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ENGINEERING CHANGE NOTICE

1. ECN 656334

Proj. ECN

2. ECN Category (mark one)		3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental	[ ]	R. H. Webb, Nuclear Safety, R3-26, 373-2251	K-99-1511 [x] Yes [ ] No	12/17/99
Direct Revision	[x]	6. Project Title/No./Work Order No.	7. Bldg./Sys./Fac. No.	8. Approval Designator
Change ECN	[ ]	SNF Project K Basins	K Basins	S^N
Temporary	[ ]	9. Document Numbers Changed by this ECN (includes sheet no. and rev.)	10. Related ECN No(s).	11. Related PO No.
Standby	[ ]	HNF-3960 Rev. 0	N/A	N/A
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12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[ ] Yes (fill out Blk. 12b)	N/A	N/A	N/A
[x] No (NA Blks. 12b, 12c, 12d)		Design Authority/Cog. Engineer Signature & Date	Design Authority/Cog. Engineer Signature & Date

13a. Description of Change — 13b. Design Baseline Document? [ ] Yes [x] No

Changes include:

1. Incorporation of fire hazards identified in the K Basins Fire Hazards Analysis (HNF-SD-SNF-FHA-001, Rev. 1):
   - + packing materials
   - + rags
   - + oil
   - + diesel fuel/gasoline
   - + building contents
2. Hazard analysis identified and documents liquid fuel (from transport vehicles) and crane oil to be included as a fire covered in a design basis accident (DBA) in the safety analysis report (SAR).
3. Packing materials, rags, and building contents fire hazards identified and documented as worker safety hazard.
4. "Criticality" added as a potential consequence in evaluation of cask drop in the hazard analysis worksheet (F.1A) to be consistent with evaluation in the K Basins criticality safety evaluation report (HNF-SD-SNF-CSER-005).
5. Minor cleanup editorial changes made to include correcting referenced DBA numbers in the hazard analysis worksheet, and updating references as necessary.

14a. Justification (mark one)

Criteria Change	[x]	Design Improvement	[ ]	Environmental	[ ]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

14b. Justification Details

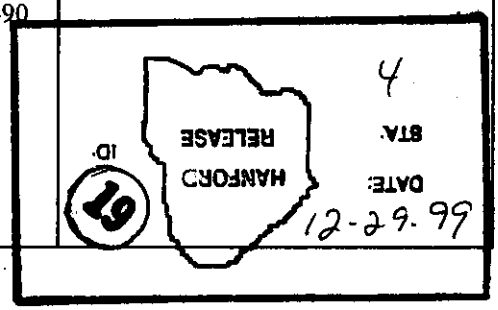
The K Basins Fire Hazards Analysis (FHA) has been issued and the changes made in this document are provided for consistency with the FHA. Changes associated with the addition of fire hazards provide the basis for development of the fire DBA in the SAR.

Editorial changes were not technical in content.

15. Distribution (include name, MSIN, and no. of copies)

M. J. Langevin	X3-76	K Basins Project Files	X3-90
R. H. Webb	R3-26		
R. L. Garrett	R3-26		
C. T. Miller	X3-79		
J. H. Wicks	X3-71		
J. R. Ellis	R3-26		
SNF Project Files	R3-11		

RELEASE STAMP



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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): 656334

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[ ] Yes	Additional	[ ] N/A	Additional	[ ] N/A	Improvement	[ ] N/A
[x] No	Savings	[ ] N/A	Savings	[ ] N/A	Delay	[ ]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[ ]	Seismic/Stress Analysis	[ ]	Tank Calibration Manual	[ ]
Functional Design Criteria	[ ]	Stress/Design Report	[ ]	Health Physics Procedure	[ ]
Operating Specification	[ ]	Interface Control Drawing	[ ]	Spares Multiple Unit Listing	[ ]
Criticality Specification	[ ]	Calibration Procedure	[ ]	Test Procedures/Specification	[ ]
Conceptual Design Report	[ ]	Installation Procedure	[ ]	Component Index	[ ]
Equipment Spec.	[ ]	Maintenance Procedure	[ ]	ASME Coded Item	[ ]
Const. Spec.	[ ]	Engineering Procedure	[ ]	Human Factor Consideration	[ ]
Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
Vendor Information	[ ]	Operating Procedure	[ ]	Electric Circuit Schedule	[ ]
OM Manual	[ ]	Operational Safety Requirement	[ ]	ICRS Procedure	[ ]
FSAR/SAR	[x]	IEFD Drawing	[ ]	Process Control Manual/Plan	[ ]
Safety Equipment List	[ ]	Cell Arrangement Drawing	[ ]	Process Flow Chart	[ ]
Radiation Work Permit	[ ]	Essential Material Specification	[ ]	Purchase Requisition	[ ]
Environmental Impact Statement	[ ]	Fac. Proc. Samp. Schedule	[ ]	Tickler File	[ ]
Environmental Report	[ ]	Inspection Plan	[ ]		[ ]
Environmental Permit	[ ]	Inventory Adjustment Request	[ ]		[ ]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
WHC-SD-WM-SAR-062 Rev. 3L		

21. Approvals

	Signature	Date	Signature	Date
Design Authority M. J. Langevin	M. J. Langevin	12/28/99		
Cog. Eng. R. H. Webb	Roger H. Webb	12/17/99		
Cog. Mgr. R. L. Garrett	Mark A. Medel for R. L. Garrett	12/28/99		
QA N/A				
Safety C. T. Miller	Mark Jenson for	12/28/99		
Environ. N/A			DEPARTMENT OF ENERGY Signature or a Control Number that tracks the Approval Signature	
Operations J. H. Wicks	J. H. Wicks	12/28/99	ADDITIONAL	

K Basins Hazard Analysis

Roger Webb
Fluor Daniel Hanford, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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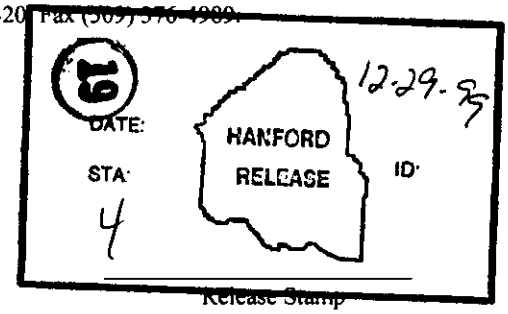
Key Words: Hazard, Frequency, Consequence, Source, Radiation, Prevention, Mitigation, Worker, Safety, Abnormal Event

Abstract: This report describes the methodology used in conducting the K Basins Hazard Analysis, which provides the foundation for the K Basins Safety Analysis Report (HNF-SD-WM-SAR-062, Rev.4). This hazard analysis was performed in accordance with guidance provided by DOE-STD-3009-94, Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports and implements the requirements of DOE Order 5480.23, Nuclear Safety Analysis Report.



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RECORD OF REVISION	(1) Document Number HNF-3960, Rev. 1	Page 1
(2) Title K Basins Hazard Analysis		

CHANGE CONTROL RECORD			
(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr. Date	(6) Cog. Mgr. Date
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1 RS	EDT: 656334; Changes include: 1. Incorporation of fire hazards identified in the K Basins Fire Hazards Analysis (HNF-SD-SNF-FHA-001, Rev. 1): + packing materials + rags + oil + diesel fuel/gasoline + building contents 2. Hazard analysis identified and documents liquid fuel (from transport vehicles) and crane oil to be included as a fire covered in a design basis accident (DBA) in the safety analysis report (SAR). 3. Packing materials, rags, and building contents fire hazards identified and documented as worker safety hazard. 4. "Criticality" added as a potential consequence in evaluation of cask drop in the hazard analysis worksheet (F.1A) to be consistent with evaluation in the K Basins criticality safety evaluation report (HNF-SD-SNF-CSER-005). 5. Minor cleanup editorial changes made to include correcting referenced DBA numbers in the hazard analysis worksheet, and updating references as necessary.	R. H. Webb Roger H. Webb 12/17/99	R. L. Garrett Mark A. Medley for R.L. Garrett 12/28/99

K BASIN HAZARD ANALYSIS

HNF-3960, Rev. 1

December 1999

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LIST OF TERMS

AC	alternating current
BPA	Bonneville Power Administration
CCTV	closed-circuit television
CSER	criticality safety evaluation report
CVDF	Cold Vacuum Drying Facility
DBE	design basis earthquake
DBF	design basis flood
DC	direct current
DOE	U.S. Department of Energy
FRS	Fuel Retrieval System
GFI	ground fault interrupters
HA	hazard analysis
HAZOP	hazard and operability study
HEPA	high-efficiency particulate air (filter)
HPT	health physics technician
IPSS	immersion pail support structure
IWTS	Integrated Water Treatment System
IXC	ion-exchange column
IXM	ion-exchange module
KE	K East
KW	K West
MCO	Multi-Canister Overpack
MLS	Multi-Canister Overpack Loading System
NLOP	north loadout pit
PCB	polychlorinated biphenyl
PCM	primary clean machine
PHMC	Project Hanford Management Contract
PV	pressure--volume
SAA	satellite accumulation area
SAR	safety analysis report
SCBA	self-contained breathing apparatus
SLOP	south loadout pit
SNF	spent nuclear fuel
TSD	treatment, storage, and disposal
WAC	Washington Administrative Code

1.0 INTRODUCTION

The K East (KE)/K West (KW) Basins in the 100 K Area of the Hanford Site have been used for storage of irradiated N Reactor and single-pass reactor fuel. The spent fuel is currently being stored underwater in racks and canisters in the basins. The Spent Nuclear Fuel (SNF) Project is adding equipment to the facility in preparation for removing the fuel from the basins to an interim storage location in the 200 Area.

In preparing this hazard analysis, a variety of hazard analysis techniques were used by the K Basins hazard analysis team, including hazard and operability studies (HAZOPs), preliminary hazard analyses, and "what if" analyses (WHC-SD-SNF-PHA-001, HNF-2032, HNF-2456, and HNF-SD-SNF-SAD-002). This document combines the hazard analyses generated from the fuel retrieval sub-project, the KW integrated water treatment sub-project, and the cask loadout system with the one previously generated for K Basins to form one integrated hazard analysis. This hazard analysis reflects design changes and current analysis. This hazard analysis also identifies the preliminary set of design features and controls that the facility could rely on to prevent or reduce the frequency or mitigate consequences of identified accident conditions based on their importance and significance to safety. The operational controls and institutional programs relied on for prevention or mitigation of an uncontrolled release are identified as potential technical safety requirements.

All operational activities and energy sources at the K Basins are evaluated in this hazard analysis. Using a systematic approach, this document identifies hazards created by abnormal operating conditions and external events (e.g., earthquakes) that have the potential for causing undesirable consequences to the facility worker, the onsite individual, or the public.

2.0 SCOPE

The systems and operational activities associated with the KE and KW Basins and support buildings were evaluated for potential hazards that could endanger facility workers or result in unacceptable releases of radioactive or hazardous chemical materials, which could affect the environment or the public. The scope of operations includes continued storage, retrieval, repackaging, and loadout of the SNF.

The related support buildings evaluated include the following:

- 165 KE – Power Control Building
- 1717 K Building – Maintenance Shop
- 183.1 KW Chlorine Vault (Spent Ion-Exchange Column [IXC] Storage)
- Spent Ion-Exchange Module (IXM) Storage Pads
- 1706 KE and KEL – Water Studies Semiworks Facility, Development Laboratory

- 190 KE – Main Pump House
- 183 KE – Clearwells, Filters, Sedimentation Basins, Headhouse, Chlorine Vault
- 165 KW – Switchgear
- 1724 K – Maintenance Shop Addition
- 185 K – Package Water Treatment Plant.

3.0 METHODOLOGY

The hazard identification process systematically and comprehensively identifies hazards that can endanger facility workers or cause unacceptable releases of radioactive or hazardous chemical materials, which can affect the environment or the public. The hazard analysis process (1) identifies hazardous conditions, (2) determines causes, and preventive and mitigative features, and (3) qualitatively estimates the consequences and frequencies of occurrence. Results of the hazard analysis are used to select candidate accidents for quantitative analysis in the K Basin Safety Analysis Report (SAR).

As part of the hazard identification process, a hazardous materials identification table (Attachment A, Table A-1) was developed from the Containment Vessel Collection Forms (HNF-3262). An energy source checklist, adapted from DOE-76-45-19, *Job and Task Analysis*, and HNF-PRO-704, *Hazard and Accident Analysis Process*, was also used to identify energy sources. The completed energy source checklist can be found in Attachment B, Table B-1.

The energy source checklist was evaluated to identify hazards not controlled by standard industrial safety programs or other institutional programs (e.g., Radiation Protection Program). These hazards were then entered into the hazard analysis table for additional analysis. Each hazardous condition was evaluated to identify the following:

- Potential accidents arising from the presence of the hazard
- Potential causes and consequences of the accident
- Design features or administrative controls credited to prevent the condition or mitigate the accident consequences
- Estimates of the likelihood and consequences of the accident.

Additional defense-in-depth features that can prevent or mitigate the accident consequences or frequency, or provide worker protection, are also included. The completed hazard analysis is included as Table C-1 in Attachment C.

The impacts of the potential unmitigated accidents developed in the hazard analysis worksheet were qualitatively ranked with respect to the frequency and severity of the consequences. Consequences were ranked in order of increasing severity, as shown in Table 3-1. Descriptions of the frequency rankings are included in Table 3-2.

Table 3-1. Qualitative Accident Severity Levels.

Consequence Assessment Code	Description
S3	There is sufficient material and energy available to cause a high or moderate impact to the maximum off-site individual.
S2	There is sufficient material and energy available to cause a high or moderate impact to the maximum on-site individual.
S1	There is sufficient material and energy available to cause an industrial injury, radiological dose, or chemical exposure to one or more facility workers.
S0	There is insufficient material and energy to adversely impact facility workers.

Table 3-2. Frequency Ranges.

Frequency Assessment	Description	Estimated Frequency
F3	Has occurred or is likely to occur during the lifetime of the facility.	Anticipated: 1.0 E-02/yr $\leq$ F3 < 1.0E-01/yr
F2	Is foreseeable, but unlikely to occur during the lifetime of the facility.	Unlikely: 1.0 E-04/yr $\leq$ F2 < 1.0 E-02/yr
F1	Is perhaps possible, but extremely unlikely to occur during the lifetime of the facility.	Extremely Unlikely: 1.0 E-06/yr $\leq$ F1 < 1.0E-04/yr
F0	Is considered too improbable to warrant further consideration.	Beyond extremely unlikely: F0 < 1.0 E-06/yr

4.0 RESULTS SUMMARY

As stated in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, "the final purpose of the hazard analysis is to identify a limited subset of accidents to be carried forward to accident analysis." The initial selection of hazard items requiring further quantitative considerations was based on consequence only. Only items ranked as S3 or S2 were considered for evaluation as design basis accidents. Results of this screening are shown in Table 4-1. Events that were categorized as S2/F1 were not further considered, unless they were identified to have fatality impacts to the facility worker. Frequency categories for each event were estimated to assist in subsequent safety analysis.

Table 4-2 identifies hazards associated with the facility workers. These hazards do not necessarily warrant detailed accident analysis in the SAR as they are controlled by worker safety or other institutional control programs.

All four detailed hazards analyses that were precursors to this hazard analysis (WHC-SD-SNF-PHA-001, HNF-2032, HNF-2456, and HNF-SD-SNF-SAD-002) and this hazard analysis were reviewed for hazards that could be initiators for "off-normal or abnormal operations" and warrant brief coverage in the SAR. Abnormal events are defined as operating conditions resulting from situations outside of normal operations, where normal operations are defined by process flow diagrams, system design descriptions, and operation and maintenance procedures. Consequences from abnormal events are typically standard industrial hazards that may include worker exposure to ionizing radiation. Events having radiological consequences greater than allowed by the facility radiological protection and ALARA (as low as reasonably achievable) programs do not fit the abnormal event profile and are required to be analyzed as accidents by the DOE safety analysis process. Abnormal events, their means of detection, consequences, and potential corrective actions are identified in Table 4-3.

Table 4-1. Summary of S2 and S3 Hazard Items (2 Sheets).

Initial Consequence Estimate	ID	Energy Source	Hazard Condition/Potential Accident
S2/F2	B.1	Nuclear Criticality	Load drops, seismic events, misloading, etc.
S3/F2	C.1	Kinetic/ Linear	Truck and trailer movement of the cask–MCO, or moving forklift or highlifter
S2/F2	C.2A	Kinetic/ Linear	Transfer bay crane moving cask/IXM; cask/IXM or hook catches gantry structure
S2/F2	C.2B	Kinetic/ Linear	Transfer bay crane moving cask/IXM; cask/IXM strikes NLOP/SLOP causing basin damage
S3/F1	E.1	Pressure/ Volume	Mis-installed MCO shield plug (vent port closed); exceeds 24-hour shipping window
S2/F2	E.2	Pressure/ Volume	Pressure in vessel, pumps, or piping; IXMs, Annular Filter Vessel, above-water piping causes spray release
S1/F2	E.3	Pressure/ Volume	Pipe/valve failure of backup service water supply to basin causes overflow of basin, spilling water (although S1, this event included because it is a carry-over event that is included in the K Basins SAR as a DBA).
S2/F2	E.4	Pressure/ Volume	Piping failure or mis-operation results in pumping water out of the basin
S2/F2	F.1	Mass, Gravity, Height	Heavy load drop damages basin boundary (excluding drain valves)
S2/F2	F.1A	Mass, Gravity, Height	Cask–MCO dropped: into IPSS, onto IPSS, onto IPSS bottom plate, onto SLOP curb, onto operations deck and then tip-and-hit the SLOP curb
S2/F2	F.2	Mass, Gravity, Height	Load drop/seismic forces damage the basin drain valves resulting in loss of water
S3/F2	F.3	Mass, Gravity, Height	Fuel containers or rack lifted out of water causing high radiation or fuel fire
S3/F1	F.4	Mass, Gravity, Height,	DBE causes failure of gantry while loading the MCO scrap basket at the highest point; basin drains down causing high radiation and fuel ignition
S2/F1	G.1	Flammable Materials	Hydrogen buildup results in hydrogen burn or explosion (Included because of potential for worker fatality).
S2/F2	G.2	Flammable Materials	Liquid fuel (from either forklift, high-lifter, or MCO transport tractor) spills and burns impacting transfer bay critical column. Failure of a critical column could result in the transfer bay bridge crane and supporting structural members dropping onto the annular filter vessel.

Table 4-1. Summary of S2 and S3 Hazard Items (2 Sheets).

Initial Consequence Estimate	ID	Energy Source	Hazard Condition/Potential Accident
S3/F1	G.3	Flammable Materials	Crane hydraulic oil leaks while performing operations above the south loadout pit and oil pools around gantry column and burns. Gantry fails and drops MCO basket, which perforates floor and results in loss of basin water.
S3/F2	K.1	Thermal	Loss of cooling results in basin water heatup to beyond limit, followed by MCO shipment and release
S3/F1	L.1	Explosive Pyrophoric	Uranium hydrides accumulated in fuel canister causes rapid burn of the fuel
S3/F1	L.2	Explosive Pyrophoric	Buildup of metal uranium metal particles causes fuel fire in settler or knockout pot; or air sparge of an annular filter vessel
S3/F1	L.3	Explosive Pyrophoric	Uranium metal/uranium hydrides burn due to dryout of basin
S3/F2	N.1	Natural Phenomena	Earthquake (DBE)
S3/F1	P.3	Loss of Power	General or partial power failure, reduced voltage; surge causes cask–MCO to hang up on crane, exceeding shipping window and causing release

DBA = design basis accident
DBE = design basis earthquake
IPSS = immersion pail support structure
IXM = ion-exchange module
MCO = multi-canister overpack
NLOP = north loadout pit
SAR = safety analysis report
SLOP = south loadout pit

Table 4-2. Summary of S1 (Worker Safety) Hazards (2 sheets).

Initial frequency estimate	ID[1]	Energy source	Description
F2	W.E.1	Pressure-Volume	Fuel Retrieval System flow in addition to recirculation pump bypass to IXMs caused by misvalving air monitoring equipment or incorrect cartridge filter start up after replacement, causing a decrease in the basin water quality resulting in increased worker exposure
F2	W.E.2	Pressure-Volume	Pipe break, clogged filter, or improper valving causes low or no flow resulting in contamination or increased worker exposure
F2	W.E.3	Pressure-Volume	Misloading of MCO (too many scrap baskets, excess fuel fines) causes cask to be pressurized during loadout, resulting in potential of contamination release through cask seals
F2	W.E.4	Pressure-Volume	Inadequate helium purge of loaded MCO during preshipping processing causes cask to be pressurized during loadout, resulting in potential of contamination release through cask seals
F3	W.F.1[2]	Mass, gravity, height	Equipment drops in pool creating a splash resulting in an aerosol release and ALARA problems during recovery
F2	W.F.2	Mass, gravity, height	Knockout pot too heavy when lifted resulting in equipment damage, potential worker injury, and possible contamination of the basin work area from splash
F3	W.F.3[2]	Mass, gravity, height	Process dip tube not seated correctly prevents shield plug from seating and results in a high radiation stream
F3	W.G.1	Flammable material	Combustible material (e.g., shipping crates, pallets, windbreak material, impact-limiting foam, plastic containment tents, anticontamination clothing) ignites and impacts critical structural columns by direct flame impingement and hot gas layer
F1	W.J.1	Radiation	Transfer of contaminated water to air lines, receiver, and compressor results in additional exposure to worker
F2	W.J.2	Radiation	Waste pad and shipping dock store spent IXMs and packaged cartridge filters (awaiting disposal or stored improperly) resulting in increased worker exposure
F2	W.J.3	Radiation	Cs-137 trapped in piping and valves generates hot spots which results in increased worker exposure
F2	W.J.4	Radiation	Loss of basin water level decreases shielding over the basin source terms resulting in increased worker exposure
F1	W.M.1	Hazardous material	Loading wrong resin into IXM results in potential to increase worker exposure

Table 4-2. Summary of S1 (Worker Safety) Hazards (2 sheets).

Initial frequency estimate	ID[1]	Energy source	Description
F1	W.P.1	Loss of power	Loss of radiation monitors result in the potential for workers to receive increased exposure

[1] Event identifier is provided for cross-reference to Table C-2
[2] Hazards that are considered initiators of "abnormal events"

ALARA = as low as reasonably achievable
IXM = ion-exchange module
MCO = multi-canister overpack
NLOP = north loadout pit

Table 4-3. Hazard Initiators for Potential Abnormal Event for K Basins (3 Sheets).

Event	Means of detection	Consequences	Corrective Actions[1]
Immersion pail lid seal fails during cask loadout operations, outside of cask, and the MCO is contaminated	HPT Surveillance	• Increased occupational radiation exposure • Operational delay	• Evaluate situation (e.g., at what level amount, location, etc. if contamination found and determine path forward • Decontaminate as necessary • Perform shipping window TSR actions as necessary
FRS equipment failure, leakage, or mis-operation causes some sludge and/or canister liquid to be discharged directly to the basin instead of to the IWTS.	• Operator observation • HPT surveillance	• Increased basin water turbidity and reduced sight capabilities • Small increase in occupational radiation exposure to personnel due to increased basin contamination	Run IWTS as necessary to clear up turbidity and reduce basin water dose levels
FRS manipulator arm drops a fuel element on the floor	Operator observation	Increased occupational radiation exposure	• Initiate manual retrieval of the element following approved procedures
MCO basket loading interrupted	Operator surveillance	Possible increased dose during recovery	• Place MCO basket in a safe position and suspend MCO loading operations • Evaluate the situation for safe recovery (which may include manual operation of the MCO loading system grapple to lower basket) • Generate and perform recovery plan, as necessary • Evaluate situation to ensure that MCO shipping window will not be exceeded
MCO basket gets stuck in go-no-go gauge	Operator observation	Operational delay	• Try to unstick MCO basket (if successful, then evaluate the basket for damage and proceed per management direction) • If MCO basket cannot be unstuck, or if the MCO basket is unstuck, but visual observation of the MCO basket shows damage, suspend FRS operations • Evaluate the situation • Generate and perform a recovery plan

Table 4-3. Hazard Initiators for Potential Abnormal Event for K Basins (3 Sheets).

Event	Means of detection	Consequences	Corrective Actions[1]
Small equipment or tools are dropped into the basin	Operator observation	• Splash or aerosol release • Increased occupational radiation exposure	• Contact health physics if water is splashed outside of the basin or onto personnel • Evaluate the situation • Generate and perform recovery plan, as necessary
The stuck fuel equipment cutter encounters a sludge pocket and stirs the sludge, adding contamination to the basin water	• Operator observation • HPT surveillance	Increased occupational exposure as a result of increased basin dose rate	• Suspend stuck fuel equipment operations • HPT surveillance • Run IWTS as necessary to clear turbidity and reduce basin water dose levels
Hydraulic leak in FRS manipulator	• Operator observation • Operator surveillance • Water conductivity monitored downstream of IXM	• Changes the chemistry of the basin water, affecting water treatment and exposing personnel to chemicals, and causes potential injury from pressurized spray • Problems with the IXM – potential reduction in decontamination factor for cesium causing ALARA problems	• Suspend manipulator operations by placing equipment in a safe position • Notify management and contact first aid as required • Perform maintenance to get manipulator back in service • Evaluate the IXMs for potential problems and change out IXMs as necessary
Loss of flow through IWTS recirculation loop because of recirculation pump failure, clogged line, or instrument malfunction	• Operator observation • Operator surveillance • Control terminal instrumentation • HPT surveillance	• Higher dose rate and higher resuspension rate from the basin water • Equipment repair will increase occupational radiation exposure to personnel • Operational delay	• Suspend FRS and sludge/debris removal operations • HPT surveillance • Evaluate situation • Generate and perform a recovery plan to restart operation of the IWTS (e.g., unclog line, perform maintenance on the recirculation pump or instrument, replace the recirculation pump)

Table 4-3. Hazard Initiators for Potential Abnormal Event for K Basins (3 Sheets).

Event	Means of detection	Consequences	Corrective Actions[1]
Small leak in above-water piping	• Continuous air monitor • Area radiation monitors • HPT observation • Operator observation	• Higher dose rate from loss of water shielding • Aerosol release	• Suspend FRS and sludge/debris removal operations • HPT surveillance • Evaluate situation • Generate and perform a recovery plan that stops the leak
Process dip tube inadvertently contacts top MCO basket during MCO shield plug installation	Operator surveillance	• Potential equipment damage • Unloading damaged baskets (may not have room to replace them in the queue) • Operational delay • Increased occupational radiation exposure	• Remove shield plug and place in a safe condition • Evaluate the situation (including visual verification that the basket was not damaged) • Generate and perform recovery plan, as necessary
FRS manipulator collides with other equipment or manual tools	Operator observation	• Force of impact injures operator and equipment • Equipment repair may increase occupational radiation exposure to personnel • Operational delay	• Suspend manipulator operations by placing equipment in a safe position • Notify management and contact first aid as required • Evaluate situation • Generate and perform recovery plan

[1] Actions to be evaluated during recovery.

ALARA = as low as reasonably achievable
FRS = Fuel Retrieval System
HPT = health physics technician
IXM = ion-exchange module
IWTS = Integrated Water Treatment System
MCO = multi-canister overpack
TSR = technical safety requirement

5.0 REFERENCES

DOE-76-45-19, 1979, *Job and Task Analysis*, U.S. Department of Energy, Washington, D.C.

DOE-STD-3009-94, 1994, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

HNF-2032, 1998, *SNF Fuel Retrieval Sub-Project Safety Analysis Document*, Rev. 0, DE&S Hanford, Richland, Washington. (Peck, S. H., 1998)

HNF-2456, 1998, *SNF Cask Loadout System Sub-Project Safety Analysis Document*, DE&S Hanford, Richland, Washington.

HNF-3262, 1998, *Facility Vulnerability Assessment Phase 3 Final Report*, Rev. 0, January 20, DE&S Hanford, Inc., Richland, Washington.

HNF-PRO-455, *Solid Waste Management*, Fluor Daniel Hanford, Incorporated, Richland, Washington.

HNF-PRO-704, *Hazard and Accident Analysis Process*, Project Hanford Policy and Procedure System, Fluor Daniel Hanford, Incorporated, Richland, Washington.

HNF-SD-SNF-RD-001, 1999, *Spent Nuclear Fuel Project Standards/Requirements Identification Document*, Rev. 2, DE&S Hanford, Inc., Richland, Washington.

HNF-SD-SNF-FHA-001, 1999, *Fire Hazards Analysis for the K Basins Facilities at 100 K Area*, Rev. 1, Fluor Daniel Hanford, Inc., Richland, Washington.

HNF-SD-SNF-SAD-002, 1998, *Integrated Water Treatment System Subproject Safety Assessment Document*, Rev. 2, DE&S Hanford, Richland, Washington.

HNF-SD-SNF-SEL-001, *Safety Equipment List for K Basins*, Rev. 2, DE&S Hanford, Richland, Washington.

HNF-SD-SNF-TI-015, 1998, *Spent Nuclear Fuel Project Technical Databook*, Rev. 6, DE&S Hanford, Richland, Washington.

HNF-SD-TP-SARP-017, 1998, *Safety Analysis Report for Packaging (Onsite) Multicanister Overpack Cask*, Rev. 1, Waste Management Federal Services, Inc., Richland, Washington.

WAC 173-303, "Dangerous Waste Regulations," *Washington Administrative Code*, as amended.

WHC-SD-SNF-PHA-001, 1994, *Preliminary Hazards Analysis of K-Basin Fuel Encapsulation and Storage*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. (Strickland, G. C., 1994)

Williams, N. H., 1998, *Closure of Special Condition of Approval from the Fuel Retrieval Subproject Safety Evaluation Report*, (Letter FDH 9858841 to E. D. Sellers, U.S. Department of Energy, Richland Operations Office), October 19, Fluor Daniel Hanford, Inc., Richland, Washington.

Attachment A

HAZARDOUS MATERIAL LIST

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Table A-1. Hazardous Material List (2 Sheets).

	Hazardous Material	Location	Quantity
105 KE/KW Basin systems	Radiologically contaminated water	105 KE 105 KW	~1.2 E+06 gal ~1.2 E+06 gal
	Radionuclides:[1]		
	Pu-236 Pu-238 Pu-239 Pu-240 Pu-241 Pu-242 Am-241 Cm-244 Eu-154 Cs-134 Cs-137 Ce-144 Pr-144 Pr-144 Pm-147 Sb-125 Te-125 Ru-106 Sr-90 Y-90		
	Chemicals:		
	Purolite NRW-37	105 KW	315 gal
	Ion Exchange Resin Isopropyl Alcohol	105 KW	1 gal
	Plasti Dip Heavy Duty Flexible Rubber Coating	105 KE	19 gal
Other supporting structures, systems, and components	Radionuclides: 39 Spent IXCs	183.1 KW	
	Chemicals:		
	Hydraulic Fluid (for FRS)	190 KE	(2) 55 gal/drums
	Liquid Propane	190 KE	500 gal
	Dow Frost Heat Transfer Fluid	183 KE	807 gal
	Sodium Bicarbonate	183 KE	90 gal
	Liquid Alum (aluminum sulfate)	183 KE	empty
	Lubricating Oil	190 KE	12 gal
	Turbine Oil	190 KE	25 gal
	Buffer Reagent for PC Hardness Analyzer	183 KE	3.5 gal
	Purolite NRW-37 Ion Exchange Resin	183.1 KW	39 IXCs
	Magnafloc 990-N	183 KE	1205 gal
	Sulfuric Acid	190 KE	5 gal
	Valvoline Oil SAE30	190 KE	26 gal
	Amercoat 90 HS Resin	190 KE	30 gal
	Delo 400 SAE 40 HD Motor Oil	190 KE	40 gal
	Sodium Hydroxide	183 KE	4 gal
	Turbine Oil	183 KE	33 gal
	Indicator Solution for Pump Calorimeter Total Alka	183 KE	14 gal
	Turbine Oil	190 KE	23 gal
	Ethyl Alcohol, 200 proof	1717 K	1 gal
	Coffing Transmission Oil	1717 K	20 gal
	Dectol R&O Oil 68, Conoco	1717 K	22 gal
	Regal Oil R&O 220	1717 K	199 gal
	Sili Kroil	1717 K	3 gal
	Jet-Lube TFW	1717 K	1 gal

Table A-1. Hazardous Material List (2 Sheets).

	Hazardous Material	Location	Quantity
Other supporting structures, systems, and components cont.	Chemicals cont.:		
	WD-40	1717 K	1 gal
	PPG Interior Enamel Semi-Gloss Acrylic Latex	1717 K	620 gal
	Amberlite IR-120 Cation Exchange Resin	1706 KE	748 gal
	Krylon Spray Paint	165 KE	10 gal
	Lectra Clean II	165 KE	1.4 gal
	Sodium Sulfite	1706 KEL	less than 1 gal[5]
	Lead	Recycle[4]	20 ft^3 maximum
	P-Bis (O-Methylstyryl)Benzene	SAA[2]	1.5 gal
	Toluene	SAA[2]	20 gal
	Toluene	90d SP[3]	55 gal
	Sulfuric Acid	Recycle[4]	20 ft^3 maximum
	Nitric Acid	1706 KE	17 gal
	Liquid Nitrogen	Lab	80 gal
	Isopropyl Alcohol	1705 KE	23 gal
	Sodium Hydroxide	1706 KE	2 gal
	Unleaded fuel, Conoco (in carbon steel tank)	1717 KE	154 gal

[1] HNF-SD-SNF-TI-015, *Spent Nuclear Fuel Project Technical Databook*, Rev. 6, DE&S Hanford, Richland, Washington.

[2] This is an established satellite accumulation area (SAA) and is under the control of the operator. The requirements for establishing this SAA are based on WAC-173-303, "Dangerous Waste Regulations," and PHMC procedure HNF-PRO-455, *Solid Waste Management*. Weekly inspections are performed and documented per HNF-PRO-455.

[3] This is an established <90-day storage area and is under the control of the operator. The requirements for establishing, maintaining, and inspecting this <90-day storage area are based on WAC-173-303 and HNF-PRO-455. The volume and percentage of primary chemicals fluctuate based on plant operations and quantities shipped to a TSD.

[4] This recycle staging area is for staging of lead acid batteries, non-PCB ballasts, aerosol cans, non-regulated oil, and fluorescent light bulbs. These materials are considered recycled and are shipped to the recycle consolidation center.

[5] Quantity represents heel left in the bottom of a 50-gal tank.

FRS = Fuel Retrieval System
KE = K East
KW = K West
IXC = ion-exchange column
PCB = polychlorinated biphenyl
PHMC = Project Hanford Management Contract
SAA = satellite accumulation area
TSD = treatment, storage, and disposal facility

Attachment B

HAZARD BASELINE - ENERGY CHECKLIST

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Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
A. Electrical Note: All electrical hazards are standard industrial hazards with the exception of loss of power, which is covered by external events (see hazard P.4)	1. Battery banks	N/A	Two battery rooms in basement of 165 KE (used for switchgear, rectifiers and distribution panels - part of the DC system)	None[1]
	2. Diesel units	N/A	N/A	N/A
	3. High voltage lines	N/A	230kV power poles	None[1]
	4. Transformers	Power transformers	Power transformers	None[1]
	5. Wiring	AC/DC system	AC/DC system	None[1]
	6. Switchgear	480V switchgear at 105 KE/KW	• 230 kV switchgear at the 151 K substation • 13.8 kV switchgear in the 165 K Building • 480V switchgear The system ends at the load side of the motor control center or at the secondary side of the transformers for voltages below 480V	None[1]
	7. Underground wiring	N/A	Underground tunnel	None[1]
	8. Cable runs	Various cable raceways	Various cable raceways	None[1]
	9. Service outlets and fittings	110/120V outlets are located throughout the 105 KE/KW Basin temporary welding receptacle GFIs are located throughout the basin	110/120V outlets Temp welding receptacle	None[1]

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
A. Electrical cont.	10. Electric motor driven pumps	Recirculation pump (3) Booster pump (part of the IWTS system) (KW only) Skimmer pump B-Sump pumps C-Sump pumps D-Sump pumps Submersed pumps for the PCM, decapper, and process table High-pressure pump for the PCM Hydraulic pump for the manipulator Pump for the chiller Sludge pumping equipment (electrical submersible pump) Boiler circulation pumps Air conditioning pumps Air compressor	River pumps: raw water pumps (1500 HP motor) Potable water pumps (3) (300 HP motor) Service water pumps (300 HP) Backwash pumps (300 HP motor) Water treatment facility pumps Sample pumps Outfall samplers Outfall sample pumps/piping Outfall temperature and flow monitoring Low lift pumps Septic system pumps Air compressor	None[1]
	11. Other motors	PCM lid motor Building exhaust fans Decapper exhaust Air exhauster/sampler motors Motor 3-way valves MLS gantry drive Exhaust blowers (each basin has four roof mounted) Each basin has two evaporative coolers used for summer conditions	Control/valve room (165E) contains most motor-operated valves for raw/service water systems	None[1]
	12. Heaters	Hot water boilers (8) Unit heaters Heat pumps	Unit heaters Heat pumps Water treatment structure unit heaters	None[1]
	13. Power tools	Used during construction, maintenance, and operations	Used during construction, maintenance, and operations	None[1]
	14. Hoists	Various electric hoists are mounted on manually and motor-operated trolleys rated up to 32 ton Tractor motors for hoist and flexible transfer crane	15-ton bridge crane 25-ton bridge crane	None[1]

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
A. Electrical cont.	16. Other	Electrical roll-up doors Instrumentation and cameras	Traveling water intake screen (motorized) Raw water, bypass valve cross tie (electric motorized) Electrical roll-up doors	None[1]
B. Nuclear Criticality	1. Vaults	N/A	N/A	N/A
	2. Temporary storage areas	Accumulated sludge storage: KE weasel pit KW dummy elevator pit KE/KW sand filter backwash pit (NLOP) KE/KW floor sludge KW technical view pit Water treatment: Knockout pots (KW) Particulate settler tanks (KW weasel pit) Annular filter vessel DXMs, sand filters Fuel storage: Main basins MCO basket queue	39 spent DXCs (183.1 KW)	Yes
	3. Receiving areas	N/A	N/A	N/A
	4. Casks	MCO, Chem-Nuclear Cask, PAS-1 sampling cask		Yes
	5. Burial grounds	N/A	N/A	N/A
	6. Storage tanks	N/A	N/A	N/A
	7. Storage racks	Fuel storage racks on floor of each basin (KE/KW)/MCO basket queue	N/A	Yes
	8. Canals and basins	N/A	N/A	N/A
	9. Decon solution	N/A	N/A	N/A
	10. Trucks, forklifts, dollies	DXM, DXC transport, cask transporters	DXM, DXC transport, cask transporters	Yes
	11. Hand carry	N/A	N/A	N/A
	12. Cranes/lifts	Monorail and chain hoists; transfer bay crane; gantry	N/A	Yes

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
B. Nuclear Criticality cont.	13. Hot cells, assembly	N/A	N/A	N/A
	14. Inspection areas	Process table	N/A	Yes
	15. Other	N/A	N/A	N/A
C. Kinetic/ Linear	1. Cars/trucks/ buses	Trailer and truck	Trailer and truck	Yes
	2. Forklifts/ dollies/carts	Forklift/dollies/carts/highlifters	Forklift/dollies/carts used to move storage containers in holding area (low level waste)	Yes
	3. Railroad	Rail system deactivated	Rail system deactivated	None
	4. Obstructions (collision with)	Building structures, basin structures, and process equipment	Building structures and process equipment	Yes
	5. Crane loads in motion	Canisters, IXMs, casks, cask–MCO and related equipment, MCO baskets, debris Maintenance and construction loads	Maintenance, construction and warehousing loads; IXMs, IXCs	Yes
	6. PV blowdown	Compressed gas cylinders	Compressed gas cylinders	None[1]
	7. Other	N/A	N/A	N/A
D. Kinetic/ Rotational	1. Centrifuges	N/A	N/A	N/A
	2. Motors	Tipper station; PCM drive	N/A	None[1]
	3. Pumps	All pumps with exposed shafts	All pumps with exposed shafts	None[1]
	4. Cooling tower fans	N/A	N/A	N/A
	5. Shop equipment	Power tools	Machine tools and power tools	None[1]
	6. Other	Air operated trailer landing gear Gantry shaft	N/A	None[1]
E. Pressure - Volume	1. Boilers	Package boilers - KE/KW	N/A	None[1]
	2. Heated surge tanks	Boiler expansion tank/air separator	N/A	None[1]
	3. Autoclaves	N/A	N/A	N/A
	4. Test loops and facilities	N/A	N/A	N/A

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
7. Pressure - Volume cont.	5. Gas bottles	Inert gas system Compressed gas cylinders SCBA Various gas cylinders	Bottle gas system	None[1]
	6. Pressure vessels	Housing of cartridge filters vessel Sand filter IXMs Air chilled evaporator Knockout pots Particulate settler vessel Annular filter vessels Compressed air vessel MCO (once shield plug is installed) Cask–MCO Chem-Nuclear casks PAS-1 casks Piping	N/A	Yes
	7. Stressed members	N/A	N/A	N/A
	8. Gas receivers	Shop air receiver	Shop air receivers	None[1]
	9. Negative pressure collapse	N/A	N/A	N/A
	10. Other	Pressurized water wands; Immersion pail lid seal Trailer brakes	N/A	None[1]
F. Mass, Gravity, Height	1. Human effort	Long-handled manual tools: Manual tongs/air-operated tong Hand-operated trolley system Moving carts Manually operated locking pin on top of the IPSS Maintenance, construction, and operations	Maintenance, construction and operations Moving carts Manual hoists	None[1]

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
F. Mass, Gravity, Height cont.	2. Stairs	Various building stairs Operations platform Cask loadout trailer stairs	Various stairs Water Treatment Facility	None[1]
	3. Lifts and cranes	Canisters, knockout pots IXMs, casks Cask–MCO and related equipment MCO baskets, debris Maintenance and construction loads	Maintenance, construction and warehousing loads IXMs, IXCs Low level waste containers	Yes
	4. Bucket and ladder	Maintenance activities	Maintenance activities	None[1]
	5. Trucks	Truck deliveries in and out of the transfer area	Truck deliveries in other areas	Yes
	6. Slings	Construction, maintenance, and operations	Construction, maintenance, and operations	None[1]
	7. Hoists	Construction, maintenance, and operations	Construction, maintenance, and operations	Yes
	8. Elevators	N/A	N/A	N/A
	9. Jacks	Truck jacks, pallet jacks	Truck jacks, pallet jacks	None[1]
	10. Scaffolds and ladders	Construction, maintenance, and operations	Construction, maintenance, and operations	None[1]
	11. Pits and excavations	Basin and pits	Construction activities	None[1]
	12. Elevated doors	N/A	N/A	N/A
	13. Vessels	N/A	N/A	N/A
	14. Other	Building structure and grating Roll-up door Deteriorating roof FRS Manipulator drops	Roll-up door Deteriorating roof	Yes
G. Flammable Materials	1. Packing materials	4 x 4 x 8 shipping crates, pallets	4 x 4 x 8 shipping crates, pallets	Yes
	2. Rags	Cleaning rags and anti-c	Cleaning rags	Yes
	3. Gasoline	Forklift, truck, and cranes	Gasoline fuel storage: Vehicles in parking lot	Yes

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
G. Flammable Materials cont.	4. Oil	Chiller, crane, hoist Manipulator hydraulic fluid	Motor oil Bearing lubrication Oil storage	Yes
	5. Coolant oil	N/A	N/A	N/A
	6. Paint solvent	Solvents and cleaners	Paints	None[2]
	7. Diesel fuel	Forklift used in waste accumulation area - 30 gal diesel fuel tank Trucks in transfer area (100 gal) Mobile crane for construction purposes	Truck, forklift, mobile cranes	Yes
	8. Buildings and contents	Building roofs, windbreak, electrical installation material	Building roofs, wood structures, electrical installation material	Yes
	9. Trailers and contents	Personnel trailers (mobile offices), vehicle tires	Personnel trailers (mobile office), vehicle tires	None[2]
	10. Grease	Small amount in bearings/gearboxes	Small amount in bearings/gearboxes	None[2]
	11. Hydrogen (including battery banks)	Knockout pots Canisters, basin sludge Particulate settler IXMs/IXCs; cask–MCO Annular filter vessels	IXCs (183 KW)/battery rooms each provided with dedicated fans to ensure H gas is released.	Yes
	12. Nitric acid	N/A	N/A	None[1]
	13. Organics	Decon solution	Decon solution	None[2]
	14. Gases - other	Freon/chiller Glycol/failure of basin heaters or piping P-10 gas used for portal monitors Oxygen/acetylene	Oxygen/acetylene	None
	15. Spray paint	Maintenance use	Maintenance use and storage	None[2]
	16. Other	Adjoining facility material storage	N/A	None[2]

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
H. Corrosive	1. Acids	Vehicle batteries	Vehicle batteries DC battery system	None[1]
	2. Caustics	N/A	Caustic cleaners	None[1]
	3. "Natural" chemicals (soil, air, water)	N/A	N/A	N/A
	4. Decon solutions	Maintenance use	N/A	None[1]
	5. High temperature waste	N/A	N/A	N/A
	6. Other	Nitric acid	N/A	None[1]
J. Radiation	1. Canals	N/A	N/A	N/A
	2. Plug storage	N/A	N/A	N/A
	3. Storage areas	Accumulated sludge storage: KE weasel pit KW dummy elevator pit KE/KW sand filter backwash pit (NLOP) KE/KW floor sludge KW technical view pit IXCs Water treatment: Knockout pots (KW) Particulate settler tanks (KW weasel pit) Annular filter vessel IXMs, sand filters, pumps and piping Fuel storage: Canisters; MCO basket queue; cask–MCO	Storage pad (IXMs)	Yes
	4. Storage buildings	N/A	183.1 KW (IXC storage)	Yes
	5. Radioactive sources	Check sources	N/A	None[1]
	6. Waste and scrap	Waste accumulation areas in transfer bay of each basin	Waste pad shipping dock	None

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
J. Radiation cont.	7. Contamination	Contaminated water and contaminated areas in both K Basins	N/A	None[1]
	8. Irradiated experimental and reactor equipment	N/A	N/A	N/A
	9. Electric furnace	N/A	N/A	N/A
	10. Blacklight (e.g., magniflux)	N/A	N/A	N/A
	11. Laser	N/A	N/A	N/A
	12. Medical x-ray	N/A	N/A	N/A
	13. Radiography equipment and sources	N/A	N/A	N/A
	14. Welding	Construction and maintenance	Construction and maintenance	None[1]
	15. Electric arc, other (high current circuits)	N/A	N/A	N/A
	16. Electron beam	N/A	N/A	N/A
	17. Equipment noise	Pumps, motors, power tools, etc.	Pumps, motors, power tools, etc. Noise from venting of raw water pumps (tunnel)	None[1]
	18. Ultrasonic cleaners	N/A	N/A	N/A
K. Thermal	1. Bunsen burner/ hot plates	N/A	N/A	N/A
	2. Electrical equipment	Unit heaters and space heaters Electrical motors and pumps	Space heaters Electrical furnaces heaters Switchgear room Electrical motors and pumps	None[1]
	3. Furnaces/ boilers/heater	Boiler package in KE/KW	Unit heaters	None[1]
	4. Steam lines	N/A	N/A	N/A
	5. Welding torch/arc	Construction and maintenance	Construction and maintenance	None[1]

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
K. Thermal cont.	6. Diesel units/fire box/ exhaust line	Truck exhaust	Truck exhaust	None[1]
	7. Radioactive decay heat	Decay heat from fuel Cask–MCO	N/A	Yes
	8. Exposed components	N/A	N/A	N/A
	9. Power tools	High speed grinders	High speed grinders	None[1]
	10. Convective	Motors, lighting, instrumentation, control panels	Motors, lighting, instrumentation, control panels	None[1]
	11. Solar	N/A	N/A	N/A
	12. Cryogenic	N/A	N/A	N/A
	13. Other	N/A	N/A	N/A
L. Explosive Pyrophoric	1. Caps	N/A	N/A	N/A
	2. Primer cord	N/A	N/A	N/A
	3. Dynamite	N/A	N/A	N/A
	4. Scrub chemicals	N/A	N/A	N/A
	5. Dusts	N/A	N/A	N/A
	6. Hydrogen (including battery banks and water decomposition)	Knockout pots Canisters/decapping Basin sludge Particulate settler Cask–MCO Annular filter vessels	Battery rooms each provided with dedicated fans to ensure H gas is released. IXCs (183.1 KW)	Yes
	7. Gases, other	N/A	N/A	N/A
	8. Nitrates	N/A	N/A	N/A
	9. Peroxides	Hydrogen peroxide used to control algae in basins	N/A	None[1]
	10. Pu and U metals	Fuel assemblies, fuel scrap, uranium hydrides, knockout pots, settlers, annular filter vessel	N/A	Yes
	11. Sodium	N/A	N/A	N/A
	12. Other	N/A	N/A	N/A

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
M. Hazardous Material	1. Alkali metals	N/A	N/A	N/A
	2. Asphyxiants	Basin water (drowning) Vehicle exhaust Inert gases for welding/maintenance	Clearwells (underground water storage reservoirs with depth ~20 ft water) (drowning)	None[1]
	3. Biologicals	Spiders/insects/snakes/mice	Spiders/insects/snakes/mice	None[1]
	4. Carcinogens	PCBs (in sludge)	PCBs (possible residual from transformers)	None[3]
	5. Corrosives	Battery acid	Vehicle battery acid Battery room	None[1]
	6. Asbestos	Building/piping	Building/piping	None
	7. Oxidizers	Decon agents	Decon agents	None[1]
	8. Dusts and particulates	Sand and dust Volcanic ash Construction and demolition	Sand and dust Volcanic ash Construction and demolition	None[1]
	9. Beryllium and compounds	In-fuel braze rings (underwater)	Potentially 1706-KE	None[3]
	10. Chlorine and compounds	N/A	N/A	N/A
	11. Heavy metal	Pu, U, lead, lead paint	Lead, lead paint	None
	12. Other	N/A	Sodium hydrochloride, aluminum sulfate	None
N. Natural Phenomena	1. Earthquake	Design basis earthquake	Design basis earthquake	Yes
	2. Flood	N/A	Yes	Yes
	3. Lightning	Yes	Yes.	Yes
	4. Rain	Yes	Yes	Yes
	5. Snow, freezing weather	Yes	Yes	Yes
	6. Straight wind	Yes	Yes	Yes
	7. Dust devil	(Covered by straight wind)	(Covered by straight wind)	N/A
	8. Tornado	(Covered by straight wind)	(Covered by straight wind)	N/A
	9. Ashfall	Yes	N/A	Yes

Table B-1. Hazard Baseline - Energy Checklist (12 Sheets).

Type of Hazard	Form of Hazard	105 KE/KW Basin	Other Supporting Structures, Systems, and Components	Hazards Requiring Additional Analysis
P. External Events	1. Explosion	N/A	N/A	N/A
	2. Fire	Yes	Yes	Yes
	3. Events at other sites	Yes	Yes	Yes
	4. Loss of power	Yes	Yes	Yes
R. Vehicles in Motion (external to facility)	1. Airplane	Commercial, general, and military	N/A	Yes
	2. Helicopter	Commercial, general, and military	N/A	Yes
	3. Train	N/A	N/A	N/A
	4. Truck/bus/car	Only authorized vehicle travel permitted within K Basin. Only two public roads that cross the Hanford Site. Remaining roads are restricted access roads.	N/A	None[1]
	5. Other	River barge and boat traffic	N/A	None[1]

[1] Considered to be a standard industrial hazard.

[2] Considered to be a standard fire hazard covered by the K Basins Fire Hazards Analysis (HNF-SD-SNF-FHA-001) and not considered for further evaluation.

[3] Considered to be a toxicological hazard, but when radiological consequences are controlled to meet radiological limits and guidelines, toxicological consequences will also be below toxicological guidelines.

AC = alternating current
DC = direct current
GFI = ground fault interruptor
IPSS = immersion pail support structure
IWTS = Integrated Water Treatment System
IXC = ion-exchange columnm
IXM = ion-exchange module
KE = K East
KW = K West
MCO = multi-canister overpack
MLS = MCO loading system
N/A = not applicable
NLOP = north loadout pit
PCB = polychlorinated biphenyl
PCM = primary clean machine
PV = pressure--volume
SCBA = self-contained breathing apparatus

Attachment C

HAZARD ANALYSIS WORKSHEET

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HAZARD ANALYSIS WORKSHEET

The following is a description of the Hazard Analysis Worksheet columns:

Column Number	Description of Content
1	Assigns a numeric identifier to a specific accident.
2	Identifies the energy source "hazard" from the energy source checklist in Appendix B.
3	Briefly describes the hazardous condition.
4	Identifies the cause of the hazardous condition (typically Human Error, Equipment Failure, or Natural Phenomena, or all three).
5	Describes the potential accident associated with the hazard energy and hazardous condition.
6	Contains a qualitative assessment of the result of the potential accident.
7	Identifies equipment or administrative controls credited to prevent consequences of the accident.
8	Contains a qualitative estimate of the frequency of the event, divided into two sections, without and with credited prevention measures.
9	Identifies equipment or administrative controls credited to mitigate consequences of the accident.
10	Contains a qualitative estimate of the consequence of the event divided into two sections, without and with credited mitigation measures.
11	Identifies other equipment or controls that provide additional measures for prevention or mitigation of the accident, which are not credited in the accident analysis but do provide defense-in-depth protection.
12	Provides risk ranking (from Figure 3-3 in DOE-STD-3009-94) and accident identification for cross-reference.

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Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
B.1	Nuclear Criticality[1] (B2, B4, B7, B10, B12, B14, J3)	Load drops, seismic events, misloading, etc.	Human error Equipment failure Seismic event	Failure to control fuel arrangement (mass, enrichment, geometry, form) (Specific accident conditions covered in detail in the related CSERs) (See K Basins CSER for extensive analysis of criticality hazards.)	Criticality[1]	Administrative Controls: Nuclear Criticality Safety Program Controls on fuel arrangement Design Features: Knockout pots; knockout pot screen; particulate settler tubes; annular filter vessel; knockout pot lifting tool; monorail stops (IWTS only); PCM support structure; process table support structure; MCO basket queue; MCO; Mark IA MCO baskets; canisters; racks; basins	F2	F0	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S2	S1	Administrative Controls: Personnel qualification Operational surveillances Mass controls Fuel form and enrichment controls Dimensional quality control verifications Accountability/campaign letters Design Features: Geometric design of components; spacing controls; basin water cover; inspection methods (CCTV)	N/A (see Chapter 6.0 and CSERs)
C.1	Kinetic/ Linear (C1, C2, C4, F5, J3)	Truck and trailer movement of cask–MCO or moving forklift or highlifter	Human error Equipment failure	Transport truck or forklift/ highlifter exceeds speed limit, strikes building structure or gantry structure causing damage, potentially falling into basin, damaging basin or rearranging fuel	Release Criticality[1]	Administrative Controls: Vehicle movements Nuclear Criticality Safety Program Design Features: Bumpers; sand filter; ixmx; building columns; loadout pit curbs	F2	F0	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S3	S0	Administrative Controls: Load limitations/engineering calculations Personnel qualification Vehicle configuration Operational surveillances Annual maintenance Weight verifications	8 (3.4.2.11 Uncontrolled Vehicle)
C.2A	Kinetic/ Linear (C4, C5, J3)	Transfer bay bridge crane moving cask/IXM	Human error Equipment failure	Cask or hook strikes gantry, knocks gantry into pool causing leak, spills an MCO basket on floor	Release Criticality[1]	Administrative Controls: Heavy load controls Nuclear Criticality Safety Program Engineering Evaluations: Drop calculations	F2	F1	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation Design Feature: Gantry and support structure	S2	S0	Administrative Controls: Hoisting and rigging controls Load limitations/engineering calculations Personnel qualification Accident response (leak mitigation) Operational surveillances Annual maintenance Weight verifications Design Features: Impact limiting structures (drain valve covers); reinforced concrete basin structure	5 (3.4.2.1 Heavy Load Drop)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
C.2B	Kinetic/ Linear (C4, C5, J3)	Transfer bay bridge crane moving cask/DXM	Human error Equipment failure	Cask or DXM impacts NLOP/SLOP curb, damages NLOP/SLOP causing basin leak, [bounded by tip-and-hit curb accident (drain down to -6"-6" level)]	Release Worker Dose	Administrative Control Heavy load controls	F2	F1	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S2	S1	Administrative Controls: Hoisting and rigging controls Load limitations/engineering calculations Personnel qualification Accident response (leak mitigation) Operational surveillances Design Features: Reinforced concrete basin structure; controlled lifting devices (shackles, slings, etc.); mitigation material (bentonite, sand bags, etc.)	5 (3.4.2.2 Cask–MCO Drops)
E.1	Pressure-Volume (E6, P4)	Incorrect installation of MCO shield plug (vent port closed and rupture disk closed); exceeds 24-hour shipping window; overpressure during inert gas purge	Human error	Pressurize cask causing cask failure; cask leak	Release Worker fatality	Administrative Controls: MCO assembly controls Shipping window control Basin water temperature controls Design Features: Cask–MCO; MCO HEPA filter; helium purge system, cask vent tool, cask access lift device (to access cask when hung on transfer bay bridge crane)	F1	F0	Administrative Control: Cooling and depressurization of MCO	S2	S1	Administrative Controls: Personnel qualification Independent check	3 (3.4.2.5 MCO Shipping)
E.2	Pressure-Volume (E6, J3, J4)	Pressure in vessel, pumps, or piping: DXMs, annular filter vessel, above water piping and pumps containing basin water	Human error Equipment failure Seismic event	Component failure/leak causes spray release	Release High radiation	Design Feature: Vessel design and over-pressure protection (as applicable)	F2	F2	Administrative Control: Operator response Design Features: Continuous air monitoring and radiation monitoring IWTS radiation monitoring	S2	S1	Administrative Controls: Operational surveillances Radiation Protection Program Design Features: IWTS equipment enclosures (vessels, booster pump, etc.); guarded pipe	5 (3.4.2.7 Spray Release)
E.3	Pressure-Volume (E6)	Pipe/valve failure of backup service water supply to basin	Human error Equipment failure Seismic event	Overflow basin, spill water	Release (environmental)	Administrative Control: Basin water level controls	F1	F1	Administrative Control: Basin water level controls	S1	S1		1 (3.4.2.8 Overflow of Radioactive Water from Basin)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
E.4	Pressure-Volume (E6)	Piping failure or mis-operation	Human error Equipment failure Seismic event	Failure of piping or component or equipment mis-operation results in pumping water out of basin	Release Criticality[1]	Administrative Control Basin water level controls	F2	F1	Administrative Controls: Water addition and leak mitigation Facility manning requirements Design Feature: Piping and suction control	S2	S1	Administrative Controls: Operational surveillances Authorized inspections Radiation Protection Program Design Features: IWTS equipment enclosures (vessels, booster pump, etc.); guard pipe; IWTS radiation monitor; Continuous air monitors; area radiation monitors	8 (3.4.2.9 Pump-out/Siphoning of Radioactive Water from Basin)
F.1	Mass, Gravity, Height (F3, F7, J3)	Heavy load drop (e.g., canisters, knockout pots, DKMs, MCO baskets, debris, maintenance and construction loads)	Human error Equipment failure Seismic event	Dropped load damages basin boundary (excluding drain valves) resulting in loss of basin water Rearrange or spill fuel	Release Criticality[1]	Administrative Controls: Heavy load controls Nuclear Criticality Safety Program Engineering Evaluation: Drop calculations Design Features: IPSS/IP; MCO basket shuttle; PCM support structure; process table support structure; MCO queue; knockout pots; lifting devices (limit drop height)	F3	F3	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S2	S1	Administrative Controls: Hoisting and rigging controls Personnel qualifications Operational surveillances Annual maintenance Weight verifications Independent check Design Features: Monorail stops and inter-locks; asphalt barrier and sump system	7 (3.4.2.1 Heavy Load Drops)
F.1A	Mass, Gravity, Height (B4, F3)	Heavy load drop	Human error Equipment failure Seismic event	Cask–MCO dropped: • Into IPSS • Onto IPSS • Onto IPSS bottom plate • Onto SLOP curb • Onto floor; tip-and-hit south loadout pit curb	Release Criticality[1]	Administrative Control: Heavy loads controls Engineering Evaluation: Drop calculations Design Feature IPSS/IP	F2	F2	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S2	S1		5 (3.4.2.2 Cask-MCO Drops)
F.2	Mass, Gravity, Height (F3, F7, J3)	Load drop (e.g., canisters, debris, settler, maintenance and construction loads)	Human error Equipment failure Seismic event	Dropped load/seismic forces potentially damages basin drain valve resulting in loss of basin water	Release Criticality[1]	Administrative Control: Nuclear Criticality Safety Program Engineering Evaluation: Drop calculations Design Features: IPSS/IP; horizontal beam on south loadout pit west wall; operations interface platform; drain valve covers; drain line plugs	F3	F0	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S2	S1	Administrative Controls: Hoisting and rigging controls Personnel qualifications Operational surveillances Annual maintenance Weight verifications Independent check Design Features: Asphalt barrier and sump system	7 (3.4.2.3 Damage to Drain Valve from an Operational Drop)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
F.3	Mass, Gravity, Height (F7)	Overlift fuel containers	Human error Equipment failure Seismic event	Fuel containers and/or racks lifted out of water causing high rad and/or fuel fire or aerodynamic entrainment	Release High Radiation	Administrative Control: Independent check Design Features: Lifting devices; gantry and support structure	F3	F1	Administrative Control: Radiation Protection Program	S3	S1	Administrative Controls: Hoisting and rigging controls Load limitations/engineering calculations Personnel qualification Design Features: Continuous air monitors; area radiation monitors; hoists controls; fuel handling hooks	9 (3.4.2.4 SNF Overlifts)
F.4	Mass, Gravity, Height (F7)	Pyrophoric scrap is exposed to air and ignites	Seismic event	DBE occurs while gantry is loading an MCO scrap basket. Gantry fails with MCO basket in highest position while basin water drains.	Release High Radiation	Engineering Evaluation	F1	F0	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation	S3	S1	Design Features: Lifting devices; gantry and support structure	6 (bounded by 3.4.2.4 SNF Overlifts)
G.1	Flammable Materials (G11,L6)	Hydrogen buildup in knockout pots, canisters, basin sludge, particulate settlers, annular filter vessels, IXMs/IXCs, cask–MCO	Human error Equipment failure	Hydrogen burns/ explosion	Release Worker Fatality	Administrative Controls: Shipping window control Basin water temperature controls Design Features: Knockout pots; particulate settler; annular filter vessel; MCO	F1	F1	Administrative Control: Cooling and depressurization of MCO Design Features: Cask Venting Tool Cask access lift device (to access cask when hung on transfer bay bridge crane)	S2	S1	Design Features: Structural design of components (cask–MCO, knockout pots, annular filter vessels, particulate settlers, IXMs/IXCs)	3 (3.4.2.5 MCO Shipping) (3.4.2.6 Explosions)
G.2	Flammable Materials (G7)	Diesel fuel (from either forklift, high-lifter, or MCO transport tractor) spills and burns Gasoline fires will have impacts to the facility that are comparable to the diesel fire.	Equipment failure	Diesel fuel spills and burns (either pooling around critical columns resulting in structural failure or excessive heat builds up in ceiling resulting in structural failure). If a column critical to the transfer bay bridge crane is impacted, the transfer bay bridge crane and supporting structural members could drop onto the annular filter vessels and release some of its contents.	Worker fatality Release	Administrative Controls: Vehicle controls (fuel quantity limitations) Fire Protection Program Vehicle maintenance and inspections Design Features: Critical columns on concrete stanchions prevent pooling Transfer Bay Floor sloped away from most columns	F2	F0	Administrative Controls: Emergency Response Program Hanford Site fire fighters Transfer bay door open during cask delivery/pick-up (allows heat to escape) Design Features: Floor drains Roof vents	S2	S1	Administrative Controls: Basin water maintains coverage over fuel Vehicle entry procedure Design Features: Shielding enclosure protects IWTS annular filter vessels Roof vents allow hot gas to vent Floor sloped towards drains	5 (3.4.2.13 Fires)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
G.3	Flammable Materials (G4)	Crane hydraulic oil leaks and is ignited	Equipment failure	Crane hydraulic oil leaks while performing operations above the south loadout pit and oil pools around gantry column and burns. Gantry fails and drops MCO basket, which perforates floor and results in loss of basin water.	Release	Engineering Features: Transfer bay bridge crane Shuttle with impact-limiting foam (to catch basket and prevent it from impacting floor)	F1	F0	Administrative Controls: Fire Protection Program Hanford Site fire response	S3	S1	Administrative Controls: Transfer bay bridge crane preventive maintenance Engineered Controls: Operations interface platform limit items falling into the south loadout pit IPSS and IP limit absorb energy and limit items falling into the south loadout pit Configuration of south loadout pit with installed hardware	6 (3.4.2.13 Fires)
K.1	Thermal (K7)	Radioactive decay heat from stored fuel, pump heating and lighting in basin	Human error Equipment failure Seismic event	Loss of cooling system results in heatup of basin water to greater than allowed limit for shipping a cask--MCO resulting in overpressurization Shipped cask--MCO that leaks or fails	Release	Administrative Controls: MCO shipping controls Basin water temperature controls Design Feature: Cask--MCO	F2	F1	Administrative Control: Cooling and depressurization of MCO	S3	S1	Administrative Controls: Personnel qualifications Independent check	8 (3.4.2.5 MCO Shipping)
L.1	Explosive pyrophoric (L10)	Pyrophoric uranium hydrides accumulated in fuel canister due to plugged canister vent	Chemical reaction Equipment failure	Rapid burn of fuel or fuel element underwater in decapper or PCM	Release	Engineering Evaluation	F1	F0	Administrative Control: Basin water	S3	S1		6 (3.4.3.1 Underwater Fuel Burns)
L.2	Explosive pyrophoric (L10, N1)	Buildup of uranium metal particles	Chemical reaction (auto ignition)	Fuel fire in particulate settler or knockout pots caused by heatup; loss of basin water; or overlift; or air sparge in annular filter vessel	Release	Administrative Controls: Basin water level controls Controls for water addition and leak mitigation Engineering Evaluation	F2	F1	Administrative Controls: Controls for water addition and leak mitigation	S3	S1	Administrative Control: Slow accumulation rate	6 (3.4.2.4 SNF Overlift) (3.4.2.12 Rapid Oxidation of Fuel Fines)
L.3	Explosive pyrophoric (L10, N1)	Uranium metal/uranium hydrides dryout	Human error Equipment failure Seismic event	Loss of basin pool water cause uranium metal/uranium hydrides dryout creating rapid oxidation of uranium fuel	Release	Administrative controls: Vehicle movements Heavy loads Basin water level controls Water addition and leak mitigation Design Features: Bumpers; sand filter; IXMs; building columns; loadout pit curbs	F1	F0	Administrative controls: Basin water level controls Controls for water addition and leak mitigation Engineering Evaluation	S3	S1	Design Feature: Building provides limited confinement	6 (3.4.2.4 SNF Overlift)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
N.1	Natural Phenomena (N1, F14)	Earthquake (DBE)	Seismic event	DBE causes basin leakage or fuel rearrangement	Release Criticality[1]	None	F2	F2	Administrative Controls: Controls for water addition and leak mitigation; Nuclear Criticality Safety Program Design Features: Basin, Basin water level, Building superstructure, Transfer bay bridge crane, Canisters, PCM support structure, Process table support structure, MCO basket queue, MLS shuttle, Gantry, IPSS/IP, Drain valve covers	S3	S1	Design Features: Asphalt barrier and sump system	8 (3.4.2.10 Design Basis Earthquake)
N.2	Natural Phenomena (N2)	Flood (DBF)	Columbia River floods	Loss of river pumps	None		F1	N/A		S0	N/A	None	N/A
N.3	Natural Phenomena (N3, N4, N5, N6, N9)	Lightning, Rain, Snow, Freezing Weather, Straight Wind, Ashfall (All facility design basis events)	Weather conditions	Structural damage			F2	N/A	Building designed for these design basis events	S0	N/A	None	N/A
P.1	External Events (P2)	Fire (range fire)	Lightening strike, human error, etc.	Loss of electrical (fire can't get near basin)	See K Basin (SAR) Section 11.4							None	N/A
P.2	External Events (P3)	Events at other facilities	CVD accidents	See CVDF SAR	All accidents are prevented or mitigated by CVD		N/A			N/A			N/A
P.3	Loss of Power (P4)	General or partial power failure Reduced voltage Surge	BPA problem Human error Equipment failure Seismic event	Loaded cask–MCO hung-up on crane, exceed shipping window, access problem to vent system, loss of cooling water	Release	Administrative Controls: MCO assembly controls Shipping window control Basin water temperature controls Design Features: Cask–MCO; MCO HEPA filter; spray water source	F2	F0	Administrative control for cooling and depressurization of MCO	S3	S0	Design Features: Portable monitoring equipment Emergency lighting	8 (3.4.2.5 MCO Shipping)
R.1	Vehicles in Motion (R1)	Airplane	Human error Equipment failure	Crash of commercial, general, or military airplane		Beyond Extremely Unlikely	F0			S3			0 (Chapter 1.0)

Table C-1. Hazard Analysis Worksheet (7 Sheets).

ID	Energy Source	Hazardous Condition	Cause	Potential Accident	Potential Consequence	Available Credited Prevention and Defense-in-Depth Features	Qualitative Frequency		Available Credited Mitigation and Defense-in-Depth Mitigation	Qualitative Consequence		Defense in Depth	Risk Ranking (Accident ID)
							W/O	With		W/O	With		
R.2	Vehicles in Motion (R2)	Helicopter	Human error Equipment failure	Crash of commercial, general, or military helicopter		Beyond Extremely Unlikely	F0			S3			0 (Chapter 1.0)

[1] An extensive hazards analysis focused on criticality is provided in the K Basins CSERs and is documented in Chapter 6.0.

BPA	=	Bonneville Power Administration	IXC	=	ion-exchange column
CCTV	=	closed-circuit television	IXM	=	ion-exchange module
CSER	=	criticality safety evaluation report	MCO	=	multi-canister overpack
CVDF	=	Cold Vacuum Drying Facility	MLS	=	multi-canister overpack loading system
DBE	=	design basis earthquake	NLOP	=	north loadout pit
DBF	=	design basis flood	PCM	=	primary clean machine
HEPA	=	high-efficiency particulate air (filter)	SAR	=	safety analysis report
IPSS	=	immersion pail support structure	SLOP	=	south loadout pit
IWTS	=	Integrated Water Treatment System			

Table C-2. Workers Safety Hazard Analysis Worksheet (3 Sheets).

ID	Hazard energy	Hazardous condition	Cause	Potential accident	Potential Consequence	Potential Credited prevention	Frequency	Potential Credited mitigation	Consequence	Defense-in-depth or worker safety features
W.E.1	Pressure - Volume	Decreased filtration or IXM efficiency	Human error Equipment failure	FRS flow in addition to recirculation pump bypass to IXMs caused by misvalving air monitoring equipment or incorrect cartridge filter start up after replacement, causing a decrease in the basin water quality	Worker exposure	Air monitoring equipment Procedures for change out of filters and IXM	F2		S1	Radiation Protection Program
W.E.2	Pressure - Volume	Inadequate filtration from the C-Sump return	Human error Equipment failure	Pipe break, clogged filter, or improper valving causes low or no flow from sump return, resulting in contamination of the transfer bay area	Worker exposure	Procedures (Change out filters) Redundant Filter System	F2		S1	Radiation Protection Program Hazardous Waste Program
W.E.3	Pressure-Volume (W.E.4)	Pressurized MCO	Human error	MCO mis-loaded (too many scrap baskets, excess fuel fines)	Worker exposure	Administrative Control: Shipping window control	F2		S1	Radiation Protection Program Training Program
W.E.4	Pressure-Volume (W.E.3)	Pressurized MCO	Human error	Inadequate helium purge of loaded MCO during pre-ship processing	Worker exposure	Administrative Control: Shipping window control	F2		S1	Radiation Protection Program Training Program
W.F.1	Mass, Gravity Height	Equipment drop	Human error Equipment failure	During disassembly, sorting, or inspection, equipment is dropped into the pool creating a splash resulting in an aerosol release and ALARA problems during recovery of damaged equipment (e.g., a deformed basket)	Worker exposure	Engineered lifting points Material handling equipment will have a limited swing radius and limited position change rate Procedures Inspection	F3		S1	Radiation Protection Program Training Program Personnel Personnel Qualification Requirements
W.F.2	Mass, Gravity, Height	Knockout pot too heavy	Equipment failure	During lifting of knockout pot, the pot is dropped causing damage to lifting equipment and contamination of basin	Worker exposure	Design Features: Knockout Pot Safety Class: physical strength to withstand drop loads without failure; screens limit particle size in downstream equipment Hoist Controls	F2		S1	Hoisting and Rigging Controls Personnel Qualifications Load Limitations Engineering Calculations
W.F.3	Mass, Gravity, Height	Process dip tube not seated correctly	Human error Equipment failure	During installation of MCO shield plug, the process dip tube does to seat correctly causing the MCO shield plug to not seat, which results in a high radiation stream	Worker exposure	Cameras Basket geometry Procedures Qualified operators	F3		S1	Radiation Protection Program Continuous Air Monitoring Area Radiation Monitoring
W.F.5	Mass, Gravity, Height	Immediate high radiation dose	Human error Equipment failure	FRS manipulator brings fuel element too close to surface of basin water or throws fuel element of out water	Worker exposure	Engineering evaluation determines that this is not a credible event (Williams 1998) Manipulator design	F0		S1	Radiation Protection Program Area Radiation Monitoring

Table C-2. Workers Safety Hazard Analysis Worksheet (3 Sheets).

ID	Hazard energy	Hazardous condition	Cause	Potential accident	Potential Consequence	Potential Credited prevention	Frequency	Potential Credited mitigation	Consequence	Defense-in-depth or worker safety features
W.G.1	Flammable Materials (G1, G2, G8)	Combustible materials (e.g., shipping crates, pallets, windbreak material, impact-limiting foam, plastic containment tents, anticontamination clothing)	Human error Equipment failure	Combustible material ignites and impacts critical structural columns by direct flame impingement and hot gas layer	Worker exposure Minor release	Adminstrative Controls: Fire Protection Program (including combustible quantities and spacing limits, and controls on hot work) Impact-limiting foam encased in sheet metal or below water surface	F3		S1	Hanford Site fire reponse
W.J.1	Radiation	Transfer of contaminated water to air lines, receiver, and compressor	Equipment failure	Equipment contamination	Worker exposure	Check valve Procedure Operational surveillance	F1		S1	Radiation Protection Program
W.J.2	Radiation	Waste pad shipping dock stores spent IXMs and packaged cartridge filters awaiting disposal	Human error	Equipment stored improperly	Worker exposure	Fenced area Concrete pad etched with muriatic acid and coated with epoxy	F1		S1	Radiation Protection Program Hazardous Waste Control Program
W.J.3	Radiation	137Cs trapped in piping and valves	Human error Equipment failure	Generates hot spots in piping	Worker exposure	Procedures Samples are collected routinely Radiation fields monitored IXMs Cartridge filters	F2		S1	Radiation Protection Program
W.J.4	Radiation (J3, J4)	Accumulated sludge storage: KE Weasel Pit; KW Dummy Elevator Pit; KE/KW Sand Filter Backwash Pit (NLOP); KE/KW floor sludge; KW Technical View Pit; IXCs Water Treatment: Knockout Pots (KW); Particulate Settler; Tanks (KW weasel pit); Annular Filter Vessel; IXMs; Sand Filters; Pumps and Piping Fuel Storage: Canisters; Decapper; Stuck Fuel Station; PCM; Process Table; MCO Baskets; Cask–MCO; Stiffback Grapples	Human error Equipment failure Seismic event	Loss of shielding	High radiation	Administrative Controls: Basin water level controls Radiation Protection Program Design Features: Basin/basin water Equipment enclosures	F2		S1	Administrative Controls: Operational Surveillances Personnel Qualifications Authorized Inspections Design Feature: Continuous Air Monitoring Area Radiation Monitoring
W.M.1	Hazardous Material	Loading wrong resin into IXM	Human error	Vender ships wrong resin Plant personnel load wrong resin	Possible selective removal of plutonium from basin water leading to criticality module	Procedures Training Cognizant Engineer oversight at loading	F1		S1	Beyond Extremely Unlikely

Table C-2. Workers Safety Hazard Analysis Worksheet (3 Sheets).

ID	Hazard energy	Hazardous condition	Cause	Potential accident	Potential Consequence	Potential Credited prevention	Frequency	Potential Credited mitigation	Consequence	Defense-in-depth or worker safety features
W.P.1	Loss of Power (P4)	Partial power failure Reduced voltage Surge	Human error Equipment failure Natural phenomena	Loss of safety-significant radiation monitoring for annular filter vessels	Unmonitored buildup of sludge causing increased dose to workers		F1	Surveillance Program	S1	Radiation Protection Program Loss of Radiation Monitor Alarm

ALARA = as low as reasonably achievable
FRS = Fuel Retrieval System
KE = K East
KW = K West
IXC = ion-exchange column
IXM = ion-exchange module
MCO = multi-canister overpack
NLOP = north loadout pit
PCM = primary clean machine
PHMC = Project Hanford Management Contract

Attachment D

K BASIN HAZARD ANALYSIS TEAM MEMBERS

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Attachment D

K BASIN HAZARD ANALYSIS TEAM MEMBERS

This K Basins hazard analysis was prepared by combining the hazards analysis from previous subproject and K Basins analyses. This integrated K Basins Hazard analysis was developed by the following personnel, who were also participants in the previous hazard analysis work, and are as follows:

Gail Chaffee (100 K Basins Nuclear Safety)
Bob Meichle (K Basins Nuclear Safety Subject Matter Expert)
Steve Peck (FRS Nuclear Safety Subject Matter Expert)
Lynn Semmens (IWTS Nuclear Safety Subject Matter Expert)
Roger Webb (CLS Nuclear Safety Subject Matter Expert).

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