that all drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to cold weather.) Facility worker may not be able to recognize the leak.	III III I
DC-12	E-7	Release of D2O due to Straight Wind/Tornado damages the building and the stored drums (It is assumed that max. of 1/2 of the drums, i.e., second and third stacks, damaged.)	Natural Phenomena - Straight Wind/Tornado	None	None	U	Audible, Visual, Kanne monitor inside the building	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination, Shutdown of the facility, Environment contamination	Offsite - Low Onsite- Low Facility Worker - Low (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to cold weather.) Facility worker recognizes the event and evacuates.	III III III
DC-13	E-7	Release of D2O due to missile impelled by tornado or high winds into 421-D Building damaging drums (Max. of 12 drums)	Natural Phenomena- Missile generated by high wind or tornado	None	None	EU	Audible, Visual, Kanne monitor inside the building	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination	Offsite - Low Onsite- Low Facility Worker – Med (12 drums* 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker may not be able to recognize the event.	IV IV III

Table B-3. 421-D Building Hazard Evaluation Table (4 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DC-14	E-7	Release of D2O due to Heavy rains flooding 421-2D Building (Only may impact open drums)	Natural Phenomena - Flooding	D-Area is 137 ft above sea level	None	U	Audible, Visual	Drum design and construction	Procedures, Emergency Plans (WSRC 6Q Manual series), HP is required before work starts, trained workers.	Evacuation and shutdown of D-Area	Offsite - Low Onsite- Low Facility Worker - Low	III III III
DC-15	E-7	Release of D2O due to earthquake causes non-seismically qualified systems to fail in 421-D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite- Low Facility Worker - Low (High due to earthquake) (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III III
DC-16	E-7	Release of D2O due to earthquake with a subsequent fire causes non-seismically qualified systems to fail in 421-D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite- Low Facility Worker - Low (It is assumed that 1/2 of the drums will fail and 4% will be airborne in 2 hours to account for potential boil-off of water due to fire.) Facility worker recognizes the event and evacuates.	III III III III
DC-17	E-7	Release of D2O due to damage caused by Lightning strikes on 421-D Building	Natural phenomena - Lightning	Lightning arrestor	Low Combustible Loading	A	Visual	Drum design and construction, Kanne monitor inside the building	Emergency plan for recovery, fire department and emergency team response	Environment Contamination	Offsite - Low Onsite- Low Facility Worker - Med (Facility worker may not be able to recognize the leak.)	III III I

Table B-3. 421-D Building Hazard Evaluation Table (5 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DC-18	E-7	421-D Building is damaged by heavy snow, hail, or ice storms resulting in drum damage (It is assumed that a max. of 1/2 of the drums is damaged.)	Natural phenomena – heavy snow	421-D Building Design, Drum design and construction	None	U	Audible, visual, Temp, Weather Forecast	Drum design and construction, Steel frame building, Kanne monitor inside the building	Procedures, Emergency Plans (WSRC 6Q Manual series)	Shutdown of the facility, Environment contamination	Offsite - Low Onsite- Low Facility Worker – Low (1/2 of the drums is assumed to be released and 2% will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III

Table B-4. 421-4D Building Hazard Evaluation Table (1 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DD-1	E-1	Release of D20 from 421-4D due to a small fire in 421-4D Building caused by ignition of combustible material (One drum at a time is processed) Because of very low combustible loading, fire would be small, localized, and contained and would not be able to breach the integrity of drums.	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation	None	Combustible material control program	A	Smell, Visual, smoke alarm, Kanne monitor inside the building	Smoke or fire alarm, building drains and sump, berms, Drum design and construction	Evacuation, emergency plan for recovery, workers trained in use of hand fire extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either boil off or breach drum integrity to release D2O.)	III III III
DD-2	E-1	Release of D20 from 421-4D due to a large fire in the building caused by ignition of combustible material. (It was assumed that 1/2 of the inventory is released from the drums.)	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation	None	Combustible material control program	U	Smell, Visual, smoke alarm, Kanne monitor inside the building	Smoke or fire alarm, building drains and sump, berms, Drum design and construction, Kanne monitor inside the building	Evacuation, emergency plan for recovery, workers trained in use of hand fire extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (Fire intensity and duration have to be sufficient enough to either pressurize and breach drum integrity to release D2O. 1/2 of the drums is assumed to release the inventory. 4% of the released will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III
DD-3	E-3	Release of D2O from leaky drums stored in 421-4D Building	Loss of material integrity, corrosion, drum handling error	Drum design and construction	SOPs (Maintenance & surveillance)	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, berms	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Med (Only a few may leak simultaneously) Facility worker may not be able to recognize the event.	III III I

Event Categories

E-1 - Fire
E-2 - Explosion
E-3 - Loss of Containment/Confinement
E-4 - Direct Radiological/Chemical Exposure
E-5 - Nuclear Criticality
E-6 - External Hazards
E-7 - Natural Phenomena

Table B-4. 421-4D Building Hazard Evaluation Table (2 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DD-4	E-3	Release of D2O from drums stored in 421-4D by damage caused by forklift (It was assumed that 12 drums damaged, for 3 stacks of 4 drums banded together.)	Operator Error, Procedural Violation, Equipment Failure, dropping	Drum design and construction	Procedures, Worker training	A	Audible, Visual, Kanne monitor inside the building	Kanne monitor inside the building, Building floor drain, sump, berms	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low (12 drums* 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker recognizes the event and evacuates.	III III III
DD-5	E-4	Direct skin contact with D2O due to spill or leak from equipment	Operator Error, Procedural Violation, Equipment Failure	Drum design and construction	Procedures, Worker training	A	Visual, Kanne monitor inside the building	PPE, Kanne monitor inside the building	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Med Facility worker may not recognize the event.	III III I
DD-6	E-2 E-6	Release of D2O from 421-4D due to Tractor/Truck run into the building with fuel tank fire/explosion damaging drums stored in the building (It is assumed that a max. of 1/2 of the drums damaged.)	External Event - Fire/Explosion - Fuel tank fire/explosion of delivery or utility trucks, Lift truck battery explosion	Standard Vehicle Design	Combustible Loading, Vehicle traffic restriction	U	Visual, Audible, Kanne monitor inside the building	Drum design and construction, Building drains and sump	Evacuation, emergency plan for recovery, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low (It is assumed that 1/2 of the inventory will be released in 2 hours and conservatively 4% will be airborne due to fire.) Facility worker recognizes the event and evacuates.	III III III
DD-7	E-6	Release of total D2O inventory due to a large aircraft crashing into the building	External event - Aircraft crash	Not under pathways for landing and take-off for a large commercial airport, Small footprint of the building	None	BEU	Visual, Audible	Building floor drain, berms, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DD-8	E-6	Release of total D2O inventory due to small aircraft/helicopter crashing into the building	External event - small aircraft/helicopter crash	Small footprint of the building	Helicopter flight restriction over structures	BEU	Visual, Audible	Building floor drain, berms, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DD-9	E-6	No impact	External Event - Loss of Offsite Power	None	None	A				N/A	N/A	N/A

Table B-4. 421-4D Building Hazard Evaluation Table (3 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DD-10	E-7	Release of D2O from drums due to leak caused by freezing and thawing (It is assumed that 1/2 of the drums will fail and leak.)	Natural Phenomena - Freezing	Drum design and construction	Freeze Protection procedures	A	Visual, Kanne monitor inside the building	Kanne monitor inside the building, Drum design and construction, Building floor drain, berms, sump	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Med (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to cold weather.) Facility worker may not be able to recognize the event.	III III I
DD-11	E-7	Release of D2O due to Straight Wind/Tornado damages the building and the stored drums (It is assumed that max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Straight Wind/Tornado	None	None	U	Audible, Visual	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination	Offsite - Low Onsite - Low Facility Worker - Low (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours. Evaporation rate will be probably much lower than 2% due to cold weather.) Facility worker recognizes the event and evacuates.	III III III
DD-12	E-7	Release of D2O due to missile impelled by tornado or high winds into 421-4D Building damaging drums (Max. of 12 drums)	Natural Phenomena - Missile generated by high wind or tornado	None	None	EU	Audible, Visual	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination, Shutdown of the facility, Environment contamination	Offsite - Low Onsite - Low Facility Worker - Med (12 drums * 55 gal/drum * 3.785 liter/gal * 11 Ci/liter) Facility worker may not be able to recognize the event.	IV IV III

Table B-4. 421-4D Building Hazard Evaluation Table (4 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DD-13	E-7	Release of D2O due to Heavy rains flooding 421-2D Building (Only may impact open drums)	Natural Phenomena - Flooding	D-Area is 137 ft above sea level	None	U	Audible, Visual	Drum design and construction	Procedures, Emergency Plans (WSRC 6Q Manual series), IIP is required before work starts, trained workers.	Evacuation and shutdown of D-Area	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DD-14	E-7	Release of D2O due to earthquake causes non-seismically qualified systems to fail in 421-2D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite - Low Facility Worker - Low (High due to earthquake) (It is assumed that 1/2 of the drums will fail and 2% will be airborne in 2 hours.) Facility worker recognizes the event and evacuates.	III III III
DD-15	E-7	Release of D2O due to earthquake with a subsequent fire causes non-seismically qualified systems to fail in 421-4D Building (It is assumed that a max. of 1/2 of the drums, i.e., 1/2 of second stack and all drums on the third stacks, is damaged.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump, Kanne monitor inside the building	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite - Low Facility Worker - Low (High due to earthquake) (It is assumed that 1/2 of the drums will fail and 4% will be airborne in 2 hours to account for potential boil-off of water due to fire.) Facility worker recognizes the event and evacuates.	III III III
DD-16	E-7	Release of D2O due to damage caused by lightning strikes on 421-4D Building	Natural phenomena - Lightning	Lightning arrestor	Low Combustible Loading	A	Visual	Drum design and construction, Kanne monitor inside the building	Emergency plan for recovery, fire department and emergency team response	Shutdown of the facility, Environment contamination	Offsite - Low Onsite - Low Facility Worker - Mod Facility worker may not be able to recognize the event	III III I

Table B-4. 421-4D Building Hazard Evaluation Table (5 of 5)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DD-17	E-7	421-4D Building is damaged by heavy snow, hail, or ice storms resulting in drum damage (It is assumed that a max. of 1/2 of the drums is damaged.)	Natural phenomena – heavy snow	421-4D Building Design, Drum design and construction	None	U	Audible, visual, Temp, Weather Forecast	Drum design and construction, Steel frame building	Procedures, Emergency Plans (WSRC 6Q Manual series)	Shutdown of the facility, Environment contamination	Offsite - Low Onsite- Low Facility Worker – Low (1/2 of the drums is assumed to be released and 2% will be airborne in 2 hours.)	III III III

Table B-5. 772-D Building Hazard Evaluation Table (1 of 3)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DE-1	E-1	Release of samples due to a fire in 772-D Building caused by ignition of combustible material. (All radioactive inventory released.)	Electrical equipment, Welding spark, electrical short, unknown ignition source, worker error, improper maintenance operation, Nitric acid contact with organic material	None	SOPs	A	Smell, Visual, smoke alarm, Kanne monitor inside the RCA	Smoke or fire alarm, automatic sprinkler system	Evacuation, emergency plan for recovery, workers trained in use of hand fire extinguishers, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-2	E-3	Spill samples.	Loss of material integrity, corrosion, drum handling error	None	SOPs (Maintenance & surveillance)	A	Visual, Kanne monitor inside the building	Hood and drains, radionuclide benches	Spill Procedures, Trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low (Only small amount in samples is handled in the Lab.)	III III III
DE-3	E-3	Release of D2O or other radioactive material inventory from waste drums stored in 772-D (All radioactive inventories released.)	Operator Error, Procedural Violation, corrosion, Equipment Failure	Drum design and construction	Procedures, Worker training	A	Visual, Kanne monitor inside the building	Building floor drain, sump	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-4	E-4	Direct skin contact with samples due to spill or leak from equipment	Operator Error, Procedural Violation, Equipment Failure	PPE	Procedures, Worker training	A	Visual, Kanne monitor inside the building	PPE	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-5	E-6	Release of D2O from 772-D due to Tractor/Truck run into the building with fuel tank explosion damaging drums stored in the building (All radioactive inventories released.)	External Event- Explosion - Fuel tank explosion of delivery or utility trucks	Standard Vehicle Design	Combustible Loading, Vehicle traffic restriction	U	Visual, Audible, Kanne monitor inside the building	Drum design and construction, Building drains and sump	Evacuation, emergency plan for recovery, fire department and emergency team response	Contamination, Shutdown of the facility	Offsite - Low Onsite - Low Facility Worker - High due to explosion, Low for radiation	III III III

Event Categories

E-1 - Fire

E-2 - Explosion

E-3 - Loss of Containment/Confinement

E-4 - Direct Radiological/Chemical Exposure

E-5 - Nuclear Criticality

E-6 - External Hazards

E-7 - Natural Phenomena

Table B-5. 772-D Building Hazard Evaluation Table (2 of 3)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DE-6	E-6	Release of total D2O and other radioactive material inventory due to a large aircraft crashing into the building	External event - Aircraft crash	Not under pathways for landing and take-off for a large commercial airport, Small footprint of the building	None	BEU	Visual, Audible	Building floor drain, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DE-7	E-6	Release of total D2O and other radioactive material inventory due to small aircraft/helicopter crashing into the building	External event - small aircraft/helicopter crash	Small footprint of the building	Helicopter flight restriction over structures	BEU	Visual, Audible	Building floor drain, sump	Procedures, Emergency Plans (WSRC 6Q Manual series)	N/A	N/A	N/A
DE-8	E-6	Release of samples by evaporation caused by loss of power to the exhaust fans.	External Event - Loss of Offsite Power	None	None	A	None	None	Evacuation	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-9	E-7	Release of D2O and other radioactive material inventory from drums due to leak caused by freezing and thawing	Natural Phenomena - Freezing	None	Freeze Protection procedures	A	Visual, Kanne monitor inside the building	Drum design and construction, Building floor drain, berms, sump	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained workers	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-10	E-7	Release of D2O and other radioactive material inventory due to Straight Wind/Tornado damages the building and the stored drums (All radioactive inventories released.)	Natural Phenomena - Straight Wind/Tornado	None	None	U	Audible, Visual	Drum design and construction, Building floor drain, sump	Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel.	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-11	E-7	Release of D2O and other radioactive material inventory due to missile impelled by tornado or high winds into 772-D Building damaging drums (All radioactive inventories released.)	Natural Phenomena - Missile generated by high wind or tornado	None	None	EU	Audible, Visual	Drum design and construction, Building floor drain, sump	Spill Procedures, Emergency Plans (WSRC 6Q Manual series), trained personnel	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	IV IV IV

Table B-5. 772-D Building Hazard Evaluation Table (3 of 3)

Event No.	Event Category	Postulated Event Description	Causes	Preventive Features		Initiating Event Freq. Level	Method of Detection	Mitigative Features		Unmitigated Consequence Level		Scenario Class
				Design	Administrative			Design	Administrative	Impact on Other Systems	Impact on Receptors	
DE-12	E-7	Release of D2O and other radioactive material inventory due to Heavy rains flooding 772-D Building	Natural Phenomena - Flooding	D-Area is 137 ft above sea level	None	U	Audible, Visual	Drum design and construction	Procedures, Emergency Plans (WSRC 6Q Manual series), IIP is required before work starts, trained workers.	Evacuation and shutdown of D-Area	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-13	E-7	Release of D2O and other radioactive material inventory due to earthquake causes non-seismically qualified systems to fail in 772-D Building (All radioactive inventory released.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-14	E-7	Release of D2O and other radioactive material inventory due to earthquake with a subsequent fire causes non-seismically qualified systems to fail in 772-D Building (All radioactive inventory released.)	Natural Phenomena - Earthquake	None	None	U	Visual, Ground motion, Audible	Drum design and construction, Building floor drain, sump	Evacuation, Spill Procedures, Emergency Plans (WSRC 6Q Manual series), Inspection after earthquake	Evacuation and shutdown of D-Area, Airborne and ground Release	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-15	E-7	Release of D2O and other radioactive material inventory due to damage caused by lightning strikes on 772-D Building	Natural phenomena - Lightning	Lightning arrestor	Low Combustible Loading	A	Visual	Drum design and construction, None	Emergency plan for recovery, fire department and emergency team response	Contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III
DE-16	E-7	Release of D2O and other radioactive material inventory due collapse of 772-D Building caused by heavy snow, hail, or ice storms resulting in drum damage (All radioactive inventories released.)	Natural phenomena - heavy snow	772-D Building Design, Drum design and construction	None	U	Audible, visual, Temp, Weather Forecast	Drum design and construction, Steel frame building	Procedures, Emergency Plans (WSRC 6Q Manual series)	Shutdown of the facility, Environment contamination	Offsite - Low Onsite - Low Facility Worker - Low	III III III