Original Destroyed Use as Original mw 10/21/98

S

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 648808

Proj. ECN

2. ECN Category (mark one) Supplemental [] Direct Revision [x] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	3. Originator's Name, Organization, MSIN, and Telephone No. Lynn S. Semmens, SNF, X3-85, 373-9099	4. USQ Required? [] Yes [x] No	5. Date 10/20/98
	6. Project Title/No./Work Order No. A.9/KW Basin Integrated Water Treatment System	7. Bldg./Sys./Fac. No. NA	8. Approval Designator S,Q, D
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-SNF-SAD-002 REV 1	10. Related ECN No(s). NA	11. Related PO No. NA

12a. Modification Work [] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	12b. Work Package No. NA	12c. Modification Work Complete na Design Authority/Cog. Engineer Signature & Date	12d. Restored to Original Condition (Temp. or Standby ECN only) na Design Authority/Cog. Engineer Signature & Date

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

Complete document to be replaced with Revision 2 which incorporates updated safety analysis and criticality analysis. Updates include updates to event frequencies, source terms, dispersion parameters, dose conversions. Criticality evaluations for current designs of annular filter vessels and knockout pots are provided. Format has been changed ~~to~~ to be consistent with and facilitate update of the K Basin SAR for fuel removal operations. RLM 6/11/98

No USQ is required because this ECN does not change the facility or its procedures. However, it does provide information for input to the K Basin SAR which will eventually be submitted to DOE for approval to operate the system.

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

Updates required to reflect current design and updated accident parameters and to reformat to match SAR format.

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

Bergsman, KH (2)	X3-85	Meichle, RH	X3-79
Harrington, SB	R3-26	Morgan, RG	R3-26
Hoefer, VL	X3-76	Semmens, LS (5)	X3-85
Johnson, HL	X3-78	Rasmussen, RW	X3-85
Kurta, JM	X3-74	SNF Project Files	R3-11
Loomis, JE	X3-85	K Basin Project Files	X3-85

RELEASE STAMP

DATE: HANFORD RELEASE

STA: 4 ID: 58

OCT 21 1998

A-7900-013-2 (05/96) GEF095

A-7900-013-1

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) 648808

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	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	[]	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

21. Approvals

Signature	Date	Signature	Date
Design Authority K. H. Bergsman L.S. Semmens per telecon	6/11/98	Design Agent NA	
Cog. Eng. L. S. Semmens L.S. Semmens	6/11/98	PE NA	
Cog. Mgr. D. W. Bergmann DWB	6/11/98	QA NA	
QA H. L. Johnson L.S. Semmens per telecon	6/11/98	Safety NA	
Safety R. H. Meichle RH Meichle	6/11/98	Design NA	
Environ. NA		Environ. NA	
Project Mng R. W. Rasmussen RW Rasmussen	6-11-98	Other NA	
Operations V. L. Hoeffer CA Thomp	6/11/98		
SRB P. G. LeRoy PG LeRoy	6-11-98		
~~Engineering J. M. Kurtz~~ RWM 6/11/98			

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature NA

98-SFD-169

ADDITIONAL

S

K West Integrated Water Treatment System Subproject Safety Analysis Document

L.S. Semmens
Fluor Daniel Northwest, Inc., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

ECN: 648808
Org Code: 403
B&R Code: EW3135040
UC: 510
Charge Code: LDK2C
Total Pages: 276

Key Words: K Basin Water Treatment System, IWTS, Safety Analysis, Accident Evaluation

Abstract: This Accident Analysis evaluates unmitigated accident scenarios, and identifies Safety Significant and Safety Class structures, systems, and components for the K West Integrated Water Treatment System.

DATE:
STA: 4
HANFORD RELEASE
ID: 58
OCT 2 1 1998

10/20/98

Release Approval Date

Release Stamp

Approved for Public Release

RECORD OF REVISION

(1) Document Number: HNF-SD-SNF-SAD-002, Rev. 2

Page 1

(2) Title
K West Integrated Water Treatment System Subproject Safety Assessment Document

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
	(7)		
0	EDT: 621521		
1	ECN: 635910 Complete Revision.		
RS 2	ECN: 648808 Complete Revision which incorporates updated safety analysis and criticality analysis.	L.S. Semmens L S Semmens	S.H. Peck R L Marusich for 10/19/98

K WEST BASIN
INTEGRATED WATER TREATMENT SYSTEM SUBPROJECT
SAFETY ANALYSIS DOCUMENT

HNF-SD-SNF-SAD-002
Revision 2

June 11, 1998

This page intentionally left blank.

EXECUTIVE SUMMARY

This Safety Analysis Document (SAD) defines hazards associated with operation of the K West Basin integrated water treatment system (IWTS), documents the safety analysis, and identifies the need for controls to ensure safe operation of the IWTS equipment. The SAD provides the K West Basin IWTS safety basis in support of the revisions of the *K Basin Safety Analysis Report* (SAR)[1], technical safety requirements (TSR), and the K Basin safety equipment list. This SAD is part of the package of material provided to the U.S. Department of Energy (DOE) in support of Critical Decision 3B. Preoperational testing, startup, and operation of the IWTS equipment will be authorized based on DOE review and approval of the revised K Basin SAR. The K East Basin will be addressed in a separate document.

E.1 FACILITY BACKGROUND AND MISSION

The K Basins are located on the south bank of the Columbia River near the north end of the Hanford Site. The K Basins, built in the early 1950's, are two large basins for underwater storage of irradiated fuel produced by the K Reactors. K Reactor fuel stored in the basins was shipped for processing to the 200 East Area after the reactors were shut down in the early 1970's.

[1]DESH, 1998, K Basins Safety Analysis Report, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Incorporated for Fluor Daniel Hanford, Incorporated, Richland, Washington.

The K Basins presently store a large quantity of N Reactor spent nuclear fuel (SNF), which has been deteriorating for many years. The SNF Program was formed in 1994 to manage the 2130 metric tons of SNF located in various Hanford Site facilities. The recommended path forward[2] requires removing the spent fuel from the K Basins and placing it in interim dry storage at a new facility on the Site. The IWTS Subproject was established to provide the equipment necessary to support retrieving, cleaning, and loading the SNF in multi-canister overpack (MCO) baskets. The scope of the IWTS analyzed and addressed in this document is limited to the K West Basin. This scope is defined in the *Specification for Design, Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment System*[3].

E.2 FACILITY OVERVIEW

The *K Basins Safety Analysis Report*[1] provides descriptions of the K East and K West Basin storage facilities. The facilities consist of the two fuel storage basins (K East and K West) and related support facilities. Table E-1 of the K Basins SAR[1] lists the buildings and facilities that support the K Basin fuel storage mission. Inactive buildings are the responsibility of the Environmental Remediation and Restoration contractor.

---

[2]WHC, 1994, *Hanford Spent Nuclear Fuel Project Recommended Path Forward,* WHC-EP-0830, Westinghouse Hanford Company, Richland, Washington.

[3]Bergsman, K. H., 1998, *Specification for Design, Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment System,* WHC-S-0564, Rev. 1A, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

The IWTS filters water from the fuel retrieval system (FRS) operations and maintains basin water quality for dose minimization and water clarity. The IWTS supplies treated water for fuel removal processes and other uses in the basin. Major components of the IWTS include the following:

- Submerged pumps and intake interfaces
- Filtration units (knockout pots, particulate settlers, annular filters)
- Ion exchange modules.

The following water treatment system and facility systems will be modified as part of the IWTS:

- Basin recirculation (interface)
- Skimmer loop (interface)
- Treated water supply and demineralized water makeup
- Monorail above the knockout pots
- Tie-in to the existing K Basin electrical system
- Transfer area arrangement.

E.3 FACILITY HAZARD CLASSIFICATION

The hazard classification for K Basins fuel storage in the 100-K Area of the Hanford Site has been established and documented in the *K-Basins Fuel Encapsulation and Storage Hazard*

Categorization[4]. This hazard categorization addressed the potential for release of radioactive and nonradioactive hazardous material located within the K Basins and their supporting facilities. The analysis covered normal K Basin fuel storage and handling operations, fuel encapsulation, and canister clean-up and disposal. The K Basins are hazard category 2 facilities. As shown in the *Hazard Categorization for K West Integrated Water Treatment System*[5], the K West IWTS does not change the existing K Basins hazard category.

E.4 SAFETY ANALYSIS OVERVIEW

This safety analysis considers potential releases of radioactive and hazardous material during normal and accident conditions. The hazard identification process systematically and thoroughly reviews the IWTS design and operations to identify hazards and select accidents and abnormal operations for further review. Hazards with the highest potential risk or consequences were chosen for accident analysis.

In the accident analysis, the unmitigated onsite and offsite dose consequences for the release of radionuclides were calculated. The unmitigated dose consequences were compared to the risk evaluation guidelines to establish the need for prevention and mitigation. Mitigated consequences

---

[4]Porten, D. R., 1994, *K-Basins Fuel Encapsulation and Storage Hazard Categorization,* WHC-SD-SNF-HC-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

[5]Semmens, L. S., 1997, *Hazard Categorization for K West Integrated Water Treatment System*, HNF-SD-SNF-HC-013, Rev. 0, DE&S Hanford, Incorporated for Fluor Daniel Hanford, Incorporated, Richland, Washington.

were compared to the risk evaluation guidelines. Tables ES-1 and ES-2 list the accidents and mitigated consequences associated with the IWTS installation and operation.

As a result of the hazards analysis, preventative and mitigative features and administrative controls have been identified. Safety class design features include the knockout pots, knockout pot screens, particulate settler vessels, and annular filter vessels. All safety class features are passive. The filter vessel radiation monitoring system is the only safety-significant structure system or component identified for the IWTS.

Table ES-1. Design Basis Accident Summary.

Section and accident	Frequency per year	Consequences rem EDE (Sv)					
		Onsite (100 m)		Near river bank (480 m)		Hanford Site boundary (12,040 m)	
		EDE	Guideline	EDE	Guideline	EDE	Guideline
3.4.2.1 Spray release from stream 9 (booster pump to annular filter vessel)	Less than 1.0 E-02 (unlikely)	1.59 E-01 (1.59 E-03)	10	8.92 E-03 (8.92 E-05)	NA	2.69 E-04 (2.69 E-06)	0.5
3.4.2.2 Spray release from stream 10 (filter backwash) maximums	Less than 1.0 E-02 (unlikely)	8.43 E+00 (8.43 E-02)	10	2.48 E-01 (2.48 E-03)	NA	5.95 E-03 (5.95 E-05)	0.5
3.4.2.3 Filter vessel hydrogen deflagration	3.3 E-06 (extremely unlikely)	2.04 E+01 (2.04 E-01)	25	5.99 E-01 (5.99 E-03)	NA	9.97 E-03 (9.97 E-05)	0.5
3.4.2.4 Filter vessel fuel oxidation	5.8 E-06 (extremely unlikely)	1.18 E+01 (1.18 E-01)	25	5.26 E-01 (5.26 E-03)	NA	2.46 E-02 (2.46 E-04)	0.5
3.4.2.5 Drop of one K West ion exchange module onto another	Less than 1.0 E-02 (unlikely)	6.87 E-01 (6.87 E-03)	10	2.02 E-02 (2.02 E-04)	NA	3.36 E-04 (3.36 E-06)	0.5

EDE = effective dose equivalent.
NA = not applicable.

Table ES-2. Beyond Design Basis Accident Summary.

Section and accident	Frequency per year	Consequences, rem EDE (Sv)		
		Onsite (100 m)	Near river bank (480 m)	Hanford Site boundary (12,040 m)
3.4.3 Seismic event (fuel burn when water leak uncovers two top particulate settlers)	Beyond extremely unlikely	Note		2.50 E+00 (2.50 E-02)

Note: Post-earthquake releases occurring several days after the initiating event do not represent a risk to unprotected onsite receptors or to near-river occupants.

EDE = effective dose equivalent.

E.5 ORGANIZATIONS

As a subcontractor to Fluor Daniel Hanford, Incorporated, DE&S Hanford, Incorporated (DESH) is responsible for K Basin operations and the IWTS Subproject. Chem-Nuclear Systems, Inc., is the IWTS design agent. Principle IWTS vendors include the following:

- Fluor Daniel Northwest, Inc.
- Los Alamos Technical Associates
- Waste Management Federal Services, Inc., Northwest Operations.

E.6 SAFETY ANALYSIS CONCLUSIONS

This SAD provides information to support the conclusion that proposed installation and operation of the IWTS equipment and related K Basin facility modifications are in compliance with DOE and other agency rules, regulations and orders, and can be performed with acceptable risks to the public and onsite personnel.

The accidents analyzed include spray releases, hydrogen deflagrations, fuel oxidations, criticality events, and drop accidents. Where the unmitigated consequences of these accidents are not acceptable, safety class or safety significant design features and/or administrative controls have been implemented to prevent or mitigate the hazard.

Installation testing will not include handling any SNF. The scope of installation testing to be authorized is sufficient to ensure that the equipment is installed as specified and that the equipment and controls function.

E.7 SAFETY ANALYSIS DOCUMENT ORGANIZATION

This SAD has been prepared following the guidance contained in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*[6]. The structure and content of the SAD, its chapters and appendixes parallel the format delineated in that standard.

---

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

E.8 OUTSTANDING ISSUES AND DESIGN STATUS

This section provides identification of unresolved issues and gives an indication of the current status of the design. As the remaining issues are resolved and the design is completed, the configuration of the safety basis will be maintained. The revised K Basin SAR will reflect the final design.

IWTS design, equipment procurement, and preconstruction activities in the K Basin were approved by the DOE based on Critical Decision 3A. The preconstruction modifications include weasel pit cleanout, ion exchange module relocation, and piping and electrical installation. Installation of the remaining IWTS equipment and installation testing will be approved by the DOE based on information provided for review during the Critical Decision 3B process. This SAD is part of the package of material provided to DOE in support of Critical Decision 3B.

The following list summarizes the risks associated with approval of installation of the IWTS.

- Drops of equipment during installation. These drops have been evaluated to demonstrate that equipment drops will not result in leakage from the basins.

- Potential changes in the design of the IWTS equipment. The safety analysis and the design are sufficiently complete and conservative to minimize the risk associated with changes to the IWTS equipment or the safety analysis after installation has occurred. The design change control process provides reasonable assurance that any changes will be adequately reviewed to ensure that the change meets the safety analysis requirements.

As of May 1998, an issue is outstanding regarding the addition of "polishing filters" to the IWTS. Operational experience may result in polishing filters being added to maintain the clarity of the basin water. If the polishing filters are added, additional hazards and safety analyses will be performed, which may identify TSRs or other controls to be applied to IWTS operational activities.

Table ES-3 provides a status of the IWTS design and procurement as of May 1998. This table demonstrates that the risk of significant design changes is small.

The following two recently closed K Basin unreviewed safety questions (USQ) have some impact on IWTS equipment installation or installation acceptance testing.

- **Basin Perforation Issue (USQ K-97-0175)**. The intent of the weight–height lifting restrictions imposed to prevent fracture of the basin floor is met by IWTS.

- **Basin Drain Valve Issue (USQ K-97-0265)**. IWTS equipment and operations are over or in close proximity to basin drain valves in two cases. One case is the weasel pit, where the particulate settlers are located. The issue involves clean out of the weasel pit, settler installation, and operation. The second case is along the north wall of the basin where three drain valves are located. The IWTS project will be installing flexible hose along the length of the north wall above the location of the three drain valves. Resolution of the weasel pit clean out issue will be addressed by hazard/safety evaluation of the clean-out work package and USQ determination subject to required approvals in accordance with *Drain Valve Justification for Continued Operation* (JCO), DOE letter 98-SFD-063[7]. Resolution of the issues for installing the settlers and flexible hosing will be addressed by the closure evaluations for the JCO.

Table ES-3. IWTS Design and Procurement Status.

IWTS equipment	Design status	Procurement status
Submerged pumps	Complete	CNS procured - Used in FAT
Knockout pot	Refining design of internal features based on results of FAT	Prototype used in FAT
Particulate settlers	Complete for settlers, structural support modifications are in progress for drop and weasel pit seismic considerations	CNS fabricated particulate settlers - used in FAT
Booster pump	Complete	CNS procured - used in FAT
Annular filter vessels	Complete	CNS fabricated - used in FAT
Ion exchange modules	Complete (same as existing)	Procured, initial inventory on site
Piping and hoses (with exception of discharge piping)	Complete	CNS fabricated/procured - used in FAT
Piping and hoses (discharge piping and connections)	Complete	Being fabricated on site
Knockout pot lifting hook	In progress - key dimensions established	Not procured
Instrumentation and control	Complete except for annular filter vessel radiation monitor	CNS procured (except for the radiation monitor) - used in FAT
Air sparge vent	Preliminary design complete	Not procured
Annular filter vessel enclosure	Complete	Being fabricated

CNS = Chem-Nuclear Systems, Inc.
FAT = factory acceptance test

[7] Wagner, J. D., 1998, *Approval of K Basins Safety Analysis Report (SAR) WHC-SD-WM-SAR-062, Revision (Rev.) 3B and K Basins Technical Safety Requirements (TSR)*, Rev. 0-B, letter 98-SFD-063 to H. J. Hatch, Fluor Daniel Hanford, Inc., dated March 20, 1998, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Documents that provide source information for the safety analysis and/or implementation of safety criteria are identified in Table ES-4. Table ES-5 identifies the drawings used to define the physical configuration of the IWTS. In both tables, the "STATUS" column identifies the revision (Rev 0, 1, 2, etc.) with unreleased documents indicated as draft. The status identified is for May 1998.

Table ES-4. Source and Implementation Documents.

Document	Status
EDT 621526, *K West IWTS Design Report* and *K West IWTS Design Drawings*	Rev. 0
Technical Information and Calculations to support IWTS Design and Installation (currently unreleased)	draft
HNF-SD-SNF-TI-059, *A Discussion of the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*	Rev. 0
HNF-SD-SNF-FHA-001, *Fire Hazards Analysis for the K Basins Facilities at 100K Area*	Rev. 1 (draft)
WHC-SD-NR-CSER-011, *Criticality Safety Evaluation of the 100K Area Ion Exchange Modules and Ion Exchange Columns*	Rev. 1
HNF-SD-SNF-CSER-011, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems, Subproject A.9*	Rev. 1
HNF-SD-SQA-CSA-530, *CSER 97-005: Feasibility Study of the Criticality Safety of the 100 K East Basin Weasel Pit for Fuel Retrieval Sludge*	Rev. 0
HNF-SD-SNF-CN-006, *Evaluation of Radiolytic Gas Generation from Water Dissociation in a Multi-Canister Overpack*	Rev. 0
K West IWTS Interface Agreement Sheets	approved
WHC-SD-SNF-HC-001, *K-Basins Fuel Encapsulation and Storage Hazard Categorization*	Rev. 0
WHC-SD-NR-CSA-003, *K Basin Criticality Accident Analysis*	Rev. 0
HNF-SD-SNF-HC-013, *Hazard Categorization for K West Integrated Water Treatment System*	Rev. 0
HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Facility Standard Requirements Identification Document*	Rev. 1
HNF-1777, *K West Basin Integrated Water Treatment System (IWTS) E-F Annular Filter Vessel Accident Calculations*	Rev. 3
HNF-1778, *K West Basin Integrated Water Treatment System (IWTS) Spray Leak Accident Calculations*	Rev. 2
HNF-2862, *K West Basin Integrated Water Treatment System Ion Exchange Module, Particulate Settler, and Knock-Out Pot Accidents*	Rev. 0
WHC-SD-SNF-FRD-023, *Functions and Requirements for K Basin Transfer Bay Cranes - Project A.5-A.6*	Rev. 0
WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report*	Rev. 3C
HNF-SD-SNF-TI-009, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities*	Rev. 1
WHC-SD-NR-ANAL-014, *Consolidated Fuel Decay Heat Calculations*	Rev. 0
HNF-S-0564, *Specification for Design, Fabrication, Testing, and Technical Support for the K West Basin Water Treatment System*	Rev. 1A

Table ES-5. IWTS Equipment Design Drawings.

Document	Status
H-1-83301, KW Fuel Storage Basin WTS Process Flow Diagram Working (nominal) Values and (estimated) Maximum Values, sheets 1-2	Rev. 0
H-1-80550, KW Fuel Storage Basin WTS P & ID Fuel Retrieval Pumps, Knock-out Pot, Settler, and Booster Pump, sheet 8	Rev. 1
H-1-80550, KW Fuel Storage Basin WTS P & ID Filtration System, sheet 9	Rev. 1
H-1-80550, KW Fuel Storage Basin WTS P & ID IXM System, sheet 10	Rev. 1
H-1-80550, KW Fuel Storage Basin WTS P & ID Distribution System, sheet 11	Rev. 1
H-1-83310, KW Fuel Storage Basin WTS General Arrangement Plan Views, sheets 1-2	Rev. 0
H-1-83311, KW Fuel Storage Basin WTS General Arrangement Elevations	Rev. 0
H-1-83320, KW Fuel Storage Basin WTS Knock-Out Pot Assembly and Details, sheets 1-2	Rev. 2
H-1-83321, KW Fuel Storage Basin WTS Knock-Out Pot Hose & Piping Details	Rev. 0
H-1-83322, KW Fuel Storage Basin WTS Knock-Out Pot to Settler Piping Isometric	Rev. 0
H-1-83323, KW Fuel Storage Basin WTS Knock-Out Pot Screen	Rev. 0
H-1-83330, KW Fuel Storage Basin WTS Settler System, sheets 1-2	Rev. 3
H-1-83331, KW Fuel Storage Basin WTS Settler to Booster Pump Piping Isometric	Rev. 0
H-1-83332, KW Fuel Storage Basin WTS Settler Frame Assembly and Details, sheets 1-2	Rev. 3
H-1-83340, KW Fuel Storage Basin WTS Booster Pump Skid Assembly and Details, sheets 1-4	Rev. 1
H-1-83341, KW Fuel Storage Basin WTS Annular Filter Vessel Assembly and Details, sheets 1-4	Rev. 1
H-1-83342, KW Fuel Storage Basin WTS Filter Vessel Frame and Shielding, sheets 1-3	Rev. 1
H-1-83343, KW Fuel Storage Basin WTS Filter Vessel Inlet Baffle	Rev. 0
H-1-83344, KW Fuel Storage Basin WTS Filter Vessel Effluent Screen	Rev. 0
H-1-83345, KW Fuel Storage Basin WTS Filter Vessel Vent Screen	Rev. 0
H-1-83346, KW Fuel Storage Basin WTS Filter Vessel Top Sparger Screen	Rev. 0
H-1-83347, KW Fuel Storage Basin WTS Filter Vessel Piping Isometrics Sluice, Inlet, Outlet, Ventilation, and Service Air Headers, sheets 1-5	Rev. 1, draft
H-1-83349, KW Fuel Storage Basin WTS Filtration System Cold Vac. Inlet Spool Iso	Rev. 0
H-1-83350, KW Fuel Storage Basin WTS IXM System Piping Isometrics Inlet, Outlet, Drain, and Ventilation, sheets 1-3	Rev. 1, draft
H-1-83351, KW Fuel Storage Basin WTS IXM System Curbing and Platform Details, sheets 1-3	Rev. 1
H-1-83360, KW Fuel Storage Basin WTS Distribution Piping Isometrics, sheets 1-8	Rev. 1
H-1-83400, KW Fuel Storage Basin WTS Electrical I&C General Notes	Rev. 1
H-1-83401, KW Fuel Storage Basin WTS Electrical One Line	Rev. 1

This page intentionally left blank.

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TERMS

ALARA	as low as reasonably achievable
ARF	airborne release fraction
CVDF	Cold Vacuum Drying Facility
DBA	design basis accident
DESH	Duke Engineering & Service Hanford, Inc.
DOE	U.S. Department of Energy
EDE	effective dose equivalent
ERPG	Emergency Response Planning Guideline
FHA	fire hazards analysis
FRS	fuel retrieval system
HAZOP	hazards and operability
IWTS	integrated water treatment system
IXM	ion exchange module
JCO	justification for continued operations
LCO	limiting condition for operation
LCS	limiting control setting
MAR	material at risk
MCO	multi-canister overpack
MTU	metric tons uranium
RF	respirable fraction
SAD	safety analysis document
SAR	safety analysis report
SL	safety limit
SNF	spent nuclear fuel
SSC	structure, system, and component
TNT	trinitrotoluene
TRU	transuranic
TSR	technical safety requirement
URD	unit release dose
USQ	unreviewed safety question

1.0 SITE CHARACTERISTICS

Site characteristics are described in WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (DESH 1998). Implementing the integrated water treatment system (IWTS) does not change the K Basin site characteristics because the IWTS is located completely within the K Basins and is covered by the existing description.

The only design basis natural phenomenon identified in the K Basin SAR that applies to the IWTS is the design basis earthquake.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

2.0 FACILITY DESCRIPTION

2.1 INTRODUCTION

This chapter describes the K West Basin integrated water treatment system (IWTS) equipment and processes. The K East Basin IWTS will be addressed in a separate document. WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (SAR) (DESH 1998), describes the K Basin facilities and processes.

2.2 REQUIREMENTS

The facility standards and criteria that apply to the IWTS subproject are found in HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document* (Watson 1998). The specific standards and requirements that apply to the IWTS equipment are found in HNF-S-0564, *Specification for Design, Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment Systems* (Bergsman 1998).

2.3 FACILITY OVERVIEW

The IWTS is located in the 105K West Basin and transfer areas and is totally enclosed within the existing K Basin structures. The K Basins SAR (DESH 1998) contains an overview of the K Basin facilities.

2.4 FACILITY STRUCTURE

The IWTS pumps, knockout pots, and settler vessels are supported by the K West Basin floor. The filter vessels, ion exchange modules (IXM), and booster pump are supported by the K West Basin transfer area floor. Figure 2-1 shows the general location of this equipment within the K West Basin structure. The K Basins SAR (DESH 1998) describes these K Basin structures.

2.5 PROCESS DESCRIPTION

This section describes the IWTS equipment and operation. The IWTS maintains basin water quality during fuel retrieval and removal activities. The IWTS filters and treats the basin water to minimize dose and maintain water clarity. It also supplies treated water directly to the basin and to fuel removal processes in the basin. This system interfaces with the existing basin water treatment system associated with current fuel storage operations. The IWTS project features accommodate the increased radionuclide particulate and dissolved solids expected during fuel removal operations.

The IWTS treats the basin water by filtration and ion exchange. Basin water enters the IWTS through submerged pumps that provide suction to the areas where operations such as fuel retrieval system (FRS) canister decapping and fuel cleaning disperse sludge into the basin water. Other IWTS input streams include basin water from existing recirculation pumps, basin water returned by truck from the Cold Vacuum Drying Facility (CVDF) and basin water from existing skimmer pumps for periodic backwash. The ITWS nominal flow rate is 20 L/sec (320 gal/min) with minimum required input flow rates from the following FRS operations.

- Canister decapper (4.4 L/sec [70 gal/min), continuous)
- Primary clean machine (5 L/sec [80 gal/min], continuous)
- Process table (9.5 L/sec [150 gal/min], continuous).

Other IWTS input flows include the following:

- Recirculation pump flow (20 L/sec [320 gal/min], intermittent)
- Cold vacuum drying water return (3.8 L/sec [60 gal/min], intermittent)
- Skimmer loop for backwash (9.5 L/sec [150 gal/min], intermittent.

Treated water from the IWTS is supplied to the distribution header for delivery to the following basin users as required to meet operational needs.

- Multi-canister overpack (MCO): south loadout pit flush (13 L/sec [200 gal/min], continuous)

- MCO: cask rinse (0-1 L/sec [0-15 gal/min], intermittent)

- Fuel retrieval system operations (4 L/sec [60 gal/min], continuous)

- Discharge chute flush (2 L/sec [30 gal/min], continuous)

- Debris processing: pump supply (2 L/sec [30 gal/min], continuous)

- Debris processing: equipment flush (1 L/sec [15 gal/min], intermittent)

- Sludge removal: sludge line flush (0-3 L/sec [0-50 gal/min], intermittent)

- Excess water removal (0-5 L/sec [0-80 gal/min], intermittent).

Water in the basin is managed using a closed-loop system. Most water is circulated through the treatment system and returned to the basin users. Water that exceeds the needs of the basin users is returned to the basin via the south loadout pit at higher than required flow rates. The existing basin recirculation system will operate to cool the basin water and circulate it throughout the basin.

The new K West Basin IWTS subproject equipment and interfaces consist of the following subsystems:

- Submerged pumps and intake interfaces
- Filtration units (safety-class knockout pots and associated safety-class screens, safety-class particulate settlers, safety-class annular filter vessels and associated safety-significant radiation monitor)
- IXMs (same design as currently in use in basin)
- Basin recirculation (interface with existing system)
- Skimmer loop (interface with existing system)
- Treated water supply and demineralized water makeup
- Excess water removal.

The arrangement of equipment in the basin and transfer area is shown in Figures 2-2 and 2-3. Additional details for these subsystems and interfaces, prepared by the design agent, Chem-Nuclear System, Inc., are available in the K West IWTS design report and design drawings (Bergsman 1997). Bergsman (1997) lists the layout drawings, flow diagrams, and piping and instrumentation diagrams that describe the K West Basin IWTS and its interfaces with related systems such as the CVDF, fuel retrieval, plant air, and skimmer systems. The K Basins SAR (DESH 1998) describes the other K Basin processes.

2.5.1 K West Basin IWTS Equipment Description

This section describes the major equipment associated with the IWTS.

2.5.1.1 Submerged Pumps and Intake Interfaces. Three stainless steel submerged pumps and underwater hoses support the FRS. The intakes for these submerged pumps, which provide flow to the IWTS filtration units, are designed to provide suction to FRS operations. The pumps, located just above the fuel racks in the basin's west bay, include the following:

- A unit mounted on the FRS primary clean machine
- A unit mounted on a stand located about 3 m (10 ft) southwest of the FRS primary clean machine to support the FRS process table activities
- A unit mounted on a stand located about 3 m (10 ft) west of the FRS primary clean machine to support the FRS canister decapping activities.

Flexible nonmetallic hoses connect the pumps' discharge nozzles to a common header located in the middle of the basin's west bay. The header where the three pump flows join is stainless steel.

Basin water is returned to the IWTS from the CVDF. The water is treated (filtration and ion exchange) at the CVDF, then transferred to a truck and returned to the IWTS on the suction side of the booster pump. This allows the water from CVDF to be pumped through the IWTS filters and IXMs before being returned to the basin.

2.5.1.2 Filtration Units. Filtration equipment includes a series of units that remove particulate in graduated steps. These filtration units, described in sections 2.5.1.2.1 through 2.5.1.2.3 and shown with nominal dimensions in Figures 2-4 through 2-7, include knockout pots for large particulate, particulate settlers for mid-sized particulate, and annular filters for small particulate. A booster pump located in the transfer area provides the increased pressure needed to raise the process flow from the particulate settlers up to and through the annular filter vessels. Valved connections in the system provide the capability to add filters if necessary.

2.5.1.2.1 Knockout Pots. The knockout pots, shown in Figure 2-4, are designed to a critically safe geometry and constructed of 16-in. schedule 10 stainless steel pipe with a nominal vessel height of 86 cm (34 in.). The overall height of the knockout pot, including the handling fixture is approximately 138 cm (54 in.). The knockout pots are pressure vessels designed to the requirements of Section VIII of the boiler and pressure vessel code (ASME 1995). The knockout pots, located in the west bay of the basin, are submerged to take advantage of the shielding provided by the basin water and are instrumented to monitor differential pressure between the inlet and the outlet. The knockout pots provide criticality control. The knockout pots are equipped with a screened outlet that captures particles with diameters larger than 500 µm to support downstream criticality safety. The screens are designed to meet safety-class specifications. Full knockout pots are stored underwater. Passive vents release any hydrogen that builds up during storage.

The knockout pot design includes provisions for handling the pots with a lifting tool similar to the existing canister handling devices.

2.5.1.2.2 Particulate Settlers. The particulate settlers, shown in Figure 2-5, are located in the weasel pit at the east end of the basin. The particulate settlers are pressure vessels designed to the requirements of Section VIII of the boiler and pressure vessel code (ASME 1995). These settlers, designed to a critically safe geometry, consist of an array of 20-in. diameter, schedule 10 stainless steel pipes 4.9 m (16 ft) long. The array is configured as 2 side-by-side stacks of 5 pipes 15 cm (6 in.) apart horizontally and vertically. A manifold is provided to evenly divide flow among the 10 pipes. Each settler has a high-point vent manifolded together with other settler vents and discharged through an air-water combination valve beneath the water surface. The settler tubes are separated by saddle supports.

2.5.1.2.3 Annular Filter Vessels. The three 304 stainless steel annular filter vessels, located in the transfer area, are designed to a critically safe geometry. The annular filter vessels are designed to the requirements of Section VIII of the boiler and pressure vessel code (ASME 1995). These vessels, shown in Figures 2-6 and 2-7, have a nominal 5 µm filtration capability. These are deep-bed sand filters (mechanical filters) approximately 5.6 µm (198 ft^3) each in volume. The vessels are located in a shielded enclosure above the water in the basin transfer area. The IWTS filter vessels are similar to the large sand filter that has operated at the basin for many years and are passively vented in a similar fashion. Each annular filter vessel is constructed of an inner and an outer tank. The purpose of the normally empty inner tank is criticality safety.

The filter vessels are sized for a cross-sectional flow rate of 200 L/min/m^2 (5 gal/min/ft^2) and a volumetric flow of 90 L/min/m^3 (0.67 gal/min/ft^3) with a nominal design flow rate of 7 L/sec (110 gal/min). These flow rates optimize filter efficiency and improve effluent quality. Each vessel contains about 2.6 m^3 (90 ft^3) of filter media. The filter media consist of fine sand and garnet with a foundation layer of coarse sand to improve underdrain and backwash performance. Normal flow enters the top of the filter vessels and exits the bottom.

The filter vessels have valves and flanges to allow for connecting compressed air for air sparging. The IWTS system has the capability to add flocculent either upstream from the knockout pot or the booster pump to optimize filtration and maintain pool clarity in support of underwater work activities if necessary.

2.5.1.3 Ion Exchange Modules. The IWTS IXMs are identical to the IXMs previously used in the basins and are described in section 2.6.2.2.4 of the K Basin SAR (DESH 1998). These mixed-bed IXMs with associated control piping and valves are located above water in the basin transfer area near the north load-out pit. Monitoring and control instrumentation include conductivity and differential pressure. Samplers are included at the common inlet and individual outlet of the IXMs to provide reliable monitoring and control of transuranic loading. IXMs are loaded with a mixture of cation and anion organic bead resins optimized to remove cesium and other dissolved radionuclides from the basin water. Piping connects the IXM discharge to supply treated water to basin users including the MCO–cask load-out pit flush, fuel retrieval activities, and discharge chute flush. The remainder of the flow capacity is available for other basin uses described in section 2.5.

2.5.1.4 Basin Recirculation. The basin recirculation subsystem consists of existing pumps, suction, discharge piping, and air-cooled chiller unit. Piping and fittings are added to enable part of the recirculation pump flow to be directed to the new IWTS equipment. Valving is installed to allow recirculation water from the recirculation pump to be directed through the filter and/or IXM portion of the IWTS when the FRS is not operating. The recirculation system, described in the K Basin SAR (DESH 1998), is required to maintain pool temperature. The portion of the flow from the main recirculation header that is not diverted to the IXMs is discharged into the basin using the existing piping.

2.5.1.5 Skimmer Loop. The existing skimmer loop subsystem draws water off the surface of the basin for treatment by the existing sand filter and IXM. The skimmer loop system is described in the K Basin SAR (DESH 1998). Flow from the skimmer loop is used to provide water for regeneration of the IWTS annular filter vessel bed. The water will be taken from the discharge side of the skimmer pumps before it enters the filter.

2.5.1.6 Treated Water Supply and Demineralized Water. IXM discharge water will be supplied to the fuel retrieval, cask–MCO load-out, sludge removal, and debris removal stations as well as to the basin. Fresh demineralized water is introduced to the basin for a final rinse of the

MCOs when they are removed from the basin. Any additional water needed by the system to offset water loss from evaporation or removal of fuel and sludge will be supplied by the fresh demineralized makeup water subsystem.

2.5.1.7 Excess Water Removal. If required, excess treated basin water may be removed through the IWTS piping. Water may be removed via a connection located in the transfer bay and pumped to a tanker truck. The excess then water would be transported to the 200 Area Effluent Treatment Facility.

2.5.2 IWTS Operation Description

The following sections describe the primary and secondary operations of the IWTS system. Primary operations occur during fuel retrieval. Secondary operations include backwashing, receipt of CVDF water, and maintenance of basin water quality.

A flow schematic of the K West IWTS is shown in Figure 2-8. This schematic depicts the normal IWTS operations. The IWTS is designed for a 95 percent availability.

2.5.2.1 Primary Operations. During primary IWTS operation, three stainless steel submerged pumps will provide suction from the FRS operations (canister decapping, primary clean machine, and process table) adequate to ensure capture velocity requirements are met and provide flow to the IWTS filtration units. To prevent the transfer of large particulate to the downstream sections of the IWTS, the common pump header discharges to one of the submerged knockout pots located in the west bay of the basin. The knockout pot is instrumented to monitor the differential pressure between the inlet and outlet. As the flow passes through the knockout pot and screen, particulate larger than 500 μm will be captured in the knockout pot.

From the knockout pots, the flow is routed to the submerged particulate settlers located in the weasel pit at the east end of the basin. In the settler, the incoming fluid process stream velocity will be drastically reduced from approximately 4.3 m/sec to 0.014 m/sec (14 ft/sec to 0.05 ft/sec). This reduced velocity and resultant retention time in the settler will allow additional particulate from the fluid stream to settle. At this flow rate particulate larger than 15 to 50 μm (depending on density) will settle out.

The particulate settler's output is routed to the booster pump located in the transfer area above the basin water level. The booster pump discharge, including any remaining particulate matter, is routed to the annular filter vessels located in the transfer area. The flow is distributed among three 304 stainless steel annular filter vessels with a nominal 5μm filtration capability. The filter vessel media are loaded with approximately 30 cm (12 in.) of coarse sand, followed by 45 cm (18 in.) of garnet, and topped with approximately 76 cm (30 in.) of fine sand. The vessel instrumentation includes differential pressure, temperature, and radiation. When a predetermined differential pressure or radiation level is reached, the control system will alarm, indicating operator action for filter bed regeneration, as described in section 2.5.2.3.

The flow from the annular filter vessels is routed to the IXMs located in the transfer area. The IXMs are loaded with a mixture of cation and anion organic bead resins optimized to remove cesium and other dissolved radionuclides and to control pool chemistry. The effluent of the IXMs is directed to the various basin user outlets as described in section 2.5.

2.5.2.2 Secondary Operations. When the FRS system is shut down, basin water quality can be maintained by routing the recirculation water to the suction of the booster pump. This will route water through the annular filter vessels to the IXMs. If filtration is not required, a filter bypass valve allows water to flow directly to the IXMs.

If one submerged pump fails or is taken off line, the other submerged pumps will trip and the system will shut down. Should the booster pump suction fall below a specific pressure set point indicating loss of suction, the booster pump will trip and the system will shut down. If the annular filter vessel differential pressure or radiation level exceeds the high-high set points, the booster pump will trip and the system will shut down. At a preset differential pressure, the knockout pot will be removed from service and remotely disconnected from the process line for interim storage in the basin. The maximum differential pressure is 350 kPa (50 lbf/in^2). The process connections then will be connected to a knockout pot located near or in the same location as the previously used pot. Only one knockout pot is in service at a time, however, as many as 30 pots could be required to accommodate the design basis quantity of sludge that may be retained by the pots. Full pots may remain in place until sludge disposition is determined.

When a predetermined differential pressure is reached across a filter vessel or a predetermined dose rate is reached, the control system alarms and the filters are isolated and removed from service for operator action. All three filters are regenerated individually before returning the system to service. Fuel retrieval is stopped during filter regeneration. Filter regeneration is accomplished using water, air, or a combination of water and air in various flow paths into and out of the filter vessel. Regeneration sequences are selected and controlled by operations personnel from a control area. These sequences are fully automated except for the infrequently used air sparge that requires manual action to supply air. The regeneration techniques provided for each vessel are the top sparge, full-bed backwash, and air sparge.

Top Sparge. In the top sparge process, water is admitted near the top of the vessel through a distribution pipe and exits the top of the vessel through the backwash outlet valve. During this process, the top layer of the filter media (highest concentration of particulate) is agitated with a water sparge using skimmer loop water and the top sludge particles trapped in the layer of media are carried out by a sweeping action to the particulate settlers for hold-up and subsequent processing. The reduced flow from the top sparge will allow the settlers to retain more of the smaller particles. This process is used to reduce differential pressure without disturbing the bottom half of the filter bed. Normally this process is the preferred method of filter regeneration when the process water characteristics have a mixture of particulate with a bias toward large particles.

Full-Bed Backwash. This process is required when the top sparge action does not lower the pressure drop or radiation levels to the point that reasonable durations of normal operation occur before another top sparge. Water flow is reversed by entering the vessel bottom and exiting the top via the backwash outlet valve. During this process, the entire bed is backwashed using skimmer loop water sweeping particulate from throughout the media to the particulate settlers. A nominal backwash flow rate, which is approximately half the normal process flow rate, is expected to be used, which should provide an adequate carrying velocity to fluidize and remove the fuel particles. This flow rate will allow the settlers to retain more of the small particles.

Air Sparge. The filter bed may be air sparged if excessive backwashing is required to keep the differential pressure or radiation levels in the filter low. Air sparging consists of injecting compressed air into the filter vessel media bed to disturb the aggregate. In similar equipment, air sparging has been shown to restore filter efficiency. The filter vessels have valves and flanges to allow for connecting a compressed air source. Air sparging, when performed, typically involves air flows of approximately 140 standard cubic feet per minute for approximately 1 hour. Only one filter vessel will be sparged at any given time. The air displaced from the filter vessel during sparging requires the venting system described in section 2.5.2.3.

2.5.2.3 Annular Filter Vessel Air Sparge Venting Operations. The venting system for the annular filter vessels is a new emission point for the K West Basin. The venting arrangement for normal operation of the annular filter vessels is shown in Figure 2-9. The annular filter vessels are not vented during normal operations. When the pumps shut down and water flow to the filters stops, the annular filter vessels are passively vented to the new high-efficiency particulate air filtered emission point. During air sparge filter regeneration, filters will be actively vented through the new high-efficiency particulate air-filtered emission point. DOE/RL-98-02, *Radioactive Air Emissions Notice of Construction for 105-KW Filter Vessel Sparging Vent* (DOE-RL 1998), was approved by the Washington State Department of Health (Conklin 1998).

2.6 CONFINEMENT SYSTEMS

See the current version of the K Basins SAR (DESH 1998) for a discussion of the K Basin confinement systems. Changes to the confinement system include connecting the water treatment system to the fuel retrieval equipment. These changes include piping to remove water from the decapping equipment, the primary clean machine, and the process table. The IWTS adds above-water piping and annular filter vessels that are part of the confinement system.

2.7 SAFETY SUPPORT SYSTEMS

See the current version of the K Basins SAR (DESH 1998) for a discussion of the K Basin safety support systems for worker protection. The IWTS will add a radiation monitoring system for the filter vessels within the filter vessel enclosure. This monitoring system is used to control the source term in the filter vessels by alarming when no more than 200 Ci of cesium are detected in a filter vessel. If the radiation monitoring system is not operating, the IWTS cannot operate.

2.8 UTILITY DISTRIBUTION SYSTEMS

See the current version of the K Basins SAR (DESH 1998) for a discussion of the K Basin utility distribution systems. The IWTS equipment will tie into the K Basin electrical system to obtain electrical power for equipment operation.

2.9 AUXILIARY SYSTEMS AND SUPPORT FACILITIES

See the K Basins SAR (DESH 1998) for a discussion of the K Basin auxiliary systems. The IWTS subproject changes to these systems are defined in sections 2.9.1 through 2.9.3.

2.9.1 K Basin Water Supply Systems

No change is required to the K Basin water supply system for the IWTS.

2.9.2 Infrastructure Systems

No change is required to the K Basin infrastructure system for the IWTS.

2.9.3 Cranes and Hoists

To safely handle the increased loads of the knockout pots, the load rating on the monorail above the knockout pots is to be increased. This monorail will be upgraded to a 4,000-lb rating, similar to other monorails being upgraded for FRS.

2.10 REFERENCES

ASME, 1995, *Boiler and Pressure Vessel Code*, Section VIII, "Pressure Vessels," American Society of Mechanical Engineers, New York, New York.

Bergsman, K. H., 1997, *K West IWTS Design Report* and *K West IWTS Design Drawings*, EDT 621526, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Bergsman, K. H., 1998, *Specification for Design, Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment Systems*, HNF-S-0564, Rev. 1A, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Conklin, A. W., AIR 98-307, 1998, Letter to Mr. James E. Rasmussen, Director U.S. Department of Energy, Washington State Department of Health, Olympia, Washington.

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DOE-RL, 1998, *Radioactive Air Emissions Notice of Construction for 105-KW Filter Vessel Sparging Vent*, DOE/RL-98-02, Rev. 0, U.S. Department of Energy, Richland, Washington.

Watson, D. J., 1998, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document*, HNF-SD-SNF-RD-001, Rev. 1, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Figure 2-1. K West Integrated Water Treatment System
General Equipment Location in Basin Structure.

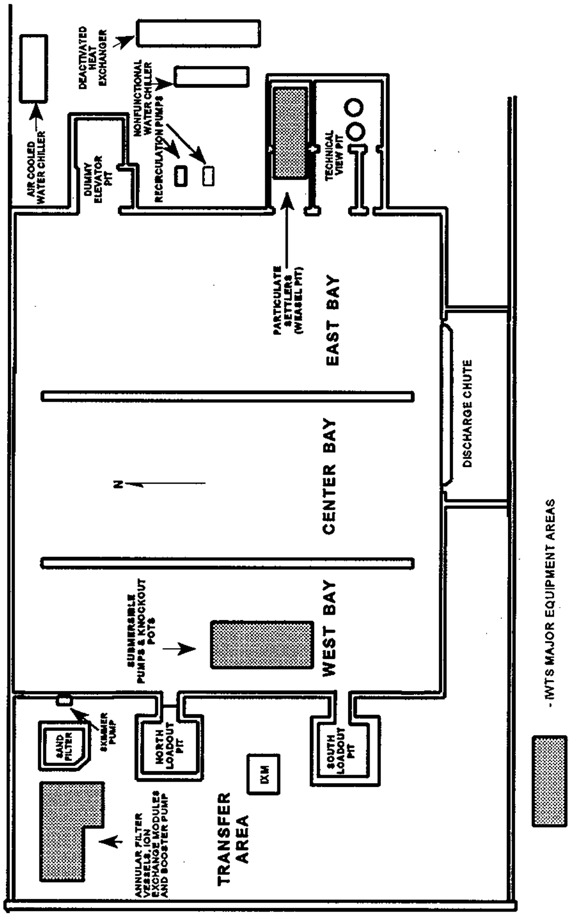


Figure 2-2. K West Integrated Water Treatment System
Equipment Arrangement in Basin.

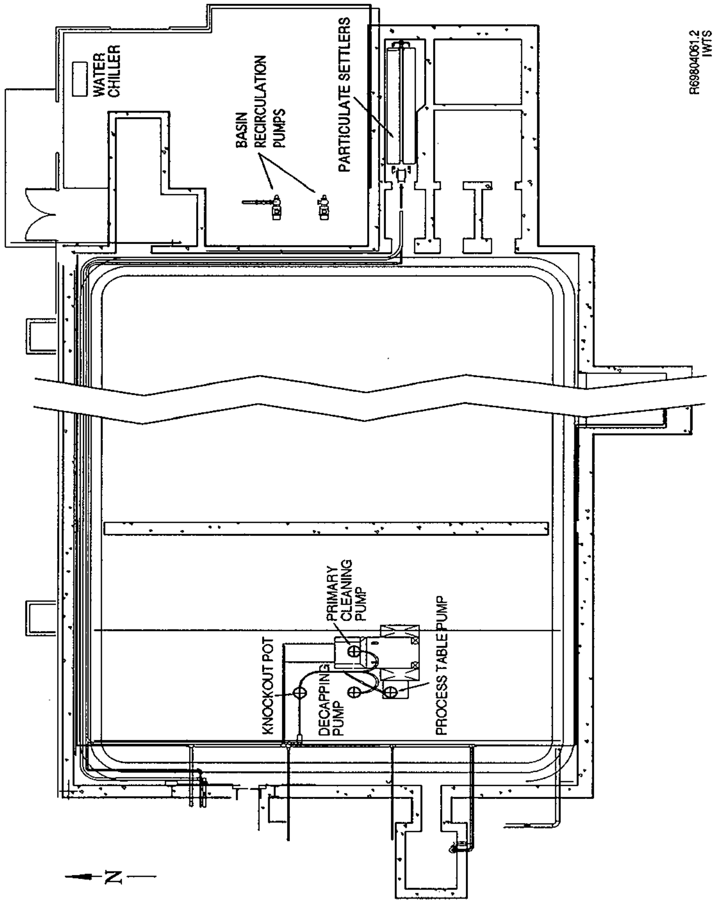


Figure 2-3. K West Integrated Water Treatment System Equipment Arrangement in Transfer Area.

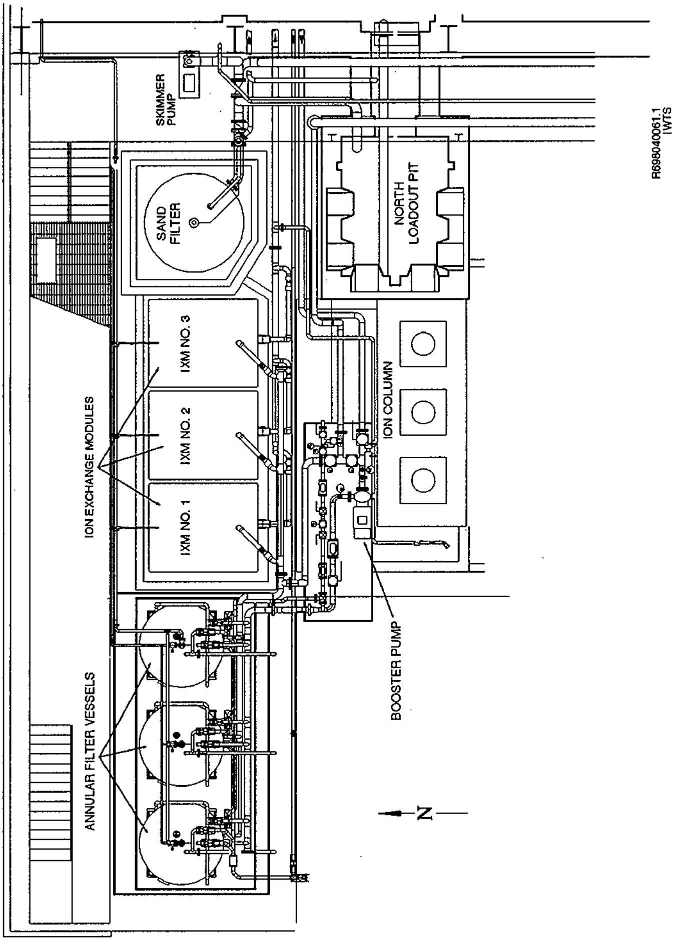


Figure 2-4. Knockout Pot.

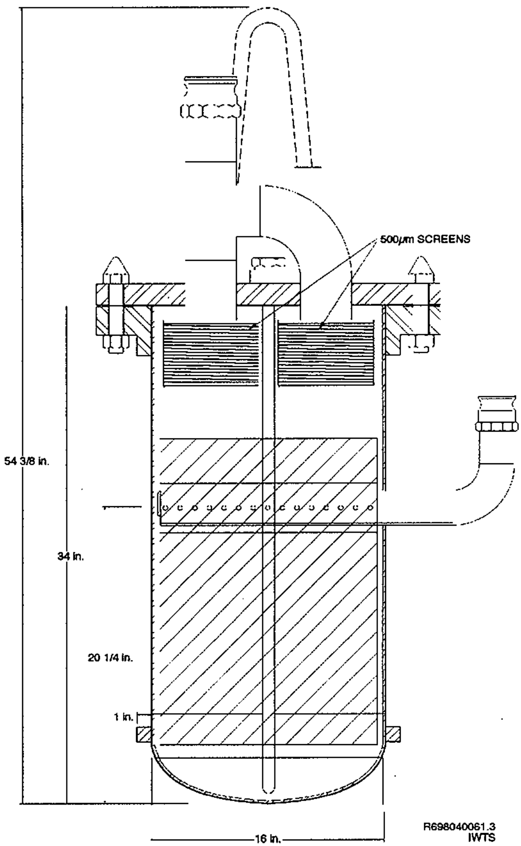


Figure 2-5. Particulate Settlers.

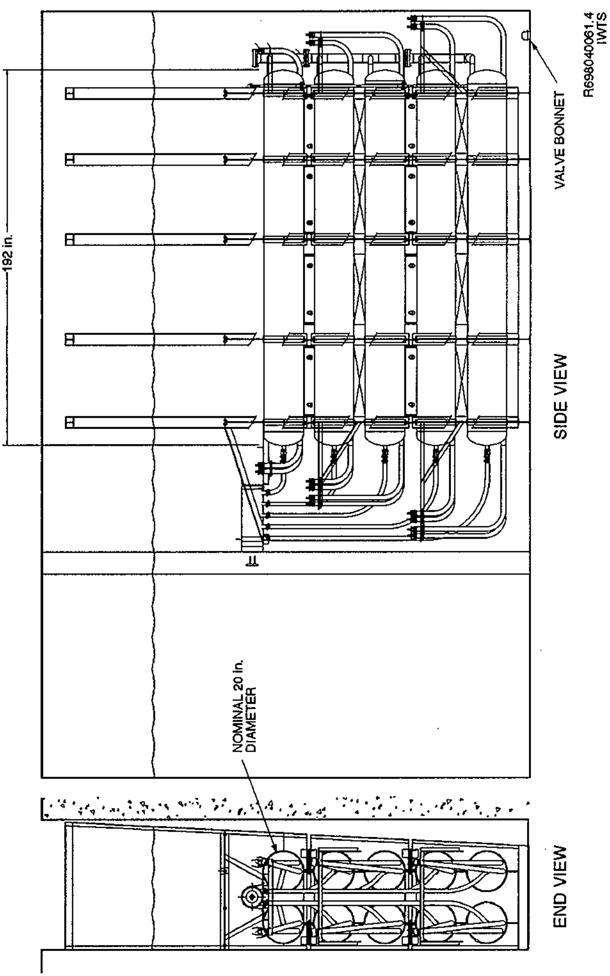


Figure 2-6. Annular Filter Vessel.

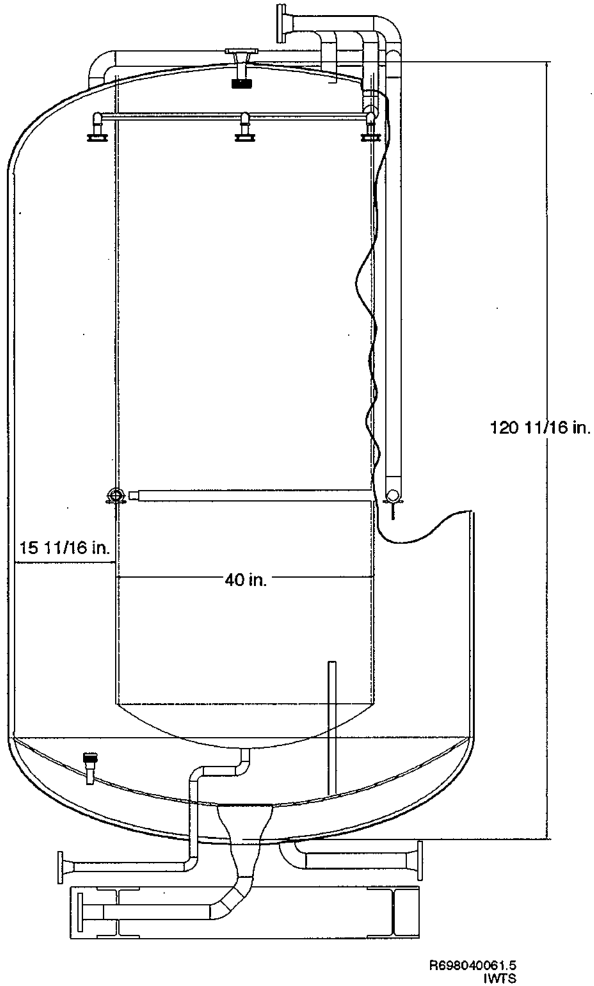


Figure 2-7. Annular Filter Vessel Enclosure.

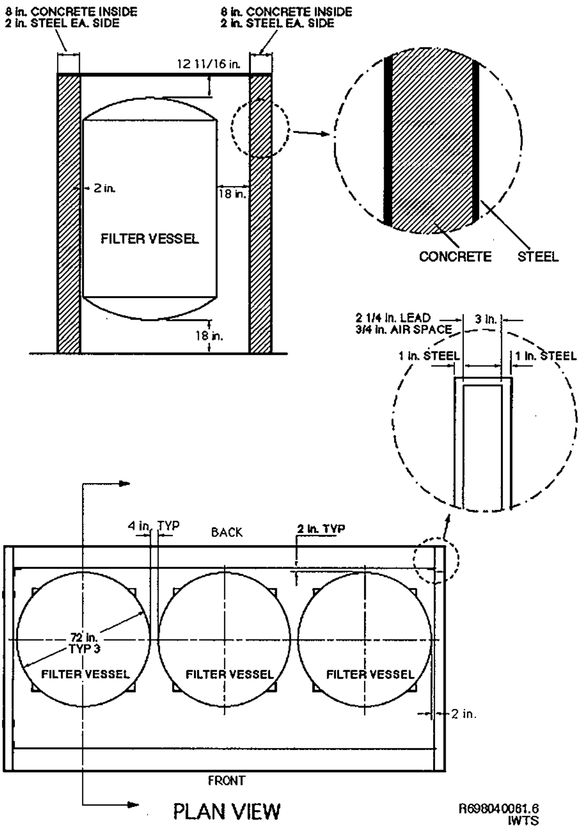


Figure 2-8. K West Integrated Water Treatment System Flow Schematic.

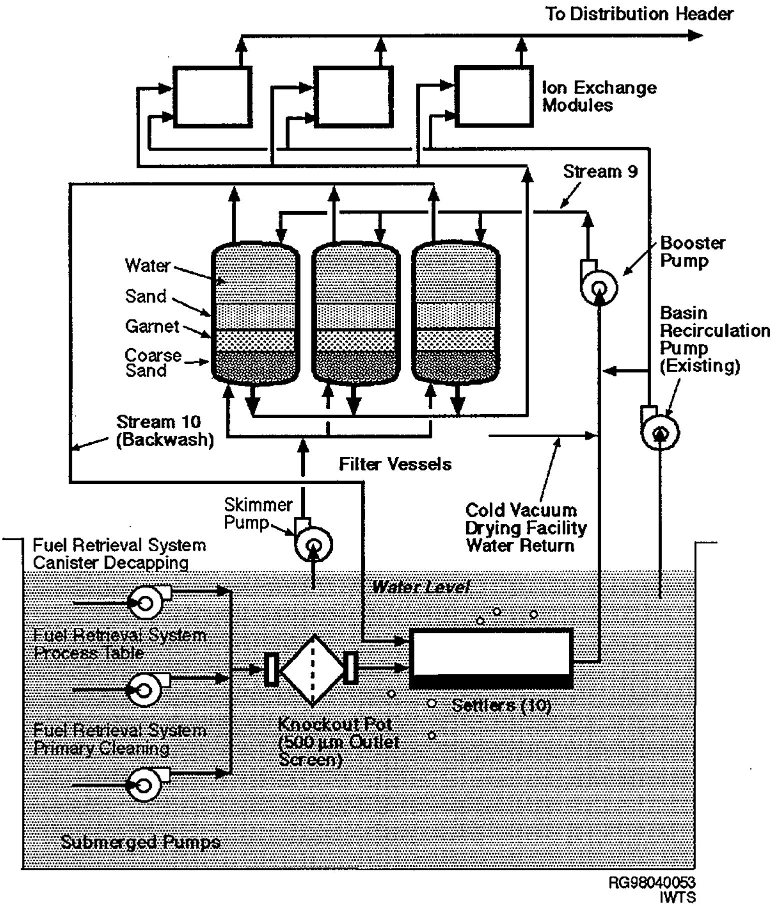
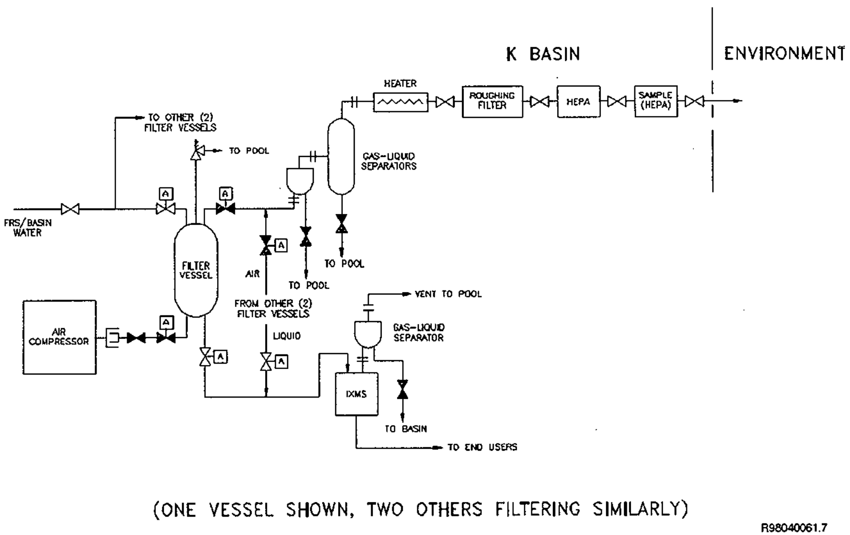


Figure 2-9. Venting Arrangement for Normal Operation of Filter Vessels.



This page intentionally left blank.

3.0 HAZARD AND ACCIDENT ANALYSES

3.1 INTRODUCTION

This chapter defines the processes used to identify and assess potential hazards associated with maintenance and operation of the integrated water treatment system (IWTS), presents the results of the hazards and operability (HAZOP) study, and develops the abnormal events and design basis accidents representative of the potential conditions associated with the IWTS operation. The chapter covers hazard identification, facility hazard classification, hazard evaluation, and accident analysis (including probabilities and consequences). The analyses were developed using a graded approach that considered the hazard magnitude, complexity of equipment and operations activities, and equipment life cycle.

3.2 REQUIREMENTS

The hazard and accident analyses developed for the IWTS were performed to comply with the U.S. Department of Energy orders, regulations, and standards in the K Area standard and requirements identification document database. HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document* (Watson 1998a), identifies the requirements that adequately protect workers, the public, and the environment.

3.3 HAZARD ANALYSIS

This section describes the hazard identification and evaluation performed for the IWTS. The evaluation covers potential process-related, natural phenomena, and externally initiated hazards to the workers, the public, and the environment caused by the IWTS.

3.3.1 Methodology

The American Institute of Chemical Engineers *Guidelines for Hazard Evaluation Procedures* (AIChE 1992) defines a hazard two ways:

- An inherent physical or chemical characteristic that may cause harm to people, property, or the environment

- A combination of a hazardous material, an operating environment, and an unplanned event that might lead to an accident.

The implications of both definitions are considered in the hazards identified and the evaluation methods used. Potential IWTS hazards (combinations of a hazardous material, an operating environment, and an unplanned event) were identified and qualitatively evaluated through a HAZOP study.

3.3.1.1 Hazard Identification. Hazards identification is pinpointing material, system, process, and plant characteristics that can produce undesirable consequences as a result of an accident. Hazards can be identified by conducting a HAZOP study that documents the effects of deviations from the design intent of the process parameters. The major equipment items within a process are designated as nodes. Applicable process parameters (guide words) such as flow, pressure, level, and temperature are chosen for each node. A series of questions is asked about each parameter; each question concerns an abnormal condition (deviation) of the parameter (for example, "no flow"). Guide words, phrases, or words used to describe process deviations are used as brainstorming tools to explore the means by which process parameters might vary from their design intent. Process parameters that were examined include flow, temperature, pressure, viscosity, composition, level, and structural integrity. Guide words and their meanings are as follows:

"No/none"	negation of design intent
"More"	quantitative increase
"Less"	quantitative decrease
"As well as"	qualitative increase
"Part of"	qualitative decrease
"Reverse"	logical opposite of intent
"Other than"	complete substitution.

3.3.1.2 Hazard Evaluation. Hazard evaluation is the qualitative analysis of the significance of hazardous situations associated with a process or an activity. This evaluation was accomplished through the HAZOP where the potential causes and consequences of the deviations were examined, and the frequency and potential worst-case consequences were ranked, based on the team's experience and judgment, to determine possible safety significance. A HAZOP analysis is a "form-driven" method of hazard evaluation, which means that the results of the hazard evaluation are codified on a form to help ensure that a systematic approach is followed and that the hazardous conditions are described consistently for comparison purposes. The HAZOP analysis form used for the K West Basin IWTS project is shown in Appendix 3A.

The first column in the HAZOP analysis form (see Appendix 3A), designated "Process parameter," states which parameter is being analyzed. The second column, "Guide word/deviation," is a guide word that applies to that process parameter. The third column, "Cause," lists a potential cause of the deviation. The fourth column, "Resulting abnormal condition," lists a result of the particular deviation caused by a particular situation. The fifth column, "Consequence," briefly describes a potential undesirable consequence of the abnormal condition. The sixth and seventh columns, "Engineered features" and "Administrative controls," list equipment, programs, and procedures that might be used to prevent the abnormal condition or mitigate its consequences. The "Freq. rank" column estimates the annual likelihood of the abnormal occurrence. The frequency of the consequences of the deviations are given qualitative rankings shown in Table 3-1. The "Cons. rank" column is a "first-cut" qualitative consensus estimate of the safety severity of the postulated consequence. The safety consequences of the deviations are given significance rankings shown in Table 3-2.

Table 3-1. Frequency (f) Ranges.

Rank	Description	Frequency range
F0	Beyond extremely unlikely	$f < 10^{-6}$/yr
F1	Extremely unlikely	10^{-6}/yr $< f \leq 10^{-4}$/yr
F2	Unlikely	10^{-4}/yr $< f \leq 10^{-2}$/yr
F3	Anticipated	10^{-2}/yr $< f < 10^{-1}$/yr

Table 3-2. Safety Consequence Severity Rankings.

Rank	Consequence severity
S0	No significant effects on persons or the environment.
S1	Facility worker injury or exposure to hazardous materials; reportable release of hazardous materials within or near the facility.
S2	Hazardous material exposure to a person (collocated onsite worker) at a distance from the facility; significant hazardous material discharge outside the facility.
S3	Hazardous material exposure to a person (member of the public) at a distance from the facility; significant hazardous material discharge offsite.

3.3.2 Hazard Analysis Results

The HAZOP team's discussions resulted in a listing of hazards (combinations of hazardous material and abnormal events) that could potentially result in accidents having consequences affecting the public, the collocated onsite worker, and/or the facility (near-field) worker.

3.3.2.1 Hazard Identification. Tables 3-3 and 3-4 list the potential accident scenarios resulting from the hazards discussed in the HAZOP study. The tables summarize the accidents, list the causes, the consequences, the material at risk (MAR), the consequence rankings, and the frequency rankings.

Table 3-3 lists the accidents that the team agreed might potentially disperse radioactive or toxic aerosols to a receptor outside the K Basin facility. These accidents could result in consequences ranked S2 and S3 in the HAZOP discussion. These rankings are, in general, qualitative and more conservative than the quantitative accident calculations. The determination requirements for safety-class engineered features (S3 consequences), safety-significant engineered features (S2 consequences or defense-in-depth for S3 consequences), and/or technical safety requirements (TSR) are based on the quantitative accident analysis.

Table 3-4 lists the S1 accidents from the HAZOP in Appendix 3A that might have consequences to the facility worker, but are not expected to disperse radioactive material outside the K Basin facility. These accidents fall into one of two consequence categories. The first consequence category (designated S1-A) consists of accidents that could result in the worker getting a larger than originally planned radioactive or hazardous exposure, a dose that is greater

Table 3-3. Accidents Potentially Having Consequences Outside of K West Basin. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Loss of basin water* (Analyzed in K Basin SAR, section 3.4.2.10)	Catastrophic failure of above-water piping caused by natural phenomena, external phenomena, overpressurization, water hammer, fire (flexible hose), or thermal expansion stress during process activity with bottom pump inlet resulting in pumping basin below very low level	Pool release of basin water and resuspension of loose contamination in pool water	Basin water Fuel and sludge particles	Basin level monitoring, alarms Radiation alarms	Procedures	S2/S3	F1
Spray release from above-water piping* (Analyzed in sections 3.4.2.1 and 3.4.2.2)	Leak in pressurized portions of above-water piping caused by natural phenomena, external phenomena, overpressurization, water hammer, fire (flexible hose), or thermal expansion stress	Airborne release of aerosol spray of contaminated basin water	Basin water, fuel, and/or sludge particles	Piping design and testing Shield pipe and enclosures Constant air monitors	Procedures Surveillance	S2	F2
Hydrogen deflagration in filters (Analyzed in section 3.4.2.3)	Loss of water cover on fuel in filters	Release of fuel particulate	Fuel accumulation in filters	Radiation monitor to limit accumulation of fuel	Procedures calling for backwash	S2	F1
Fuel oxidation in filters (Analyzed in section 3.4.2.4)	Loss of water cover on fuel; heatup	Release of oxide aerosol	Particulate on filter	Radiation monitor limiting accumulation	Procedures calling for backwash	S2	F2 (Modified to F1 per accident analysis)

Table 3-3. Accidents Potentially Having Consequences Outside of K West Basin. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Failure of ion exchange module* (Analyzed in section 3.4.2.5)	Dropping an ion exchange module or dropping one ion exchange module on top of the other during changeout activity	Release of cesium-loaded ion exchange resin	Loaded resin Small amount of basin water	Lifting equipment designed to handle the ion exchange module	Critical lift procedures Periodic inspections Training	S2/S3	F2
Loss of basin water * (Analyzed in section 3.4.2.6)	Loss of basin structural integrity caused by dropping a heavy object (i.e., ion exchange module)	Pool release of basin water and resuspension of loose contamination in pool water	Basin water Fuel and sludge particles	Basin level monitoring, alarms Radiation alarms	Procedures Training	S2/S3	F0
Criticality in ion exchange modules or filters* (Analyzed in Appendix 6A)	Transfer of a significant amount of greater than 0.635-cm (0.25-in.) diameter fuel pieces	Release of fission product gases and contaminated aerosols	Fissile and contaminated material	Screens in transfer lines from other processes Favorable geometry		S2	F0
Hydrogen deflagration in settlers (Analyzed in section 3.4.3)	Loss of pool water in DBE	Release of fuel particulate	Particulate in settler	N/A	Emergency response to DBE	S2	F1 (Modified to F0 per accident analysis)

Table 3-3. Accidents Potentially Having Consequences Outside of K West Basin. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Fuel fire in settlers (Analyzed in section 3.4.3)	Loss of pool water in DBE	Release of oxide aerosol	Particulate in settler	N/A	Emergency response to DBE	S2	F1 (Modified to F0 per accident analysis)

Note: * These events were evaluated in the K Basin SAR (DESH 1998a); installation of the integrated water treatment system may change the frequency and consequences of the events.

DESH, 1998a, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DBE = Design basis earthquake.
F0 = Beyond extremely unlikely.
F1 = Extremely unlikely.
F2 = Unlikely.
N/A = Not applicable.
S2 = Hazardous material exposure to onsite collocated worker at a distance from the facility; significant hazardous material discharge outside the facility.
S3 = Hazardous material exposure to person at Site boundary; significant hazardous materials discharge offsite or to the groundwater.

Table 3-4. Accidents Potentially Having Consequences to K West Basin Workers. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Increased radionuclide concentration in basin	Loss of flow through recirculation loop because of recirculation pump failure, clogged line, or instrument malfunction	Higher dose rate and higher resuspension rate from basin water	Basin water	Flowmeters Redundant pumps	Procedures	S1-A	F3
Lowering of basin water level*	Leak in above-water piping	Higher dose rate from loss of water shielding fuel	N/A	Basin level indicator Area radiation monitors	Procedures	S1-A (unless basin level is lowered considerably)	F2
Leak of manipulator hydraulic fluid into basin	Failure of fuel retrieval equipment	Problems with IXM—potential extraction of cesium causing ALARA problems	Cesium loaded on IXM	Conductivity instrumentation downstream of IXM	Conductivity monitored Sampling Fuel retrieval surveillance	S1-A	F3
Leak of ethylene glycol from basin heaters into basin*	Failure of heater piping	Decreased IXM effectiveness	Basin water contaminants	Conductivity instrumentation downstream of IXM	Conductivity monitored Sampling Basin surveillance	S1-A	F2
Transfer of biota to IXM	Presence of biota in water and failure of screen	Decreased effectiveness of IXM because of slime buildup	Basin water contaminants	Conductivity instrumentation downstream of IXM	Conductivity monitored Sampling	S1-A	F3

Table 3-4. Accidents Potentially Having Consequences to K West Basin Workers. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Transfer of debris to IXM or filters	Presence of debris in water	Decreased IXM effectiveness	Basin water contaminants	Conductivity instrumentation downstream of IXM	Conductivity monitored	S1-A	F3
Plugged piping	Solids material, particularly in filters and IXM	"Hot spots" in piping	N/A	Flow, pressure indication	Surveillance	S1-A	F3
Leak of basin water from sample lines	Freezing, pipe break, leaving on sample tap	Spills of contaminated water	Small quantities of contaminated water	N/A	Surveillance	S1-A	F3
Loss of deionized water supply	Loss of service water, problems in water softener	No water to clean MCOs, no makeup water to basin	Basin water contaminants	Flow, pressure indication	Possibility of sampling the deionized water supply	S1-A	F1, F2
Loss of resin from IXM	Screen failure	Water quality problems, contaminated resin in piping	Contaminated resin	Pressure indicator	N/A	S1-A	F2
High cesium in sample lines and to end users*	Breakthrough in IXM	High dose rates in sampling lines and user lines	Dissolved cesium	Conductivity instrumentation downstream of IXM	Surveillance Sampling Limited IXM loading based on conservative calculations	S1-A	F2
Knockout pot plugged	More particulate than expected	High dose rates	N/A	Differential pressure across knockout pot	Surveillance	S1-A	F2
Release of excessive amounts of krypton	Reactive fuel and corrosion of uranium	Worker airborne dose	Krypton in fuel	N/A	Surveillance	S1-A	F1

Table 3-4. Accidents Potentially Having Consequences to K West Basin Workers. (3 sheets)

Accident	Causes	Consequence	Material at risk	Engineered features	Administrative controls	Consequence ranking	Frequency ranking
Failure of booster pump	Plugged pipe or air in line	Catastrophic failure of pump or piping causing worker injury	N/A	Pressure instrumentation	N/A	S1-I	F2
Decreased filtration or IXM efficiency	FRS flow in addition to recirculation pump bypass to IXMS caused by misvalving air monitoring equipment	Higher dose rates for end users	Decreased basin water quality	Air monitoring equipment	Procedures	S1-A	F3
Transfer of excess particulate into system from FRS operations or debris removal	Failure of strainers	Higher dose rates from piping	N/A	Flow and pressure indication	N/A	S1-A	F2

Note: * These events were evaluated in the K Basin SAR (DESH 1998a); installation of the integrated water treatment system may change the frequency and consequences of the events.

DESH, 1998a, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

ALARA = As low as reasonably achievable.
F1 = Extremely unlikely.
F2 = Unlikely.
F3 = Anticipated.
IXM = Ion exchange module.
MCO = Multi-canister overpack.
N/A = Not applicable.
S1-A = Accidents that could result in worker getting a larger than planned radioactive or hazardous exposure, greater than ALARA levels, but not resulting in a serious injury.
S1-I = Accidents that could result in being injured because of an industrial hazard that could be prevented or mitigated by standard safety programs.

than as low as reasonably achievable (ALARA) levels, but not being seriously injured. The second category (designated S1-I) consists of accidents that could result in a worker being injured in a scenario caused by an industrial hazard. Industrial hazards are prevented or mitigated by standard (institutional) safety programs.

3.3.2.2 Hazard Classification. A preliminary hazard categorization was performed for the K Basins facilities (Porten 1994) using the methodology and criteria found in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.* It was determined that the K Basins is a hazard category 2 facility. A hazard category 2 facility is one in which the "Hazard Analysis shows the potential for significant on-site consequences" (DOE-STD-1027-92). DOE-STD-1027-92 interprets this definition to mean "Facilities with the potential for nuclear criticality events or with sufficient quantities of hazardous material and energy, which would require on-site emergency planning activities." A hazard categorization for the IWTS process determined it to be hazard category 2; it does not affect the K Basins hazard category. The hazard categorization is documented in HNF-SD-SNF-HC-013, *Hazard Categorization for K West Integrated Water Treatment System* (Semmens 1997).

3.3.2.3 Hazard Evaluation. This section documents a HAZOP study conducted for the K West Basin IWTS. The HAZOP team consisted of representatives from the design group, K Basin Operations, K Basin Engineering, Safety Analysis, and K Basin Safety organizations. While the main emphasis was on equipment being added by the K West Basin IWTS, effects on interfacing equipment were discussed and documented.

The HAZOP methodology consists of dividing the system into sections (nodes) and discussing the causes and effects of deviations from design intent of selected process parameters. The likelihoods and consequences of the postulated abnormal conditions are ranked for the purpose of sorting potential accident initiators. In addition, the HAZOP team considers design and operating changes that might improve the system's safety and efficiency and makes recommendations.

The results of the HAZOP study include the estimated frequencies and calculated consequences of accidents postulated to have effects outside the K West Basin facility. Based on the results of the hazards evaluation and accident analysis, a list of safety-class and safety-significant structures, systems, and components (SSC) was developed. In addition, the results provide the basis for selecting TSRs. The TSRs ensure that operations are conducted within the limitations of the analysis and/or that safety-class and safety-significant SSCs are appropriately maintained and tested so their safety function will not be compromised. The HAZOP tables summarizing the team discussions are included in Appendix 3A.

3.3.2.3.1 Planned Design and Operational Safety Improvements. Because the IWTS is an addition to the equipment and systems in the K West Basin, no design and operational safety improvements are planned beyond those already included in the design.

3.3.2.3.2 Defense in Depth. Defense in depth is a fundamental approach to hazard control for nuclear facilities. It builds in layers of defense against release of hazardous materials so no single layer, no matter how good, is completely relied on. The current version of the K Basins safety analysis report (SAR) (DESH 1998a) describes the facility defense-in-depth considerations. Beyond the facility defense in depth, the IWTS has these additional features:

- The annulus filter enclosure
- The booster pump enclosure
- Pipe-in-pipe design for above-basin water piping
- Filtered vents.

3.3.2.3.3 Worker Safety. Worker safety is an integral part of the IWTS and overall K Basins design. The K Basin SAR (DESH 1998a) covers worker safety. The existing institutional programs and controls address the accidents having potential consequences to K West basin facility workers (Table 3-4). Institutional safety programs include criticality prevention, radiological protection, industrial hygiene, industrial safety, radiological and hazardous ALARA programs, and emergency preparedness. The activity job hazard/safety analysis and prejob safety meetings provide the workers information to help them identify and control or mitigate hazards. Hazards are controlled and/or mitigated using engineered controls, administrative controls, work restrictions, and/or personnel protective equipment. K Basin administrative procedures require job hazard analyses as part of the job planning. Table 3-9 of the K Basin SAR identifies the typical worker safety hazards addressed by the job hazard analysis (DESH 1998a). Comments and clarification to the draft Appendix E of the fire hazards analysis have been provided to the cognizant engineer for incorporation into the next revision.

Monthly, quarterly, and yearly safety inspections are conducted to identify unsafe conditions throughout the facility, including the IWTS equipment. Unsafe conditions will result in postings, personnel protective equipment requirements, and/or timely corrective actions, as appropriate.

3.3.2.3.4 Environmental Protection. The K Basins SAR (DESH 1998a) describes the environmental protection considerations.

3.3.2.3.5 Accident Selection. The accidents selected for analyses resulted from the HAZOP study process. The consequences of these accidents and their anticipated frequencies of occurrence bound the consequences of all other accidents considered in the HAZOP study process. The following accidents have been selected for analysis:

- Spray release from process supply stream during normal operations
- Spray release during filter vessel backwash
- Hydrogen deflagration in the filter vessel
- Fuel oxidation in the filter vessel
- Drop of one ion exchange module (IXM) onto another
- Knockout pot drop in basin
- Criticality evaluation (see Appendix 6A).

3.4 ACCIDENT ANALYSIS

This section presents the results of the accident analysis performed for the potential K West Basin IWTS accidents identified in section 3.3.2.3.5. The general methodology for this accident analysis is described in Appendix 3B. The radiological dose consequences for both onsite and offsite receptors are estimated and compared with applicable risk evaluation guidelines. The accident analyses aid in determining safety-class and safety-significant SSCs and provide the bases for developing TSRs needed to protect the onsite and offsite receptors. The results of the considered accidents bound the consequences of any credible accident from the K West Basin IWTS.

Table 3-5 provides the radiological dose and toxic chemical concentration guidelines from Letter 97-SFD-172 (Sellers 1997). The radiological risk guidelines are given in terms of whole body effective dose equivalent (in rem) for the onsite and offsite receptors. The toxic chemical guidelines are given in terms of emergency response planning guidelines (AIHA 1990). The risk evaluation guidelines are defined in terms of qualitative annual frequency of occurrence. For each accident scenario, the consequences calculated using the methods described and the assigned frequency category are compared to the appropriate risk evaluation guidelines. This comparison is discussed in the accident analysis sections.

Table 3-5. Risk Evaluation Guidelines.

Event frequency category	Event frequency (yr^{-1})	Toxic chemical concentration guideline[a]		Radiological dose guideline (rem)	
		Onsite	Offsite	Onsite	Offsite
Anticipated	$> 10^{-2}$ to $\leq 10^{-1}$	≤ERPG-1	≤ERPG-1[b]	1	0. 5
Unlikely	$> 10^{-4}$ to $\leq 10^{-2}$	≤ERPG-2	≤ERPG-1	10	5
Extremely unlikely	$> 10^{-6}$ to $\leq 10^{-4}$	≤ERPG-3	≤ERPG-2	25	5

Note: [a]The K West Basin integrated water treatment system does not use hazardous chemicals; this column is included for information only.
[b]In all cases, use the lower of either the ERPG-1, the permissible exposure level (time-weighted average), or the threshold level value (time-weighted average) using the most recently published industry standards in summing the toxicological doses.

ERPG = emergency response planning guideline.

3.4.1 Methodology

The accident analyses use specific and consistent methodology to quantify the consequences of the postulated accidents selected for analysis. Appendix 3B contains the models, data, and other bases used in calculating accident source terms, release fractions, atmospheric dispersion, and dose consequences for the selected accidents. The appendix also includes dose estimates for the receptor locations used in these analyses.

The steps involved in the analysis of each accident are as follows.

- **Scenario development**. A detailed sequence of steps needed to initiate and develop each accident was prepared using conservative assumptions and a clearly defined logic path.

- **Source term analysis**. Credible source terms were developed for each accident with the potential to release radionuclides or other hazardous materials. The source terms were based on known compositions and quantities of hazardous materials that are stored or handled in the K Basins. The analysis included the MAR, the release fraction or rate that determines the initial source term, and the overall or process leak path factors that determine the release from the facility.

- **Consequence analysis**. The consequence analysis was structured to determine the receptor doses or exposures for each identified exposure pathway. Consequence calculations were performed that analyzed the doses to onsite personnel and the general public for those accidents with a potential for producing such exposures.

- **Comparison with guidelines**. Conclusions regarding the estimated radiological and toxic chemical consequences (risk for the accident) were determined by comparing them with the risk acceptance guidelines.

- **Summary of safety-class SSCs and TSR controls**. The requirements for safety-class SSCs and TSRs depend on the results and conclusions from the detailed accident analysis. The analysis for each accident identifies the safety-class SSCs and assumptions that were judged to require TSR coverage to meet the evaluation guidelines.

3.4.2 Design Basis Accidents

Detailed analyses of the worst-case or design basis accidents (DBA) are included in this section. The types of accidents considered include internally initiated operational accidents and natural phenomena that could affect the IWTS equipment or operations. External human-caused events that can cause releases at the facility or have a major impact on facility operations are covered by the K Basins SAR (DESH 1998a) and are not affected by the IWTS subproject. The accidents selected for analysis are those defined in section 3.3.2.3.5. Each accident evaluation consisted of the analyses listed in section 3.4.1.

3.4.2.1 Spray Release From Process Supply Stream During Normal Operations (Stream 9). This accident consists of a spray release from stream 9, which is located between the booster pump and the annular filter vessels (see Figure 2-8). Stream 9 may contain liquid from up to four different operational sources.

3.4.2.1.1 Scenario Development. Spray releases from the IWTS above-water piping and booster pump are possible when the system is pressurized. Spray releases resulting from events that could cause a major rupture in process lines, while releasing large quantities of liquid, would not result in a respirable leak rate as large as that from a smaller, optimized orifice. All spray releases are calculated for an optimized orifice (pin-hole) leak.

One postulated spray release accident bounds the consequences of credible process supply stream spray release accidents. In this accident, liquid is released through a leak in the piping or pump between the booster pump and the filter vessels. The slurry stream processed by the IWTS during a given 24-hour period could be composed of any combination of radionuclides from the following:

- K West Basin water
- Disintegration of fuel assemblies
- Canister sludge
- High-cesium content fuel.

The doses associated with these sources are calculated independently and added to establish the maximum dose possible from this accident (Watson 1998b). The actual dose would be less than this value because the leak effluent would be a mixture of the individual components considered.

This spray release accident would be caused by a leak in a fitting, pipe, or pump in the pressurized stream. The booster pump and about half of the piping are encased in close-fitting shielding, which minimizes the effects of a spray release. Leaks from piping with a diameter larger than 3 in. are anticipated to occur with an annual frequency of 2.9×10^{-5} per m (8.8×10^{-6} per ft) of piping (Eide et al. 1990). Stream 9 uses approximately 15 m (50 ft) of 4-in. piping. An annual external leak rate for valves is estimated to be 8.8×10^{-4} per year (Eide et al. 1990). Stream 9 affects 19 valves during primary operations. Conservatively assuming the leaks all result in spray releases yields a leak frequency of

$$(2.9 \times 10^{-5}\ /\text{m-yr})(8\ \text{m}) + (19\ \text{valves})(8.8 \times 10^{-4}\ /\text{yr-valve}) = 1.7 \times 10^{-2}/\text{yr}.$$

These limited data, available for external leaks in piping and valves, include mostly leaks that are not representative of an optimum spray release. It also does not consider the probabilities of the following other conditions that must exist for the event to occur.

- Maximum allowable inventory in piping system
- Leak must be optimal spray release
- Vessel enclosure does not reduce respirable spray
- Spray release continues undetected for at least 12 hours.

Therefore, the calculated frequency is too conservative and should be reduced to provide a more realistic estimate of event occurrence.

Because of the conditions that must exist for this event to occur, the estimated annual frequency of this event is deemed unlikely ($>1.0 \times$ E-04 and $\leq 1.0 \times$ E-02). This frequency estimate substantiates the F2 (unlikely) frequency estimated during the hazard analysis (Table 3-3) for a spray release from above the water piping.

3.4.2.1.2 Source Term Analysis. The source terms for this analysis are based on known compositions and quantities of hazardous materials stored or handled in the K Basins. Details of the radiological inventory and source term development are provided in Appendix 3B. The assumptions used in the analysis are discussed in the following paragraphs.

Doses resulting from radionuclide concentration in the water from the four potential sources already described are calculated independently. The following assumptions apply to all four cases.

- Consequences are being calculated at 12 and 24 hours (HNF-PRO-704). The duration of the release is assumed to continue during these times.

- The greatest respirable spray release could be generated in stream 9 (4-in. pipe connecting the settlers to the filter vessels) or at the booster pump to stream 9.

Assumptions for Spray Release of K West Basin Water. In the analysis of the K West Basin water spray release, the IWTS is assumed to maintain the K West Basin water with the maximum radionuclide concentrations specified in HNF-S-0564, *Specification for Design Fabrication, Testing, and Technical Support for the K West Basin Water Treatment System* (Bergsman 1998). This composition (see Appendix 3B, Table 3B-1) is assumed for the liquid flow at the spray release location.

Assumptions for Spray Release During Fuel Retrieval of a Disintegrating Fuel Assembly. The following additional assumptions were used to analyze the spray release that occurs during retrieval of a disintegrating fuel assembly.

- The fuel composition is that expected from a Mark IV assembly containing 16.72 percent ^{240}Pu (see Appendix 3B). This composition is assumed for the radioactive portion of the liquid flow at the spray release location.

- During FRS operations, the equivalent mass of one fuel assembly is assumed to be the maximum that disintegrates per canister. Twelve canisters are assumed to be processed in a 24-hour period.

Assumptions for Spray Release During Fuel Retrieval of Canister Sludge. The following additional assumptions were used to analyze the spray release that occurs during the retrieval of canister sludge.

- The radionuclide composition is that expected from K West Basin canister sludge (see Appendix 3B, Table 3B-3). This composition is assumed for the radioactive portion of the liquid flow at the spray release location.

- During FRS operations, the sludge in each canister is assumed to enter the IWTS process line. Twelve canisters, containing no more than a combined total of 14 L (0.5 ft^3) of sludge, are assumed to be processed in 24 hours.

Assumptions for Spray Release During Retrieval of High-Cesium-Content Fuel. The following assumptions were used to analyze the spray release that occurs during retrieval of high-cesium-content fuel.

- The radionuclide composition from K West Basin canister water is expected to be as listed in Appendix 3B, Table 3B-2. This composition is assumed for the radioactive portion of the liquid flow at the spray release location.

- During FRS operations, the sludge in each canister is assumed to enter the IWTS process line. Twelve canisters, each containing no more than 25 Ci of dissolved cesium and related soluble products, are assumed to be processed in 24 hours.

3.4.2.1.3 Consequence Analysis. Calculations were combined with the results of computer predictions of respirable leak rates from sprays to assess the potential consequences of the accident scenario (Watson 1998b). The spray release is modeled using the SPRAY computer code (Hey and Leach 1994). Appropriate values of the atmospheric dispersion factor have been calculated and are listed in Tables 3-6 through 3-10 using the logarithmic interpolation procedure described in HNF-SD-SNF-TI-059, *A Discussion of the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site* (Rittmann 1998).

Four sources of radiological contaminants could be present simultaneously in the liquid exiting the booster pump.

Spray Release of K West Basin Water. Using the total unit release dose (URD) from Appendix 3B, Table 3B-1, the onsite dose at 100 m (328 ft) from the building is calculated using the following equation.

$$D_{onsite\_100} = (ST)(\chi/Q')(BR)(URD)$$

where

ST	=	source term, respirable released quantity (L)
χ/Q'	=	atmospheric dispersion factor (s/m^3)
BR	=	breathing rate (3.33×10^{-4} m^3/s for light activity)
URD	=	unit release dose (rem/L).

For this accident, a bounding respirable source term of 4.74 L (1.25 gal) has been calculated (12-hour onsite exposure); χ/Q' is calculated for a release longer than 2 hours to a receptor 100 m (328 ft) from K Basins, using a logarithmic interpolation between the bounding dispersion factor with plume meander and the chronic annual average (Rittmann 1998). From Table 3B-1, the URD is 1.73×10^1 rem/L for the radionuclide composition. These values lead to an onsite dose at 100 m (328 ft) of

$$\begin{aligned} D_{onsite\_100} &= (4.74\ L)(6.28 \times 10^{-3}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)(1.73 \times 10^1\ rem/L) \\ &= 1.71 \times 10^{-4}\ rem. \end{aligned}$$

Additional receptor doses are summarized in Table 3-6.

Table 3-6. Summary of Maximum Dose Consequences from a Spray Release of K West Basin Water.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	6.28 E-03	1.71 E-04 (1.71 E-06)	10
Hanford Site boundary 12,040 m west (offsite)	5.32 E-06	2.91 E-07 (2.91 E-09)	5
West river bank (480 m northwest)	1.76 E-04	9.61 E-06 (9.61 E-08)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

Spray Release During Fuel Retrieval of a Disintegrating Fuel Assembly. The portion of respirable particles (diameter$\leq$10 µm) released during the disintegration of a fuel assembly is conservatively estimated to be 0.1 wt%. This value may be compared with one expected for similar materials that undergo brittle fracture from high impact forces. Section 5.3.3.2.1 of DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (DOE 1994), states that, for solids that undergo brittle fracture, the respirable fraction is bounded by

$$ARF \times RF = A \times \delta \times g \times h$$

where

ARF	=	airborne release fraction
RF	=	respirable release fraction
A	=	empirical correlation (2.11×10^{-11} cm^3-s^2/g-cm^2)
δ	=	density (g/cm^3)
g	=	gravitational acceleration constant (980 cm/s^2 [conservative value: fuel is in water, but the drag and buoyancy effects are ignored])
h	=	fall height (cm).

To produce a respirable fraction (ARF × RF) of 0.001, a fall from 26.8 m (88 ft) (in air) would be required. The mass of each Mark IV assembly is about 22.7 kg (50 lb). During the disintegration of 12 assemblies, 272 g of respirable radioactive material will be generated:

$$2.27 \times 10^4 \text{ g} \times 12 \times 0.001 = 272 \text{ g}.$$

Given a total flow rate of 1.21×10^3 L/min (320 gal/min) in stream 9 and the SPRAY-calculated respirable leak rate of 6.59×10^{-3} L/min ($1.74 \text{ x } 10^{-3}$ gal/min), the fraction of the total respirable radioactive material generated that exits through the leak is 5.4×10^{-6}. The total source term over 24 hours is

$$272 \text{ g} \times 5.4 \times 10^{-6} = 1.47 \times 10^{-3} \text{ g}.$$

Using the total URD from Rittmann (1998), the estimated dose to an onsite receptor at 100 m (328 ft) is

$$\begin{aligned} D_{onsite\_100} &= (1.47 \times 10^{-3} \text{ g})(12\text{hr}/24\text{hr})(6.28 \times 10^{-3} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s}) \\ &\quad (4.38 \times 10^5 \text{ rem/g}) \\ &= 6.73 \times 10^{-4} \text{ rem}. \end{aligned}$$

Additional receptor doses are summarized in Table 3-7.

Table 3-7. Summary of Maximum Dose Consequences from a Spray Release During Retrieval of a Disintegrating Fuel Assembly.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	6.28 E-03	6.73 E-04 (6.73 E-06)	10
Hanford Site boundary 12,040 m west (offsite)	5.32 E-06	1.14 E-06 (1.14 E-08)	5
West river bank (480 m northwest)	1.76 E-04	3.77 E-05 (3.77 E-07)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

Spray Release During Fuel Retrieval of Canister Sludge. Twelve canisters containing a total of 14 L (0.5 ft^3) of sludge (density = 2.61 g/cm^3 [163 lb/ft^3]), are processed in 24 hours. The knockout pot and the particulate settlers may remove some sludge from the stream before it reaches the leak location. No credit is taken for this reduction. All sludge reaching the leak is assumed to be small enough to be respirable. The total respirable release fraction is identical to that calculated for the spray release during retrieval of a disintegrating fuel assembly, 5.4×10^{-6}, so the total respirable sludge release is 7.82×10^{-5} L. Using the total URD from Appendix 3B, Table 3B-3, the dose may be calculated for the onsite receptor at 100 m (328 ft):

$$
\begin{aligned}
D_{onsite\_100} &= (7.82 \times 10^{-5}\,L)(12\,hr/24\,hr)(6.28 \times 10^{-3}\,s/m^3) \\
&\quad (3.33 \times 10^{-4}\,m^3/s)(1.14 \times 10^{9}\,rem/L) \\
&= 9.32 \times 10^{-2}\,rem.
\end{aligned}
$$

Additional receptor doses are summarized in Table 3-8.

Table 3-8. Summary of Maximum Dose Consequences from a Spray Release During Fuel Retrieval of Canister Sludge.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	6.28 E-03	9.32 E-02 (9.32 E-04)	10
Hanford Site boundary 12,040 m west (offsite)	5.32 E-06	1.58 E-04 (1.58 E-06)	5
Near river bank (480 m northwest)	1.76 E-04	5.22 E-03 (5.22 E-05)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

Retrieval of High-Dissolved-Cesium-Content Liquid from Fuel Canisters. The retrieval of 12 canisters, each containing 25 Ci of dissolved cesium, over 24 hours is considered. Because these products are soluble, no credit is allowed for any removal before the leak is located. The respirable release fraction developed for the previous accidents is used, 5.4×10^{-6}. Using the total URD from Appendix 3B, Table 3B-2, the estimated onsite dose at 100 m (328 ft) is calculated as

$$\begin{aligned} D_{onsite\_100} &= (12 \text{ canisters})(5.4 \times 10^{-6})(12 \text{ hr}/24 \text{ hr})(6.28 \times 10^{-3} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s}) \\ &\quad (9.61 \times 10^{8} \text{ rem/canister}) \\ &= 6.51 \times 10^{-2} \text{ rem.} \end{aligned}$$

Additional receptor doses are summarized in Table 3-9.

Table 3-9. Summary of Maximum Dose Consequences from a Spray Release During the Retrieval of High-Cesium-Content Fuel.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	6.28 E-03	6.51 E-02 (6.51 E-04)	10
Hanford Site boundary 12,040 m west (offsite)	5.32 E-06	1.10 E-04 (1.10 E-06)	5
Near river bank (480 m northwest)	1.76 E-04	3.65 E-03 (3.65 E-05)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

Summary of Dose Consequences from a Spray Release of Liquid Exiting the Booster Pump. Table 3-10 summarizes the bounding total dose consequences that could be expected from a leak in stream 9. The total dose consequences are the sums of the four individual stream 9 accident consequences calculated.

Table 3-10. Summary of Total Radiological Dose Consequences from a Spray Release in Stream 9.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	6.28 E-03	1.59 E-01 (1.59 E-03)	10
Hanford Site boundary 12,040 m west (offsite)	5.32 E-06	2.69 E-04 (2.69 E-06)	5
Near river bank (480 m northwest)	1.76 E-04	8.92 E-03 (8.92 E-05)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

3.4.2.1.4 Comparison to Guidelines. The radiological dose consequences estimated for an IWTS spray release during worst-case normal operations (leak in stream 9) have been shown to be less than evaluation guidelines for the estimated frequency of occurrence.

3.4.2.1.5 Summary of Safety-Class Structures, Systems, and Components and Technical Safety Requirement Controls. No safety-class or safety-significant SSCs are identified and no TSR controls are required.

3.4.2.2 Spray Release During Filter Vessel Backwash (Stream 10). This accident consists of a spray release from stream 10, which is the backwash flow from the annular filter vessels to the particulate settlers (see Figure 2-8).

3.4.2.2.1 Scenario Development. Spray releases from the IWTS backwash above-water piping is possible any time the system is pressurized. Spray releases resulting from events that could cause a major rupture in process lines, while releasing large quantities of liquid, would not result in a respirable leak rate as large as that from a smaller, optimized orifice. All spray releases are calculated for an optimized orifice (pin-hole) leak. Orifice leaks may be justified as bounding because all piping is new stainless steel piping. FRS operations are expected to be completed within about 2 years.

A spray release during the annular filter vessel backwash (stream 10) would be caused by a leak in a fitting or pipe in the pressurized stream. Leaks from piping with a diameter smaller than 3 in. are anticipated to occur with an annual frequency of 2.9×10^{-4} per m (8.8×10^{-5} per ft) of piping (Eide et al. 1990). Stream 10 uses approximately 30 m (100 ft) of 2-in. piping, however about three-fourths of this piping is encased in close-fitting, continuous shielding. An annual external leak rate for valves is estimated to be 8.8×10^{-4} per year (Eide et al. 1990). Stream 10 affects nine valves during each filter backwash. Conservatively assuming the leaks all result in spray releases yields a leak frequency of

$$(2.9 \times 10^{-4}/\text{m-yr})(8\ \text{m}) + (9\ \text{valves})(8.8 \times 10^{-4}/\text{yr-valve}) = 1.0 \times 10^{-2}/\text{yr}.$$

The limited data available for external leaks in piping and valves include mostly leaks that are not representative of an optimum spray release. They also do not consider the probabilities of the following other conditions that must exist for the event to occur.

- Maximum allowable inventory in filter vessel
- Leak must occur during the backwash (less than 5 percent of operating time)
- Leak must be optimal spray release
- Vessel enclosure does not reduce respirable spray
- Spray release continues undetected for all three filter backwashes.

Therefore the calculated frequency is too conservative and should be reduced to provide a more realistic estimate of event occurrence.

The estimated annual frequency of this event is considered to be unlikely ($>1.0 \times$ E-04 and $\leq 1.0 \times$ E-02). This frequency estimate substantiates the F2 (unlikely) frequency estimated during the hazard analysis (Table 3-3) for a spray release from above-water piping.

3.4.2.2.2 Source Term Analysis. The source terms for this analysis are based on known compositions and quantities of hazardous materials stored or handled within the K Basins. Details of the radiological inventory and source term development are provided in Appendix 3B. The assumptions used in the analysis are discussed in the following paragraphs.

The following assumptions were used in the analysis of the spray release that occurs during filter backwashing (mitigated and unmitigated).

- The fuel composition reaching the filter is that expected from a Mark IV assembly containing 16.72 percent ^{240}Pu.

- A bounding source term was developed to account for the potential for a significant fraction (up to 90 percent) of the total fuel retained in the filter to be oxidized.

- Because up to 90 percent of the cesium may be soluble in oxidized fuel, the ratio of transuranic isotopes to particulate cesium in the filter is conservatively assumed to be 10 times higher than the ratio of transuranic isotopes to cesium content in the fuel.

- The maximum total fuel source term from the three filters does not exceed the maximum estimated basin sludge mass of 16.2 metric tons of uranium (Bergsman 1998).

- The duration of the release equals the duration of the filter backwash (all three filters), which is assumed to be less than 60 minutes (20 min/filter).

- The greatest respirable spray release could be generated in stream 10 ([2-in.] pipe connecting the filter vessels to the start of the settlers).

Two approaches for mitigating the spray release consequences during filter vessel backwash were evaluated.

The following additional assumptions were applied to the case 1 mitigated analysis of the spray release during filter backwashing.

- The duration of the release equals the duration of the filter backwash, which is assumed to be 30 min per filter (90 min total). All radionuclides originally retained by the filter exit the filter to stream 10 during the backwashing.

- Each filter vessel contains the maximum fuel source term associated with 200 Ci of cesium.

The following additional assumption was applied to the case 2 mitigated analysis of the spray release during filter backwashing: Each filter vessel contains the maximum fuel source term associated with 100 Ci of cesium.

3.4.2.2.3 Consequence Analysis. Calculations were combined with the results of computer predictions of respirable leak rates from sprays to assess the potential consequences of the accident scenario (Watson 1998b). The spray release is modeled using the SPRAY computer code (Hey and Leach 1994).

For stream 10 (2-in. pipe, 414 kPa [60 lbf/in^2] gauge pressure water), the calculated respirable leak rate is 1.45×10^{-3} L/min (3.8×10^{-4} gal/min). (The SPRAY code output file is included in Appendix A of HNF-1778 [Watson 1998b].)

An umitigated accident analysis is performed to determine the safety classification of equipment and controls that would mitigate its dose consequences. Without equipment or procedures for backwashing the filters, the IWTS could be operated until all the filters were essentially plugged, stopping all liquid flow. Because the fuel quantity that would be present under this condition is not known, it will be conservatively assumed that the entire maximum basin sludge mass (16.2 metric tons) is deposited among the three filters. The duration for the accident will conservatively be assumed to be less than 1 hour so that the acute air transport factors are appropriate.

The three filters will be backwashed consecutively through a common header pipe that leads back to the settlers (see stream 10 in Figure 2-8). Stream 10 will have a liquid flow rate of 5.68×10^2 L/min during filter backwashing. The respirable liquid release fraction is

$$(1.45 \times 10^{-3} \text{ L/min}) \div (5.68 \times 10^{2} \text{ L/min}) = 2.55 \times 10^{-6}.$$

The total MAR in the three filters is 1.62×10^7 g.

The total respirable quantity of radionuclides released in the spray is

$$(2.55 \times 10^{-6})\ (1.62 \times 10^{7} \text{ g}) = 41.3 \text{ g}.$$

Different atmospheric dispersion factors are used for this accident than for the other spray release accidents. The unmitigated filter backwash accident occurs over a time interval of less than 1 hour so the acute air transport factors are appropriate (Rittmann 1998). Using the total URD from Rittmann (1998), the estimated onsite dose (100 m) is given by

$$\begin{aligned} D_{onsite\_100} &= (41.3 \text{ g})\ (7.32 \times 10^{-2} \text{ s/m}^3)\ (3.33 \times 10^{-4} \text{ m}^3\text{/s})\ (4.38 \times 10^{5} \text{ rem/g}) \\ &= 441 \text{ rem}. \end{aligned}$$

Additional unmitigated receptor doses are summarized in Table 3-11.

Table 3-11. Summary of Maximum Dose Consequences from an Unmitigated Spray Release During Filter Backwashing.

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	7.32 E-02	4.41 E+02 (4.41 E+00)	10
Hanford Site boundary 12,040 m west (offsite)	3.58 E-05	2.16 E-01 (2.16 E-03)	5
Near river bank (480 m northwest)	2.15 E-03	1.30 E+01 (1.30 E-01)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

For the mitigated backwash spray accident, the maximum transuranic (TRU) should be available in the filter immediately before a planned filter backwash. Calibrated gamma monitoring of the cesium on each filter could allow a maximum fuel loading to be imposed before a backwash is required. Different maximum fuel loadings will be examined to determine the controls needed to adequately limit the dose consequences in case of an accident. Filter backwash will be assumed to occur first when a maximum of 200 Ci of cesium has accumulated in any single filter. The filter is expected to remove essentially all particulate from the water entering the filter. All TRU is assumed to be particulate and at least 10 percent of all cesium is assumed to be particulate (up to 90 percent of cesium may be soluble). Soluble cesium is assumed to come from fuel that has been oxidized. Using the fuel composition from Rittmann (1998), when 200 Ci of cesium retained in the filter corresponds to as much as 2.05×10^5 g (2.05×10^4 g metal divided by 0.10) of TRU (metal plus oxide) in one filter.

The total material at risk in the three filters is

$$3 \times (2.05 \times 10^5 \text{ g}) = 6.15 \times 10^5 \text{ g}.$$

The total respirable quantity of radionuclides released in the spray is

$$(2.55 \times 10^{-6})(6.15 \times 10^5) \text{ g} = 1.57 \text{ g}.$$

The filter backwash accident occurs over 90 minutes, so the air transport factors for a 1 to 2 hour release, including adjustments for plume meander, are appropriate (Rittmann 1998). Using the total URD from Rittmann (1998), the estimated onsite dose at 100 m (328 ft) is calculated as follows:

$$D_{onsite\_100} = (1.57\ g)(1.24 \times 10^{-2}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)(4.38 \times 10^5\ rem/g)$$
$$= 2.84\ rem.$$

Additional receptor doses are summarized in Table 3-12.

Table 3-12. Summary of Maximum Dose Consequences from a Case 1 Mitigated Spray Release During Filter Backwashing (200 Ci ^{137}Cs Maximum per Filter).

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	1.24 E-02	2.84 E+00 (2.84 E-02)	10
Hanford Site boundary 12,040 m west (offsite)	2.60 E-05	5.95 E-03 (5.95 E-05)	5
Near river bank (480 m northwest)	5.55 E-04	1.27 E-01 (1.27 E-03)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

If the backwash operation and spray accident were assumed to occur over a period of less than 1 hour, the acute air transport factors must be used to estimate the dose consequences. The estimated onsite dose consequence at 100 m increases to almost 17 rem for this shorter duration accident (nearly twice the guidelines). If, instead, each filter is assumed to be limited to 100 Ci of cesium before a backwash is required, the total respirable fuel release during the backwash of the 3 filters will be reduced from 1.57 g to 0.79 g. For this source term, the dose consequences for the spray accident can be estimated assuming that all three filters are backwashed in less than 1 hour (acute air transport factors). For the onsite receptor at 100 m the estimated dose is

$$D_{onsite\_100} = (0.79\ g)(7.32 \times 10^{-2}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)(4.38 \times 10^5\ rem/g)$$
$$= 8.43\ rem.$$

Additional receptor doses are summarized in Table 3-13. These dose estimates make no limiting assumptions concerning the time interval associated with the backwashing operation.

Table 3-13. Summary of Maximum Dose Consequences from a Case 2 Mitigated Spray Release During Filter Backwashing (100 Ci ^{137}Cs Maximum per Filter).

Receptor location	χ/Q' (s/m^3)[a]	rem EDE (Sv)	Guidelines[b] (rem)
100 m east (onsite)	7.32 E-02	8.43 E+00 (8.43 E-02)	10
Hanford Site boundary 12,040 m west (offsite)	3.58 E-05	4.13 E-03 (4.13 E-05)	5
Near river bank (480 m northwest)	2.15 E-03	2.48 E-01 (2.48 E-03)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$.

EDE = effective dose equivalent.

3.4.2.2.4 Comparison to Guidelines. The mitigated radiological dose consequences estimated for an IWTS spray release during filter backwashing (leak in stream 10) have been shown to be less than the evaluation guidelines for the estimated frequency of occurrence.

3.4.2.2.5 Summary of Safety-Class SSCs and TSR Controls. This analysis relies on the ability of operations personnel to detect when any filter vessel contains between 100 Ci and 200 Ci of cesium and to backwash the filter before one of these quantities of cesium is exceeded. To ensure that any filter vessel contains less than 200 Ci of cesium, the radiation monitoring system is determined to be a safety-significant SSC. If each filter vessel contains less than 100 Ci of cesium, no controls are needed for the filter backwash durations or time intervals. If any filter contains between 100 Ci and 200 Ci, a time interval of longer than 30 min is required between the start of filter backwash operations for each filter. This requirement could be met, for example, by backwashing each filter for 10 minutes but not beginning the backwash of the next filter until 30 minutes after the start of the backwash of the current filter. The source term of concern is the quantity of transuranics potentially associated with the cesium, not the cesium itself.

3.4.2.3 Hydrogen Deflagration in the Annular Filter Vessel. This accident is a deflagration of hydrogen and oxygen gas generated by radiolysis of water and accumulated in the annular filter vessel headspace above the filter media. Detailed calculations for this accident can be found in HNF-1777, *K West Basin Integrated Water Treatment System (IWTS) E-F Annular Filter Vessel Accident Calculations* (Watson 1998c).

3.4.2.3.1 Scenario Development. During normal operation, all filter vessels are completely filled with liquid, and oxidation or deflagration accidents are not credible. For this accident, a leak is assumed to occur during an extended shutdown. The leak is assumed to drain water from the annular filter vessel.

For hydrogen to be generated and accumulate in the filter vessel, the vessel must be static (no flow). This condition must be maintained for some period of time for the hydrogen concentration to increase above the lower flammability limit. Finally, an ignition source is needed inside the filter vessel to cause the hydrogen gas to deflagrate. If this sequence of events occurs, some fraction of the particulate fuel retained in the filter would be released. If the filter has not been backwashed since flow into the filter stopped, the maximum amount of fuel allowed before a routine backwash could be present.

Event path analyses and annual accident frequency estimates were used to determine the annual frequency for this accident sequence (Watson 1998c). The annual frequency of occurrence for this hydrogen deflagration accident is calculated to be 3.3×10^{-6}. This frequency estimate substantiates the F1 (extremely unlikely) frequency estimated during the hazard analysis (Table 3-3) for a hydrogen deflagration in filters.

3.4.2.3.2 Source Term Analysis. The source terms for this analysis are based on known compositions and quantities of hazardous materials stored or handled in the K Basins. Details of the radiological inventory and source term development are provided in Appendix 3B. The assumptions used in the analysis of the unmitigated and mitigated hydrogen deflagration scenarios are as follows.

- The maximum fuel inventory in a single filter is one-third of the maximum estimated total K West Basin sludge inventory from Bergsman (1998).
- All particulates from the IWTS process stream are captured and retained by the filter until a backwash is performed.
- The maximum filter headspace volume above the filter media is 3.1 m^3 (109 ft^3). This headspace is conservatively assumed to be filled with a stoichiometric mixture of hydrogen and oxygen (from air) gas just before the deflagration.
- The fuel composition reaching the filter is that expected from a Mark IV assembly containing 16.72 percent ^{240}Pu.
- Extrapolating the experimental data and the corresponding correlation used by Steindler and Seefeldt (1980) up to a mass ratio (the initial mass of material to the mass of trinitrotoluene [TNT]) of at least 50 is possible.
- Significant amounts of hydrogen gas will not be generated in the filter vessel unless the water in the vessel covers at least a significant portion of the sand. Significant

water is needed in close contact with the particulate for efficient radiolysis to occur.

- The partially submerged sand and trapped fuel in the filter is treated as a liquid with entrained solids for purposes of applying the Steindler and Seefeldt (1980) correlation.

- All particulate retained by the filter is held in the fine sand and 50 percent of the fine sand interacts with the energy released during the deflagration. The particulate is distributed in the top half of the fine sand and can be acted on by the energy released from the deflagration.

3.4.2.3.3 Consequence Analysis. Hydrogen generation may occur by radiolysis when the energy released from the decaying fuel is deposited in the surrounding water, dissociating the molecule. Hydrogen also may be generated from metal fuel oxidation and from reactions of uranium hydride with water. Flammable gas mixtures could accumulate in a filter (Watson 1998c).

The heat of combustion per volume of hydrogen (with oxygen) is 2.8×10^6 cal/m^3 at standard temperature and pressure (Avallone and Baumeister 1996). If hydrogen and air fill the filter vessel headspace (total volume = 3.1 m^3) creating a stoichiometric ratio of hydrogen and oxygen, the maximum heat of combustion that could result from deflagration is (2.8×10^6 cal/m^3) (0.296) 3.1 m^3 = 2.6×10^6 cal. The heat of combustion per mass of TNT is 4.773 MJ/kg (1,140 cal/g) (Thompson 1987). The explosive energy produced by the maximum hydrogen deflagration could be generated by a mass of 2.28×10^3 g (5.0 lb) of TNT. Both Strehlow (1972) and Thompson (1987) report that the energy released or the damage done under similar conditions from a deflagration is expected to not exceed 10 percent (explosive yield) of that expected from the theoretical TNT equivalent. This reduction is caused by several factors, including incomplete combustion, the reduced local energy density of a gaseous combustion compared with a condensed-state TNT explosion, and the fact that the experiments used to determine the effects of TNT explosions placed the TNT within the affected material rather than above it. If this correction is applied to the energy released in this accident, a TNT equivalent of 2.28×10^2 g would produce the maximum expected energy release.

An unmitigated accident analysis is performed to determine the safety classification of equipment and controls that would mitigate its dose consequences. Without equipment or procedures for backwashing the filters in place, the IWTS could be operated until all the filters were essentially plugged, stopping all liquid flow. Because the fuel quantity that would be present under this condition is not known, it will be conservatively assumed that the entire maximum basin sludge mass (16.2 metric tons) is deposited among the three filters. The duration for this accident release is assumed to be less than 1 hour, therefore acute air transport factors are appropriate.

To determine the amount of respirable particulate material released from the deflagration, the Steindler-Seefeldt correlation is used (Steindler and Seefeldt 1980). The Steindler-Seefeldt correlation relates the amount of material (solid or liquid) in a specific size range released from a nearby explosion to the mass ratio of the initial mass of material to the mass of TNT. (This correlation does not apply to dry powders.) The experimental configuration of the explosive material and the MAR was typically spherical or cylindrical, with the explosive located at the center of the MAR. While these arrangements are not representative of the actual phenomena that would occur in a hydrogen deflagration within the filter vessel, they should be useful in establishing an upper bound on the amount of particulate released.

The fine sand is loaded in the filter to about 76 cm (30 in.) high and fills about 1.4 m^3 (50 ft^3) of the filter with a dry mass of about 2.1×10^6 g. The greatest postulated fuel release will occur if all the fuel is loaded in the fine sand and the mass of garnet, coarse sand, and water are ignored in determining the MAR for the deflagration. It is conservatively assumed that only the top 38 cm (15 in.) of fine sand (50 percent of the total mass) absorb energy during the deflagration. The total mass of this portion of the fine sand and the maximum trapped fuel is

$$(2.1 \times 10^6 \text{ g fine sand})(50\%) + (5.4 \times 10^6 \text{ g fuel}) = 6.45 \times 10^6 \text{ g}.$$

This mass, combined with the calculated TNT equivalent mass for the hydrogen deflagration, gives a mass ratio of

$$(6.45 \times 10^6 \text{ g}) / (2.28 \times 10^2 \text{ g}) = 2.8 \times 10^4.$$

The experimental data used by Steindler and Seefeldt (1980) to develop the correlation included only arrangements with a mass ratio of 15 or less. Steindler and Seefeldt (1980) extrapolate these data in plots of their correlation for mass ratio values up to 400 and suggest that this extrapolation is reasonable for conditions existing in a fuel-cycle facility. However they do not suggest that the correlation be applied to safety analyses for mass ratio values much higher than the available experimental data without verification.

Therefore a value of 50 will be used for the mass ratio in the Steindler-Seefeldt correlation (Steindler and Seefeldt 1980). Using a mass ratio of 2.8×10^4 in the correlation would predict the release of much less respirable material than does using a mass ratio of 50 in the correlation. Therefore, using a mass ratio of 50 is expected to provide conservative predictions of the respirable release. Because the particulate released will likely be coated with water, a maximum released particle size of 20 µm is considered respirable to allow for evaporation en route to the receptor. For a mass ratio of 50, the Steindler-Seefeldt correlation predicts that a total of about 1×10^{-2} g of particulate (less than 20 µm) will be released per gram of TNT (see Figure 6 of Steindler and Seefeldt [1980]). The total amount of respirable fine sand and fuel particulate released is expected to be

$$(1 \times 10^{-2} \text{ g/ g TNT})(2.28 \times 10^2 \text{ g TNT}) = 2.28 \text{ g}.$$

Of this total respirable particulate released, 84 percent (5.4×10^6 g/6.45×10^6 g), or 1.91 g, is calculated to be fuel solids, while the remainder is fine sand. The onsite dose at 100 m from the building is calculated using

$$D_{onsite\_100} = (ST)(\chi/Q')(BR)(URD)$$

where

ST	=	source term: respirable released quantity (g)
χ/Q'	=	atmospheric dispersion factor (s/m^3)
BR	=	breathing rate (3.33×10^{-4} m^3/s for light activity)
URD	=	unit release dose (rem/g).

For this accident, a bounding source term of 1.91 g has been calculated, χ/Q' is selected for an acute release with duration less than 1 hour to a receptor 100 m from K Basins (Rittmann 1998), and the URD is 4.38×10^5 rem/g for the assumed fuel composition. These values lead to an unmitigated onsite dose at 100 m of

$$\begin{aligned} D_{onsite\_100} &= (1.91 \text{ g})(7.32 \times 10^{-2} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s})(4.38 \times 10^5 \text{ rem/g}) \\ &= 20.4 \text{ rem.} \end{aligned}$$

Additional unmitigated receptor doses are summarized in Table 3-14.

Table 3-14. Summary of Maximum Dose Consequences from an Unmitigated Hydrogen Deflagration in the Filter Vessel.

Receptor location	χ/Q' (s/m^3)	rem EDE (Sv)	Guidelines [a] (rem)
100 m east (onsite)	7.32 E-02	2.04 E+01 (2.04 E-01)	25
Hanford Site boundary 12,040 m west (offsite)	3.58 E-05	9.97 E-03 (9.97 E-05)	5
Near river bank (480 m northwest)	2.15 E-03	5.99 E-01 (5.99 E-03)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-6}$ to $\leq 1.0 \times 10^{-4}$.

EDE = effective dose equivalent.

3.4.2.3.4 Comparison to Guidelines. The radiological dose consequences estimated for the unmitigated hydrogen deflagration in the IWTS filter vessel is shown to be less than evaluation guidelines for the estimated extremely unlikely frequency of occurrence. These potential dose consequences are orders of magnitude lower when credit is taken for the safety significant designation of the cesium detection system used to mitigate the filter backwash accident scenario.

3.4.2.3.5 Summary of Safety-Class Structures, Systems, and Components and Technical Safety Requirement Controls. No safety-class or safety-significant mitigating features are required for this scenario. However, the safety-significant designation of the cesium detection system for the mitigated backwash scenario also reduces the potential dose consequences from the hydrogen deflagration scenario.

3.4.2.4 Fuel Oxidation in an Annular Filter Vessel. This accident is fuel oxidation at elevated temperatures in an annular filter vessel. Detailed calculations for this accident may be found in HNF-1777, *K West Basin Integrated Water Treatment System (IWTS) E-F Annular Filter Vessel Accident Calculations* (Watson 1998c).

3.4.2.4.1 Scenario Development. During normal operation, all filter vessels are completely filled with liquid, and oxidation or deflagration accidents are not credible. For this accident, a leak is assumed to occur during an extended shutdown. The leak is assumed to drain water from the annular filter vessel.

For a self-initiating and propagating reaction to occur in the fuel accumulated in the filter, the water must be drained to below the level of the fuel. With the fuel no longer submerged, the fuel temperature could rise through self-heating. The fuel could spontaneously oxidize, releasing radionuclides from the vessel. The mass of damp sand and other filter media in contact with the fuel are expected to act as a sufficient heat sink to prevent the fuel from self-heating above its ignition temperature. While the duration of this accident could potentially be as great as several days, it is conservatively estimated to occur over a period of 1 to 2 hours.

Event path analysis and annual accident frequency estimates were used to determine the annual frequency for this accident sequence (Watson 1998c). The annual frequency of occurrence for this filter vessel fuel oxidation accident is calculated to be 5.8×10^{-6}. The F2 (unlikely) frequency estimated during the hazard analysis (Table 3-3) for fuel oxidation in the filter vessel has been refined and changed to F1 (extremely unlikely).

3.4.2.4.2 Source Term Analysis. The source terms for this analysis is based on known compositions and quantities of hazardous materials stored or handled in the K Basins. Details of the radiological inventory and source term development are provided in Appendix 3B. The assumptions used in the analysis are as follows.

- The maximum fuel inventory in a single filter is one-third of the maximum estimated total K West Basin sludge inventory from Bergsman (1998). By the time this inventory has accumulated in the filter, no more than 10 percent of the fuel will be metallic.

- All particulates from the IWTS process stream are captured and retained by the filter until a backwash is performed.

- The fuel composition reaching the filter is that expected from a Mark IV assembly containing 16.72 percent ^{240}Pu.

- Fuel that has not been oxidized will contain relative concentrations of cesium at least as great as those expected in the Mark IV assembly (16.72 percent ^{240}Pu). Fuel that has undergone oxidation before the accident will contain little cesium and is unavailable for direct oxidation during the accident.

- The relatively small amount of metal fuel that could be accumulated in the filter could not raise the temperature of the surrounding sand and oxide above the ignition temperature of the fuel while it is oxidizing.

- The respirable release fractions during this accident for unreacting oxidized) fuel are bounded by release fractions for the oxidation of fuel at elevated temperatures that are below the ignition temperature.

3.4.2.4.3 Consequence Analysis. The mass of fuel accumulated in the filter for the case where fuel content is not controlled by backwashing could be as much as one-third of the total maximum K West Basin sludge inventory. The maximum estimated inventory is 16.2 metric tons (Bergsman 1998), so that the total sludge mass in any one filter would not exceed 5.4×10^6 g. Much of the particulate fuel expected to reach the filter will have already been oxidized from reacting with water in the basin, but during the retrieval and cleaning process, amounts of small metal particulate may be released into the IWTS. The amount of metal fuel available in the filter vessels should be much less than 10 percent of the total fuel mass. While a greater percentage of the fuel particulate that reaches the filter may be metal, much of this metal will have oxidized while sitting in the filter during the estimated two years of operations needed to accumulate one-third of the basin inventory in the filter. The oxidized fuel, while not available to contribute to release by direct oxidation, could be available for release by the heat generated by oxidation of the intermingled metal.

Oxidation of the fuel above the ignition temperature (about 300 to 500 °C for plutonium or uranium fines [DOE 1994] [Epstein et al. 1996]) is unlikely in the massive damp fine sand matrix of the filter vessel. Given the heat capacity of all the filter media and previously oxidized fuel in the filter, one may apply engineering judgement to conclude that the ignition temperature will not be reached as the relatively small mass of metal particles oxidize. The bounding source term from the oxidizing metal fuel may be determined from an airborne release fraction (ARF) of 3×10^{-5} and the bounding release fraction (RF) is 0.04 (DOE 1994, p. 4-1). These fractions were assessed to be bounding for the oxidation at temperatures below the ignition temperature for plutonium metal (DOE 1994). The source term from the direct oxidation of metal fuel is simply given by MAR × ARF × RF, which in this case equals

$$(10\%)(5.4 \times 10^6 \text{ g})(3 \times 10^{-5})(0.04) = 0.7 \text{ g}.$$

The ARF for the oxide fuel near the metal fuel undergoing oxidation is expected to be less than the ARF for the oxidizing metal fuel. Therefore, applying the ARF and RF values associated with plutonium oxidation below the ignition temperature to the release of the previously oxidized fuel to determine its source term is conservative. The bounding source term from the oxide fuel is expected to be

$$(90\%)(5.4 \times 10^6 \text{ g})(3 \times 10^{-5})(0.04) = 5.8 \text{ g}.$$

The total source term from direct release of oxidizing metal and heating of previously oxidized fuel is calculated to be bounded by a value of 6.5 g. If the accident is assumed to occur over 2 hours, atmospheric dispersion factors that account for plume meander are appropriate (Rittman 1998). The estimated dose to an onsite receptor at 100 m is

$$D_{onsite\_100} = \{(5.8 \text{ g}) + (0.7 \text{ g})\}(1.24 \times 10^{-2} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s})(4.38 \times 10^5 \text{ rem/g})$$
$$= 11.8 \text{ rem}.$$

Additional receptor doses are summarized in Table 3-15. Regular backwashing of the filters would substantially reduce the radiological source term and dose consequences for this accident.

Table 3-15. Summary of Maximum Dose Consequences from an Unmitigated Fuel Oxidation in the Filter Vessel.

Receptor location	χ/Q' (s/m³)	rem EDE (Sv)	Guidelines[a] (rem)
100 m east (onsite)	1.24 E-02	1.18 E+01 (1.18 E-01)	25
Hanford Site boundary 12,040 m west (offsite)	2.60 E-05	2.46 E-02 (2.46 E -04)	5
Near river bank (480 m northwest)	5.55 E-04	5.26 E-01 5.26 E-03)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-6}$ to $\leq 1.0 \times 10^{-4}$.

EDE = effective dose equivalent.

3.4.2.4.4 Comparison to Guidelines. The radiological dose consequences estimated for the unmitigated fuel oxidation in the IWTS filter vessel is shown to be less than the evaluation guidelines for the estimated extremely unlikely frequency of occurrence. These potential dose consequences are orders of magnitude lower if credit is taken for the safety significant designation of the cesium detection system used to mitigate the filter backwash accident scenario.

3.4.2.4.5 Summary of Safety-Class Structures, Systems, and Components and Technical Safety Requirement Controls. No safety class or safety significant mitigating features are required for the scenario. However, the safety significant designation of the cesium detection system for the mitigated backwash scenario also reduces the potential dose consequences from the filter vessel oxidation scenario.

3.4.2.5 Drop of One Ion Exchange Module onto Another. This scenario examines the unmitigated consequences of an IXM being dropped onto another IXM during removal (Watson 1998d).

3.4.2.5.1 Scenario Development. The drop height is conservatively assumed to be 4.25 m (14 ft), the maximum drop height physically possible from the crane.

3.4.2.5.2 Source Term Analysis. Both IXMs are assumed to contain the maximum radionuclide loading as shown in Appendix 3B, Table 3B-4.

3.4.2.5.3 Consequence Analysis. The RF, which applies to impact shock-vibration, is derived from section 5.3.3.2 of DOE-HDBK-3010-94 (DOE 1994). The ARF and RF are determined as follows:

$$ARF \times RF = A \times \rho \times g \times h$$

where

A = empirical correlation (2.0×10^{-11} cm^3 per g-cm^2/s^2)
ρ = specimen density (2.2 g/cm^3 for concrete)
g = gravitational acceleration (980 cm/s^2 at sea level)
h = fall height (425 cm).

$$ARF \times RF = 1.8 \times 10^{-5}.$$

This value is quite conservative because the model is for surface-contaminated material that would be represented as being on the outside of the IXM concrete monolith. The assumption is made that the quantity of material released is bounded by modeling the isotopes as being on the surface of the concrete monolith even though the radionuclides are attached to the smaller resin beads inside.

Using this assumption, the source term in Appendix 3B, Table 3B-4, and the 30-min atmospheric dispersion factors from Table 3B-5, the onsite dose is calculated as

$$D = (ST)(\chi/Q')(BR)(URD)$$

where

$$ST = 2 \text{ IXMs} \times 1.8 \times 10^{-5} = 3.6 \times 10^{-5} \text{ IXMs}.$$

ST is the released respirable fraction of the total radioactive content of the two IXMs.

$$Dose_{on.} = (3.6 \times 10^{-5}\ IXM)(7.32 \times 10^{-2}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)(7.83 \times 10^{8}\ rem/IXM)$$
$$= 6.87 \times 10^{-1}\ rem.$$

Additional receptor doses are provided in Table 3-16.

Table 3-16. Summary of Unmitigated Dose Consequences for the Drop of One K West Basin IXM onto Another.

Receptor location	χ/Q' (s/m^3)	rem EDE (Sv)	Guidelines[a,b] (rem)
100 m E (onsite)	7.32 E-02	6.87 E-01 (6.87 E-03)	10
Hanford Site boundary (12,040 m west) (offsite)	3.58 E-05	3.36 E-04 (3.36 E-06)	5
Near river bank (480 m northwest)	2.15 E-03	2.02 E-02 (2.02 E-04)	—

Note: [a]From Table 3B-5.
[b]At annual frequency of $>1.0 \times 10^{-4}$ to $\leq 1.0 \times 10^{-2}$ per J. L. Weamer (1996).

Weamer, J. L., 1996, *Functions and Requirements for K Basin Transfer Bay Cranes - Project A.5-A.6*, WHC-SD-SNF-FRD-023, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

EDE = effective dose equivalent.

3.4.2.5.4 Comparison to Guidelines. The radiological dose consequences for dropping one IXM onto another have been shown to be less than the risk evaluation guidelines for the estimated frequency of occurrence.

3.4.2.5.5 Summary of Safety-Class Structures, Systems, and Components and Technical Safety Requirement Controls. No safety-class SSCs or TSR controls are required by this analysis.

3.4.2.6 Knockout Pot Drop in Basin. Dropping a heavy object, such as a loaded knockout pot, into the basin during operation could result in a potential criticality event and/or damage to the basin structure or the fuel storage racks (Watson 1998d).

3.4.2.6.1 Scenario Development. IWTS operating activities may require movement of heavy loads of sludge and fuel particulate in the knockout pots. A loaded knockout pot is postulated to be dropped because of equipment failure. The knockout pot drops onto the basin fuel racks or directly onto the basin floor. The impact of this drop is postulated to compromise the knockout pot geometric control of the pot contents resulting in a potential criticality event. This accident is categorized as an operational accident.

3.4.2.6.2 Source Term Analysis. Because no release is anticipated from this accident, no source terms were developed.

3.4.2.6.3 Consequence Analysis. The criticality evaluation, documented in HNF-SD-SNF-CSER-011 (Ericksen 1998), assumes that the pot is structurally capable of withstanding a drop from any height required for operations. An unmitigated drop event (above the allowable height- weight limit) can lead to a potential criticality from a single failure. A loaded knockout pot meets the height-weight limit from Table 3-10 of the K Basin SAR (DESH 1998) for lifts up to 1.8 m (6 ft). The drop of a loaded knockout pot from 1.8 m (6 ft) shall not affect the pot's ability to maintain structural integrity and, therefore, geometric control of its contents in a 1.8 m (6-ft) drop. Based on not exceeding the allowable height and weight defined in Table 3-10 of the K Basin SAR (DESH 1998), no significant damage or failure of the basin will result should a drop occur during normal operations. A dropped knockout pot would likely hit a fuel rack or the basin floor. The knockout pot when full, if dropped from a height that exceeds the height-weight limit, could challenge the basin floor. Drops on the empty fuel racks may crush or destroy the racks, which has been shown to be acceptable as analyzed in WHC-SD-SARR-006, *Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks* (DESH 1997).

A drop of an empty knockout pot onto a full knockout pot during operation or maintenance will be analyzed to verify that a postulated drop is acceptable and does not challenge the ability of the IWTS safety-class equipment to perform its safety function.

3.4.2.6.4 Comparison to Guidelines. The guideline applicable to this accident is that single failures do not cause a criticality. Because postulated knockout pot drops from the controlled height are acceptable, the knockout pot drop does not constitute a failure for criticality purposes.

3.4.2.6.5 Summary of Safety-Class Structures, Systems, and Components and Technical Safety Requirement Controls. To ensure that a knockout pot is not dropped from a height greater than analyzed, a lifting hook, specifically designed for moving knockout pots in the basin, must control the maximum lift height (1.8 m [6 ft]). Because the IWTS knockout pot lifting hook limits the drop height of a knockout pot to the analyzed values for criticality control purposes, it is required to be safety class. This control protects the assumption in the criticality analysis (Ericksen 1998) that dropping a knockout pot does not compromise its ability to maintain geometry control of its contents. The knockout pot lifting hook required minimum length ensures that the drop is within analysis assumptions. This passive component will be listed as a design feature in the TSRs.

The criticality safety evaluation includes a limit to prevent moving loaded knockout pots over other knockout pots without an approved analysis to document that integrity is maintained in a drop. This limit will be implemented by the K Basin criticality prevention specification.

3.4.3 Beyond Design Basis Accidents

The only design basis accident identified is one in which the particulate settlers are uncovered by a seismic-induced basin leak (Watson 1998d). Under normal conditions, the particulate settling tanks are submerged in K Basin water. Thus, the hydrogen accumulation rate is minimal, and the heatup rate is low. In case of a seismic event, the two top particulate settlers could be uncovered because of water leaking from the K Basin. Based on the maximum allowable post-seismic leak rate, it would take at least 5 days to uncover the particulate settlers. Therefore, this accident is considered to be beyond extremely unlikely and beyond design basis.

The particulate settlers are 10 pipes, each 4.9 m (16 ft) long with a diameter of 51 cm (20 in.), arranged in parallel. The total volume of each settler is about 1.0 m^3 (35 ft^3). If the settlers are assumed to be half-full of sludge, half the settler volume would be available for gas accumulation. The total volume that could be occupied by gas in the two uncovered settlers is 1.0 m^3 (35 ft^3). Following the technique used for the hydrogen deflagration in the filter vessel, a respirable release can be obtained for the deflagration if the energy released is equated to that produced by a mass of TNT. If a stoichiometric mixture of hydrogen and oxygen gas were generated and accumulated in the two settlers, 7.82×10^6 J (1.87×10^6 cal) of energy is the most that could be generated by the deflagration. The anticipated amount of total energy released is actually 10 percent of the maximum, or 7.82×10^5 J (1.87×10^5 cal). The mass of TNT that could generate an equivalent energy release is 1.64×10^2 g (0.4 lb). The Steindler-Seefeldt correlation (Steindler and Seefeldt 1980) uses a mass ratio of MAR to TNT to determine the respirable release. The mass ratio for the settler deflagration would be greater than 50. If a conservative value of 50 is chosen for this ratio, 1.0×10^{-2} g of respirable particulate per gram of TNT equivalent is expected to be released. If the acute air dispersion factor is applied to the accident release (duration <1 hour), then the estimated consequences to an offsite receptor are calculated as follows:

$$\begin{aligned} \text{Dose}_{\text{offsite}} &= (1.0 \times 10^{-2}\ \text{g/ g TNT})(1.64 \times 10^{2}\ \text{g TNT})(3.33 \times 10^{-4}\ \text{m}^3/\text{s})(3.58 \times 10^{-5}\ \text{s/m}^3) \\ &\quad (4.38 \times 10^{5}\ \text{rem/g}) \\ &= 8.6 \times 10^{-3}\ \text{rem.} \end{aligned}$$

If a detonation is postulated to occur at some time following the seismic event, it is reasonable to assume that a fuel oxidation event could soon follow. The methodology discussed in the filter fuel oxidation accident scenario can be used to calculate the consequences of such an event in the particulate settlers. If the sludge density is 2.61 g/cm^3 (163 lb/ft^3) (Bergsman 1998), the mass of fuel filling the bottom half of two settlers would be 2.61×10^6 g ($1.0 \times 10^6\ cm^3 \times$ 2.61 g/cm^3). If all this fuel is assumed to oxidize or be released at a temperature below the ignition temperature for the fuel, an ARF and RF of 3.0×10^{-5} and 0.04 may be applied (DOE 1994, subsection 4.2.1.1.3). The total respirable release from this accident would be

$$(2.61 \times 10^6\ \text{g})(3.0 \times 10^{-5})(0.04) = 3.1\ \text{g}.$$

If this release is assumed to occur over 2 hours, the dose to the offsite receptor is

$$\begin{aligned}\text{Dose}_{\text{offsite}} &= (3.1\text{ g})(2.60 \times 10^{-5}\text{ s/m}^3)(3.33 \times 10^{-4}\text{ m}^3\text{/s})(4.38 \times 10^5\text{ rem/g}) \\ &= 1.2 \times 10^{-2}\text{ rem.}\end{aligned}$$

If the most extreme accident condition is considered without regard to credibility, all this fuel could be assumed to burn. If the fuel is assumed to burn or be released at a temperature above the ignition temperature for the fuel, an ARF and RF of 5.0×10^{-4} and 0.5 may be applied (DOE 1994, subsection 4.2.1.1.3). The total respirable release from this accident would be

$$(2.61 \times 10^6\text{ g})(5.0 \times 10^{-4})(0.5) = 6.5 \times 10^2\text{ g.}$$

If this release is assumed to occur over 2 hours, the dose to the offsite receptor is

$$\begin{aligned}\text{Dose}_{\text{offsite}} &= (6.5\text{ x}10^2\text{ g})(2.60 \times 10^{-5}\text{ s/m}^3)(3.33 \times 10^{-4}\text{ m}^3\text{/s})(4.38 \times 10^5\text{ rem/g}) \\ &= 2.5\text{ rem.}\end{aligned}$$

The estimated consequences of a deflagration, fuel oxidation, and fuel burn in the particulate settlers are shown in Table 3-17.

Table 3-17. Summary of Offsite Unmitigated Dose Consequences of Beyond Design Basis Accidents in Particulate Settlers. (Hanford Site boundary 12,040 m west)

Accidents (caused by seismic-induced basin leak)	χ/Q' (s/m³)	rem EDE (Sv)
Hydrogen deflagration	3.58 E-05	8.6 E-03 (8.6 E-05)
Fuel oxidation	2.60 E-05	1.2 E-02 (1.2 E-04)
Fuel burn	2.60 E-05	2.5 E+00 (2.5 E-02)

Note: Post-earthquake releases occurring several days after the initiating event do not represent a risk to unprotected onsite receptors or near-river occupants.

EDE = effective dose equivalent.

3.5 REFERENCES

AIChE, 1992, *Guidelines for Hazard Evaluation Procedures*, Second Edition with Worked Examples, American Institute of Chemical Engineers, New York, New York.

AIHA, 1990, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.

Avallone, E., and T. Baumeister, Editors, 1996, *Marks' Standard Handbook for Mechanical Engineers*, Tenth Edition, McGraw-Hill, New York, New York.

Bergsman, K. H., 1998, *Specification for Design, Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment System*, HNF-S-0564, Rev. 1A, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1997, *Evaluation of Safety Issues Associated with Damage or Removal of K Basin Fuel Storage Racks*, HNF-SD-SARR-006, Rev. 0, DE&S Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998a, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998b, *Fire Hazard Analysis for the K Basins Facilities at 100K Area*, HNF-SD-SNF-FHA-001, Rev. 1 (Draft), DE&S Hanford, Inc. for Fluor Daniel Hanford, Inc., Richland, Washington.

DOE, 1994, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, Vol. I, U.S. Department of Energy, Washington, D.C.

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

Eide, S. A., S. V. Chmielewski, and T. D. Swantz, 1990, *Generic Component Failure Data Base for Light Water and Liquid Sodium Reactor PRAs*, EGG-SSRE-8875, EG&G Idaho, Idaho Falls, Idaho.

Epstein, M., W. Luangdilok, M. G. Plys, and H K. Fauske, 1996, "On Predication of the Ignition Potential of Uranium Metal and Hydride," *Nuclear Safety*, M. J. Muhkheim, Editor, Volume 37, No. 1, January-March.

Erickson, D. G., 1998, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems, Subproject A.9*, HNF-SD-SNF-CSER-011, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Hey, B. E., and D. S. Leach, 1994, *A Model for Predicting Respirable Releases from Pressurized Leaks*, WHC-SN-GN-SWD-20007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

HNF-PRO-704, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Inc., Richland, Washington.

Porten, D. R., 1994, *K Basins Fuel Encapsulation and Storage Hazard Categorization*, WHC-SD-SNF-HC-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Rittmann, P. D., 1998, *A Discussion of the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, HNF-SD-SNF-TI-059, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Sellers, E. D., 1997, *Risk Evaluation Guidelines (REGs) to Ensure Inherently Safer Designs* (Letter 97-SFD-172 to H. J. Hatch, Fluor Daniel Hanford, Inc., August 26), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Semmens, L. S., 1997, *Hazard Categorization for K West Integrated Water Treatment System*, HNF-SD-SNF-HC-013, Rev. 0, DE&S Hanford, Inc, for Fluor Daniel Hanford, Inc., Richland, Washington.

Steindler, M. J., and W. B. Seefeldt, 1980, "A Method for Estimating the Challenge to an Air Cleaning System Resulting from an Accidental Explosive Event," *Proceeding of the 16th DOE Air Cleaning Conference*, M.W. First, Editor, Harvard Air Cleaning Laboratory, Boston, Massachusetts.

Strehlow, R. A., 1972, "Unconfined Vapor Cloud Explosion- An Overview," *Proceedings of the Fourteenth International Symposium on Combustion*, R. S. Chaiken, Editor, Combustion Institute, Pittsburgh, Pennsylvania.

Thompson, 1987, *Engineering Safety Assessment*, National Nuclear Corporation Ltd., Knutsford, England.

Watson, D. J., 1998a, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document*, HNF-SD-SNF-RD-001, Rev. 1, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Watson, W. T., 1998b, *K West Basin Integrated Water Treatment System Spray Leak Accident Calculations*, HNF-1778, Rev. 2, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Watson, W. T., 1998c, *K West Basin Integrated Water Treatment System (IWTS) E-F Annular Filter Vessel Accident Calculations*, HNF-1777, Rev. 3, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Watson, W. T., 1998d, *K West Basin Integrated Water Treatment System Ion Exchange Module, Particulate Settler, and Knock-Out Pot Accidents*, HNF-2862, Rev. 0, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Weamer, J. L., 1996, *Functions and Requirements for K Basin Transfer Bay Cranes - Project A.5-A.6*, WHC-SD-SNF-FRD-023, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX 3A

HAZARDS AND OPERABILITY ANALYSIS OF INTEGRATED WATER TREATMENT SYSTEM IN K WEST BASIN

This page intentionally left blank.

Table 3A-1. Node 1: Process Description: Piping from Canister Decapping. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Pumps off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged screen	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged pipe	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Booster pump off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
	More	Other FRS pumps off-line		No significant consequences			F1	S0
	Less	Partial conditions for no (e.g., screen partially plugged)	Accumulation of particulates in piping	Increased worker dose rate from equipment	Area radiation monitors	Surveillances	F3	S1

Table 3A-1. Node 1: Process Description: Piping from Canister Decapping. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	As well as (>0.25 in. particles)	Screen failure	Possible violation of criticality requirements downstream	Criticality	Knockout pot		F1	S2
	Part of	N/A						
	Reverse	Pump failure	Backflow from other FRS pumps	Increased contamination in basin	Pump interlock Area radiation monitors	Procedures Surveillance	F2	S1
	Other than	Misvalving	Backflow from Cold Vacuum Drying Facility unloading	Increased contamination in the basin	Area radiation monitors	Procedures	F2	S1

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
FRS = fuel retrieval system.
N/A = not applicable.

Table 3A-2. Node 2: Process Description: Piping from Primary Cleaning. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	High-pressure FRS not operating	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged screen	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged pipe	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Booster pump off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
	More	Other FRS pumps off-line	N/A	No significant consequences				S0

Table 3A-2. Node 2: Process Description: Piping from Primary Cleaning. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Less	Partial conditions for no (e.g., partially plugged screen)	Accumulation of particulate in piping	Increased worker dose rate from equipment	Area radiation monitors	Surveillances	F3	S1
	As well as >0.25-in. particles	Screen failure	Possible violation of criticality requirements downstream	Criticality	Knockout pot		F2	S2
	Part of	N/A						
	Reverse	Pump failure	Backflow from other FRS pumps	Increased contamination in basin	Pump interlock Area radiation monitors	Procedures Surveillance	F2	S1
	Other than	Misvalving	Backflow from Cold Vacuum Drying Facility unloading	Increased contamination in the basin	Area radiation monitors	Procedures	F2	S1

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
FRS = fuel retrieval system.
N/A = not applicable.

Table 3A-3. Node 3: Process Description: Piping from Downdraft Table. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Pumps off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged screen	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Plugged pipe	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
		Booster pump off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
	More	Other FRS pumps off line		No significant consequences				

Table 3A-3. Node 3: Process Description: Piping from Downdraft Table. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Less	Partial conditions for no (e.g., partially plugged screen)	Accumulation of particulate in piping	Increased worker dose rate from equipment	Area radiation monitors	Surveillances	F3	S1
	As well as >0.25-in. particles	Screen failure	Possible violation of criticality requirements downstream	Criticality	Knockout pot		F2	S2
	Part of	N/A						
	Reverse	Pump failure	Backflow from other FRS pumps	Increased contamination in basin	Pump interlock Area radiation monitors	Procedures Surveillance	F2	S1
	Other than	Misvalving	Backflow from Cold Vacuum Drying Facility unloading	Increased contamination in the basin	Area radiation monitors	Procedures	F2	S1

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
FRS = fuel retrieval system.
N/A = not applicable.

Table 3A-4. Node 4: Process Description: Knockout Pot. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Level	High	Large particles	Knockout pot too heavy	Damage to lifting equipment; drop of knockout pot resulting in contamination of basin	Differential pressure indication		F2	S1
			Plugging or backflow into inlet hose	See no flow	Differential pressure indication		F2	S1
	Low	Screen plugging	Partially full knockout pot	Premature changeout; ALARA issue	See previous		F2	S1
		Knockout pot leaking	Partially full knockout pot	Contamination of basin water	See previous		F1	S1
	No	Pipe leak	Flow of particulate into basin	Contamination of basin water	See previous		F2	S1
		Pipe disconnected	Flow of particulate into basin	Contamination of basin water	See previous		F2	S1

Table 3A-4. Node 4: Process Description: Knockout Pot. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Composition	Hydrogen	Radiolysis and fuel corrosion	Hydrogen trapped in particulate matter	Possible rollover and release of hydrogen causing contamination spread during disposal	Vent to allow hydrogen to offgas to the basin as it forms		F2	S1

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.

Table 3A-5. Node 5: Process Description: Piping from Cold Vacuum Drying Facility. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Plugged pipe	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased solids in piping	Increased worker dose rate in basin area	Area radiation monitors Shielding	Surveillances	F3	S1
		Booster pump off	Lost time	Repairs necessary, causing dose to workers		ALARA program	F3	S1
			Increased basin contamination from backflow of cesium	Increased worker dose rate in basin area	Area radiation monitors	Surveillances	F3	S1
	More	N/A						
	Less	Partial conditions for no	Accumulation of particulate in piping	Increased worker dose rate from equipment	Area radiation monitors	Surveillances	F3	S1
	As well as (metric? [>0.25 in. particles])	Abnormal operations in CVDF	Possible violation of criticality requirements downstream	Criticality		Controls at CVDF	F2	S2
	Part of	N/A						

Table 3A-5. Node 5: Process Description: Piping from Cold Vacuum Drying Facility. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Reverse	Pump failure	Backflow from other FRS pumps	Increased contamination in truck from CVDF with higher dose rate	Area radiation monitors	Procedures Surveillance	F2	S1
	Reverse	Pump failure	Backflow from other FRS pumps	Spill to the floor if piping stub not capped	Area radiation monitors	Procedures Surveillance	F2	S2

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
CVDF = Cold Vacuum Drying Facility.
FRS = fuel retrieval system.
N/A = not applicable.

Table 3A-6. Node 6: Process Description: Existing Recirculation Pump Piping. (June 24, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-7. Node 7: Process Description: Decant from Particulate Holding Tank. (June 24, 1997)

Process parameter	Guide word/ Deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
This system has been eliminated from the design								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

Table 3A-8. Node 8: Process Description: Process Line Through Booster Pump. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	All fuel retrieval pumps stopped	Static line from FRS	Decreased water quality with worker exposure	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	No	Line break (large)	Leak of basin water outside of basin	Worker exposure to pool leak	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	No	Line break (large)	Possibly pumping basin dry	Design basis accident	Flow indication downstream of booster pump Area radiation monitors Basin level		F1	S2
	More	All pumps and recirculation pump operating	Insufficient filtration of water	Decreased water quality with worker exposure	Flow indication Area radiation monitors	Recirculation pump locked out while FRS is operating Basin sampling	F2	S1

Table 3A-8. Node 8: Process Description: Process Line Through Booster Pump. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Low	Decreased flow through fuel-retrieval pumps	Increased particulate buildup	Decreased water quality with worker exposure	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	Low	Line break (small)	Leak of basin water outside of basin	Spray leak of basin water	Constant air monitors Area radiation monitors		F2	S2
	As well as	Previous HAZOP studies contain information on contaminants in basin water						
	Part of							
	Reverse	Misdirection of filter backwash	Flow to booster pump	Depriming pump			F1	S1
	Other than	N/A						

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

FRS = fuel retrieval system.
HAZOP = hazards and operability.
N/A = not applicable.

Table 3A-9. Node 9: Process Description: Chemical Addition Line. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No			No significant consequences				S0
	More			No significant consequences				S0
	Less			No significant consequences				S0
	As well as	N/A						
	Part of	N/A						
	Reverse	N/A						
	Other than	Use of wrong chemical	Chemical reaction	Cannot postulate consequences because possibilities for chemical addition are unknown				
Structural integrity	Less than	Line break (large) downstream of check valve	Possibly pumping basin dry	Design basis accident	Flow indication downstream of booster pump Area radiation monitors Basin level		F1	S2

Table 3A-9. Node 9: Process Description: Chemical Addition Line. (June 24, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Structural integrity (cont)	Less than (cont)	Line break (small) downstream of check valve	Leak of basin water outside of basin	Spray leak of basin water	Constant air monitors Area radiation monitors		F2	S2

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

N/A = not applicable.

Table 3A-10. Node 10: Process Description: Process Line to North Load-Out Pit. (June 24, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Line has been eliminated or changed								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

N/A = not applicable.

Table 3A-11. Node 11: Process Description: Filter Backwash Line. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Plugged pipes	Inability to furnish backwash to filter	Worker exposure during recovery action	Recirculation pump discharge used for backwash	Procedure	F2	S1
		Line break (large)	Possibly pumping basin dry	Design basis accident	Recirculation pump inlet is above the danger level Area radiation monitors Basin level		F1	S2
		Line break (large)	Leak of basin water outside of basin	Worker exposure to pool leak	Area radiation monitors Basin level		F2	S1
	More	Misvalving	Excess flow rate to filter	Flushing more media to particulate settlers	Rate valve set in line	Procedures		S0
	Less	Misvalving	Incomplete backwash	Decreased filtration efficiency, causing more frequent backwash	Control system interlocks	Procedures	F2	S1
		Line break (small) downstream of check valve	Leak of basin water outside of basin	Spray leak of basin water with aerosol release	Constant air monitors Area radiation monitors	Procedures	F2	S2
	As well as (air)	Excess air valved into system	Lifting of media	Flushing media to particulate settlers		Procedures	F3	S0

Table 3A-11. Node 11: Process Description: Filter Backwash Line. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	As well as (particulate)	Failure to lock out FRS pumps during backwash	Transfer of particulate below filter screen	Transfer of particulate to IXM, making it become TRU sooner, with more frequent changeouts with worker exposure	Possible control interlock	Procedure	F2	S1
	Part of	N/A						
	Reverse	Misvalving	Backflow of air through the system	Operational problem		Procedures	F2	S0

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

FRS = fuel retrieval system.
IXM = ion exchange module.
N/A = not applicable.
TRU = transuranic.

Table 3A-12. Node 12: Process Description: Process Line from Valve V-115 to Filter Vessel.
(June 25, 1997) (4 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (backwash)	No	Plugged pipes or filter bed	Inability to furnish backwash to filter	Worker exposure during recovery action	Recirculation pump discharge used for backwash	Procedure	F2	S1
		Attempting to backwash while filter is loading	Inability to backwash filter	Higher loading and dose rates from filter	Permissive controls		F2	S1
		Line break (large)	Possibly pumping basin dry	Design basis accident	Recirculation pump inlet is above the danger level Area radiation monitors Basin level		F1	S2
		Line break (large)	Leak of basin water outside of basin	Worker exposure to pool leak	Area radiation monitors Basin level		F2	S1
	More	Misvalving	Channeling of filter bed	Decreased water quality with higher dose rate	Area radiation monitors	Basin sampling	F2	S1
	More	Misvalving	Excess flow rate to filter	Flushing more media to particulate holding tank	Flow indication	Procedures	F2	S1

Table 3A-12. Node 12: Process Description: Process Line from Valve V-115 to Filter Vessel. (June 25, 1997) (4 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (backwash) (cont)	Less	Misvalving	Incomplete backwash	Decreased filtration efficiency, causing more frequent backwash	Control system interlocks		F2	S1
		Line break (small) downstream of check valve	Leak of basin water outside of basin	Spray leak of basin water with aerosol release	Constant air monitors Area radiation monitors		F2	S2
	As well as (air)	Excess air valved into system	Lifting of media	Flushing media to particulate holding tank, causing changeout to occur more frequently with worker exposure		Procedures	F3	Si
	As well as (particulates)	Failure to lock out FRS pumps during backwash	Transfer of particulate below filter screen	Transfer of particulate to IXM, making it become TRU sooner, with more frequent changeouts with worker exposure	Possible control interlock	Procedure	F2	S1
	Part of	N/A						
	Reverse	Misvalving	Backflow of air through the system	Operational problem		Procedures	F2	S0

Table 3A-12. Node 12: Process Description: Process Line from Valve V-115 to Filter Vessel. (June 25, 1997) (4 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (effluent)	No	Plugged filter bed					F3	S1
		Plugged pipe					F3	S1
		Plugged strainer					F3	S1
	More	Other filters plugged	Less filtration efficiency	Decreased basin water quality with higher worker exposure		Procedures	F2	S1
	More	Other filters plugged	Bed channeling	IXM loadup with particulate with worker exposure to change IXMs		Procedures	F2	S1
	Less	Partial plugging	Less filtration efficiency because of more flow to other filters	Worker exposure from recovery action		Diagnostic procedures	F2	S1
	As well as	Particulate (screen failure)	Particulate in line to IXM	IXM becomes loaded sooner, resulting in worker exposure from changeout	Sight glass or camera to observe effluent		F2	S1

Table 3A-12. Node 12: Process Description: Process Line from Valve V-115 to Filter Vessel. (June 25, 1997) (4 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (effluent) (cont)	Part of	N/A						
	Reverse	N/A						
	Other than	N/A						

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

FRS = fuel retrieval system.
IXM = ion exchange module.
N/A = not applicable.
TRU = transuranic.

Table 3A-13. Node 13: Process Description: Service Air Line. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Air compressor failure	Decreased backwash efficiency	Worker exposure from having to repeat backwash			F2	S1
		Line plugging	Decreased backwash efficiency	Worker exposure from having to repeat backwash			F1	S1
	More	Misvalving	Loss of filter media	Worker exposure from having to add media	Rate set valve on air line		F2	S1
	Less	Misvalving	Decreased backwash efficiency	Worker exposure from having to repeat backwash			F1	S1
	As well as (oil)	Contamination of compressor air	Because of extraction of TRU, makes IXMs become TRU sooner	Worker exposure due to changing out IXM oftener	Oil-free compressor		F0*	S1
	Reverse	Valve leak	Transfer of contaminated water to air lines, receiver and compressor	Worker exposure to contaminated equipment	Check valve	Procedure Surveillance	F1	S1
	Other than	N/A						

Note Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

IXM = ion exchange module.
N/A = not applicable.
TRU = transuranic.

Table 3A-14. Node 14: Process Description: Process Line from Backwash Out-take to Filter Vessel. (June 25, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	All fuel retrieval pumps stopped	Static line from FRS	Decreased water quality with worker exposure	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	No	Line break (large)	Leak of basin water outside of basin	Worker exposure to pool leak	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	No	Line break (large)	Possibly pumping basin dry	Design basis accident	Flow indication downstream of booster pump Area radiation monitors Basin level		F1	S2
	More	All pumps and recirculation pump operating	Insufficient filtration of water	Decreased water quality with worker exposure	Flow indication Area radiation monitors	Recirculation pump locked out while FRS is operating Basin sampling	F2	S1

Table 3A-14. Node 14: Process Description: Process Line from Backwash Out-take to Filter Vessel. (June 25, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Less	Decreased flow through fuel retrieval pumps	Increased particulate buildup	Decreased water quality with worker exposure	Flow indication downstream of booster pump Area radiation monitors	Basin sampling	F2	S1
	Less	Line break (small)	Leak of basin water outside of basin	Spray leak of basin water	Constant air monitors Area radiation monitors		F2	S2
	Less	Rupture of DP line	Leak of basin water outside of basin	Pool leak of basin water	Constant air monitors Area radiation monitors		F2	S1
	Less	Diaphragm pump failure	Leak of basin water outside basin	Spray leak of basin water	Constant air monitors Area radiation monitors		F2	S2
	As well as	>300 µm particles caused by screen failure in knockout pot	Filter loading at greater rate	Worker exposure with more frequent backwash			F2	S1

Table 3A-14. Node 14: Process Description: Process Line from Backwash Out-take to Filter Vessel. (June 25, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	As well as (cont)	Lumps of flocculent	Higher differential pressure across filters	Worker exposure with more frequent backwash			F2	S1
		Hydraulic fluid	Extraction of TRU	Causes IXMs to become TRU sooner and more worker exposure			F1	S1
		Reverse (air)	Misvalving during backwash	Operational problems			F2	S0

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

DP = differential pressure.
FRS = fuel retrieval system.
IXM = ion exchange module.
TRU = transuranic.

Table 3A-15. Node 15: Process Description: Filter Top Sluice Line. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Plugged pipes	Inability to top sluice filter	Worker exposure during recovery action	Recirculation pump discharge used for backwash	Procedure	F2	S1
		Line break (large)	Possibly pumping basin dry	Design basis accident	Recirculation pump inlet is above the danger level Area radiation monitors Basin level		F1	S2
		Line break (large)	Leak of basin water outside of basin	Worker exposure to pool leak	Area radiation monitors Basin level		F2	S1
	More	Misvalving	Excess flow rate to filter	Flushing more media to particulate holding tank				
	Less	Misvalving	Incomplete top sluice	Decreased filtration efficiency, causing more frequent backwash	Control system interlocks		F2	S1
		Line break (small)	Leak of basin water outside of basin	Spray leak of basin water with aerosol release	Constant air monitors Area radiation monitors		F2	S2

Table 3A-15. Node 15: Process Description: Filter Top Sluice Line. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	As well as (air)	Excess air valved into system	Lifting of media	Flushing media to particulate holding tank, causing changeout to occur more frequently with worker exposure		Procedures	F3	S1
	As well as (particulate)	Failure to lock out FRS pumps during top sluice	No significant consequences					
	Part of	N/A						
	Reverse	Misvalving	Backflow of air through the system	Operational problem		Procedures	F2	S0

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

FRS = fuel retrieval system.
N/A = not applicable.

Table 3A-16. Node 16: Process Description: Backwash Outlet Line. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Outlet valve shut	Backwash flow to the basin via the vent	Decreased water quality and high dose rate in vent piping causing worker exposure	Valve position indication Possible permissives	Procedures	F2	S2
	No	Line plug	See previous					
	No	Large pipe break	Pool release to floor	Worker exposure to pool of contaminated water with airborne particulates	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	No	Large pipe break	Pumping down basin level	Design basis accident	Level monitoring in basin Piping designed for service conditions Air monitoring Recirculation pump inlet above danger zone	Backwash is a limited time	F2	S1
	More	Flow when filter is being loaded	Unfiltered flow to particulate holding tank	Filling particulate holding tank with vent to basin with decreased water quality and worker exposure	V-117 interlocked to stay shut when filter is being loaded	Procedures, training	F1	S1
	Less	Small pipe break	Spray release to basin area	Worker exposure to aerosol of contaminated water with airborne particulate	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	As well as	N/A						

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurtis, C. Lindquist, J. Siemer.

N/A = not applicable.

Table 3A-17. Node 17: Process Description: Filter Vessel Vent. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Blockage of vent and drain during filtration	Pressurization of filter vessel	Damage to vessel with release of liquid and particulate to process area	Filter is pressure vessel designed for greater than maximum pump head Liquid containment around filter vessels	Procedures	F2	S2
	No	Blockage of vent and PHT line during sluicing or backwash	Pressurization of filter vessel	Damage to vessel with release of liquid and particulate to process area	Filter is pressure vessel designed for greater than maximum pump head Liquid containment around filter vessels	Procedures	F2	S2
	No	Large pipe break	Pool release to floor	Worker exposure to pool of contaminated water with airborne particulate	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	No	Large pipe break	Pumping down basin level	Design basis accident	Level monitoring in basin Piping designed for service conditions Air monitoring	Surveillance	F2	S1
	More	N/A						
	Less	See "No"						

Table 3A-17. Node 17: Process Description: Filter Vessel Vent. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Less	Small pipe break	Spray release to basin area	Worker exposure to aerosol of contaminated water with airborne particulate	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	As well as (particles)	Blockage of particulate holding tank line during sluicing or backwash	Flow of particulate from filter to basin	Contamination of basin water causing higher dose rate to workers	Area radiation monitors Air monitoring in basin area	Procedures		
	Part of	N/A						
	Reverse	N/A						
	Other than	N/A						

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

N/A = not applicable.

Table 3A-18. Node 18: Process Description: Filter Bed Drain Line to Particulate Settlers. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Closed valve	Inability to renew bed	Worker exposure from recovery actions	Valve position indicators	Procedures		
	No	Plugged line	Inability to renew bed	Worker exposure from recovery actions		Procedures		
	No	Large pipe break	Pumping down basin level	Design basis accident	Level monitoring in basin Piping designed for service conditions Air monitoring	Surveillance	F1	S1
	No	Large pipe break	Pool release to floor	Worker exposure to pool of contaminated water with airborne particulates	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	More	N/A						
	Less	See"No"						
	Less	Small pipe break	Spray release to basin area	Worker exposure to aerosol of contaminated water with airborne particulates	Piping designed for service conditions Air monitoring	Surveillance	F2	S2

Table 3A-18. Node 18: Process Description: Filter Bed Drain Line to Particulate Settlers. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	As well as (air)	Air valve opened during bed changeout	Gas transfer to particulate holding tank	Suspension of aerosols to particulate holding tank vent line causing aerosol to basin	Underwater	Procedure	F2	S1
	As well as (air)	Air valve opened during bed changeout	Gas transfer to particulate settlers	Suspension of aerosols to particulate holding tank vent line causing a high dose rate in vent line underwater	Area radiation monitors	Procedure Surveillance	F2	S1
	Part of	N/A						
	Reverse	N/A						
	Other than (air)	Filter bed drain valve open and air valve opened or leaking	See "as well as" "air"					

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

N/A = not applicable.

Table 3A-19. Node 19: Process Description: Filter Vessel. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Level	High	Overloading with media during "sweetening"	Excess filter media in vessel before loading, making sluice out during backwash or top sluicing difficult	Worker exposure during recovery action, particularly if excess media cannot be sluiced with installed systems		Procedures	F2	S1
	High	Failure to backwash filter vessel (probably) for several cycles	Vessel filled with sludge, making sluice out during backwash or top sluicing difficult	Worker exposure during recovery action, particularly if material cannot be sluiced with installed systems	Differential pressure monitoring Area radiation monitoring	Procedures	F2	S1
		Greater than 300 μm particles	Vessel filled with sludge (because differential pressure does not change), making sluice out during backwash or top sluicing difficult	Worker exposure during recovery action, particularly if material cannot be sluiced with installed systems	Area radiation monitoring Knockout pot filter		F2	S1
	Low	Media removed with excess water during backwash or top sluice	Decreased filter efficiency	Increased contamination of IXMs with potential for worker exposure during changeout	Sight glass	Procedure for backwash	F2	S1
Temperature	High	Uranium corrosion combined with low flow through media	Excess hydrogen generation (particularly if temperature >60 °C [140 °F])	Hydrogen deflagration or uranium fire with release of particulates and aerosols	Temperature monitoring		F1	S2

Table 3A-19. Node 19: Process Description: Filter Vessel. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Temperature (cont)	High (cont)	Uranium corrosion combined with low flow through media	Excess release of cesium from particulates (particularly if temperature >60 °C [140 °F])	Release of cesium into solution, causing loading of IXMs and extra exposure from that activity	Temperature monitoring		F1	S1
	Low	N/A						
Pressure	High	See "No flow in vent line" (node 17)						
	Low	N/A						
Composition	Particles >300 µm	Screen failure	Possible criticality implications	Criticality	Filter vessel is designed to be critically safe			

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

IXM = ion exchange module.
N/A = not applicable.

Table 3A-20. Node 20: Process Description: Filter Effluent from Valve V-115 to Ion Exchange Modules. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Closed valve	More flow to other filters	Worker exposure during recovery actions	Valve position indicators	Procedures		
		Plugged strainer	Pressurization of filters	Worker exposure during recovery actions		Procedures		
		Large pipe break	Pumping down basin level	Design basis accident	Level monitoring in basin Piping designed for service conditions Air monitoring	Surveillance	F1	S1
		Large pipe break	Pool release to floor	Worker exposure to pool of contaminated water with airborne particulates	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	More	FRS flow in addition to recirculation pump bypass	High pressure flow to IXM, decreased efficiency	Decreased basin water quality	Air monitoring equipment	Procedures	F2	S1
	Less	See "No"						

Table 3A-20. Node 20: Process Description: Filter Effluent from Valve V-115 to Ion Exchange Modules. (June 25, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Less	Small pipe break	Spray release to basin area	Worker exposure to aerosol of contaminated water	Piping designed for service conditions Air monitoring	Surveillance	F2	S2
	As well as (particulates)	Filter inefficiency (channeling, etc.)	IXM becomes TRU sooner	Worker exposure during changeout		Procedure	F2	S1
	Part of	N/A						
	Reverse	N/A						
	Other than	N/A						

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

FRS = fuel retrieval system.
IXM = ion exchange module.
N/A = not applicable.
TRU = transuranic.

Table 3A-21. Node 21: Process Description: Particulate Holding Tank. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
This system has been eliminated from the design								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

Table 3A-22. Node 22: Process Description: Particulate Holding Tank Dewatering System. (June 25, 1997)

Process parameter	Guide word/ Deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
This system has been eliminated from the design								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

Table 3A-23. Node 23: Process Description: Ion Exchange Modules. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								
Government furnished equipment								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-24. Node 24: Process Description: Process Line from Ion Exchange Modules to Distribution Header. (June 25, 1997)

Process parameter	Guide word/ Deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-25. Node 25: Process Description: Ion Exchange Module Drain Line to Basin. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-26. Node 26: Process Description: Ion Exchange Modules Isolock Sampler with Drain to Basin. (June 25, 1997)

Process parameter	Guide word/ Deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-27. Node 27: Process Description: Air Supply Lines to Isolock Samplers. (June 25, 1997)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-28. Node 28: Process Description: Ion Exchange Module Vents. (June 25, 1997)

Process parameter	Guide word/ Deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Using previous HAZOP study information								

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, F. Bolyard, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

HAZOP = hazards and operability.

Table 3A-29. Node 29: Process Description: Process Line from Filter Backwash to Main Process Line. (July 29, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Plugging	High dose rate in piping above water	ALARA problems Operational impact	Line velocity Existing area radiation monitors Sight glass and video camera	Procedure to maintain flow Differential pressure	F3	S1
		Valving error	High dose rate in piping above water	ALARA problems Operational impact	Existing area radiation monitors Sight glass and video camera	Procedure to maintain flow Differential pressure	F3	S1
		Recirculation pump down	High dose rate in piping above water	ALARA problems Operational impact	Redundant pumps	Procedures	F3	S1
		Pipe break	Leak to the basin area High dose rate	ALARA problems Criticality in the weasel pit	Area radiation monitors, shielding to knock down spray leak aerosol	Testing	F2	S2
		Computer problems	High dose rate in piping above water	ALARA problems Operational impact	Existing area radiation monitors	Computer diagnostics	F3	S1
		Filter problems	High dose rate in piping above water	ALARA problems Operational impact	Existing area radiation monitors	Recovery procedures	F3	S1

Table 3A-29. Node 29: Process Description: Process Line from Filter Backwash to Main Process Line. (July 29, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	More	Full 450 gal/min recirculation flow	Resuspension of material in particulate settlers and transfer to second stage or venting to basin	ALARA problems in basin	Existing area radiation monitors Second-stage particulate settlers	Operating procedures	F2	S1
		Booster pump addition	Resuspension of material in particulate settlers and transfer to second stage or venting to basin	ALARA problems in basin	Existing area radiation monitors Second-stage particulate settlers	Operating procedures	F2	S1
	Less	Pump runs backward	High dose rate in filter caused by incomplete backwash	Worker exposure	Radiation monitor for filter accumulation	Pump maintenance procedures	F2	S1
	As well as	N/A						
	Part of	Air	Filter vent plugged	Particulate settlers become buoyant	Support rack for settlers designed to withstand vessel buoyancy	Procedures	S1	
	Other than	Large particles	Line plugging; see "No flow"					

Table 3A-29. Node 29: Process Description: Process Line from Filter Backwash to Main Process Line. (July 29, 1997) (3 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow (cont)	Reverse	Valve failure	Backflow to filter and potentially reaching the basin through the filter vent	ALARA problems Operational impact		Diagnostic procedures	F2	S1

Note: Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
N/A = not applicable.

Table 3A-30. Node 30: Process Description: Particulate Settlers. (July 29, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Flow	No	Plugging	High dose rate in connecting piping	Worker exposure during recovery actions	Area radiation monitors	Recovery procedures	F2	S1
	Reverse	Valving error	High dose rate in piping	ALARA problems Operational impact	Valve permissives	Procedures	F2	S1
Pressure	High	Air (70 lbf/in^2)	Venting to basin	ALARA problems	Settlers designed to withstand air pressure and provided with vent	Procedures	F2	S1
		Hydrogen generation	Venting to basin	ALARA problems	Hydrogen evolution limited by basin temperature control Vent provided to prevent pressurization of settlers	Basin temperature specifications	F2	S1
	Reverse (vacuum)	Valving error	Spill to basin	ALARA problems	Area radiation monitors	Procedures	F3	S1
Temperature	High	Low basin level	Excess hydrogen generation causing pressurization and venting to basin	ALARA problems Operational impact	Vent provided to prevent pressurization of settlers	Basin temperature specifications	F2	S1

Table 3A-30. Node 30: Process Description: Particulate Settlers. (July 29, 1997) (2 sheets)

Process parameter	Guide word/ deviation	Cause	Resulting abnormal condition	Consequence	Engineered features	Administrative controls	Freq. rank	Cons. rank
Temperature (cont)	High (cont)	Very low basin from DBE causing top tier of settlers to be uncovered	Hydrogen explosion causing dispersion of particulate	Spread of radioactive material outside basin		Emergency procedures	F1	S2
		Very low basin from DBE causing top tier of settlers to be uncovered	Fuel fire caused by fuel ignition in settlers	Spread of radioactive material outside basin		Emergency procedures	F1	S2

Note :Participants: J. Hunacek, D. Takasumi, K. Bergsman, J. Loomis, R. Meichle, S. Kensicki, T. Pauly, J. Kurta, V. Hoefer, C. Lindquist, J. Siemer.

ALARA = as low as reasonably achievable.
DBE = design basis earthquake.

APPENDIX 3B

BASES FOR ACCIDENT DOSES

This page intentionally left blank.

APPENDIX 3B

BASES FOR ACCIDENT DOSES

3B1.0 PURPOSE

This appendix provides technical information in support of the accidents addressed in Section 3.4.

3B2.0 INTRODUCTION

Inhalation dose consequences from airborne hazardous materials depend on several variables:

- Quantity of hazardous material released
- Resuspension rate or aerosolization of radionuclides and/or toxic materials from respirable particles
- Dispersion of airborne particles before they reach exposed individuals
- Duration that individuals are exposed to the particles, breathing rates, and other factors.

The following section describes the estimated hazardous material inventories, the generation of the source terms, and the calculational methods used to determine radiological consequences of the postulated accidents.

3B3.0 HAZARDOUS INVENTORIES

This section describes the estimated radiological and nonradiological hazardous material inventories associated with the integrated water treatment system (IWTS).

3B3.1 DESCRIPTION OF RADIOLOGICAL MATERIALS

Most of the fuel in the K Basins is from the N Reactor. A small amount is from older reactors. The total inventory of N Reactor fuel at the Hanford Site is approximately 2130 metric tons of uranium (MTU). The inventory contains approximately 1800 MTU of fuels-grade fuel and approximately 330 MTU of weapons-grade fuel. This inventory also contains 0.3 MTU of fuel with an uncertain 240Pu content. The fuels-grade fuel was discharged from N Reactor between 1970 and 1980; the weapons-grade fuel was discharged between 1986 and 1989, although reactor operation ceased in 1987. The K East Basin holds approximately 3,670 canisters containing approximately 50,700 Mark IV fuel assemblies. The K West Basin holds approximately 3,800 canisters containing 53,000 fuel assemblies.

The fuel inventory in the K Basins includes many elements with breached cladding caused by reactor discharge, subsequent handling, or deterioration during storage. The cladding failures range from cracks to severely corroded fuel elements. The exact number of damaged elements is unknown (Bergsman 1993). Video imaging in the K East Basin from the summer of 1994 indicated that approximately 40 percent of the outer elements and 20 percent of the inner elements have breached cladding. As a result of the cladding damage, the uranium in some elements was exposed to the water and has oxidized during storage. The uranium oxidation causes the fuel to swell and leads to further damage to the cladding, exposing fresh uranium to the basin water and oxidation (Willis and Praga 1998). The K East Basin fuel is stored in open-top canisters exposed to water in the basin. Fuel in the K West Basin was expected to be in better condition because the K West Basin fuel is stored in sealed canisters that included a corrosion inhibitor. Based on examination of fuel in canisters in the K West Basins, this expectation was not accurate.

3B3.2 RADIOLOGICAL INVENTORIES

This section describes the radiological inventory and characteristics of the K West fuel, basin water, canister sludge, ion exchange module, and filter backwash.

3B3.2.1 K West Fuel Radiological Characteristics

The total fuel mass in the K West Basin is 1038 metric tons. Approximately 2.5×10^7 Ci of fission and activation products and approximately 3.9×10^6 Ci of actinides are associated with the fuel. HNF-SD-SNF-TI-015 (Duncan 1997) provides recommended fuel characteristic summaries depending on how the data will be used. The safety or regulatory values are selected by identifying the isotopic mixture of components expected to yield the largest airborne radiological dose to an individual per unit of material released. The selection process to compare the isotopic mixtures uses a reduced set of radionuclides that dominate dose calculations for accident purposes. Plutonium and americium are expected to contribute most significantly to the dose consequences of accidents involving fuel and/or sludge mixtures. The unit release dose (URD) used for analysis 4.38×10^5 rem/g (Rittmann 1998). This URD was used in this analysis to assess potential consequences of activities involving fuel and/or sludge mixtures.

3B3.2.2 K West Basin Water Radiological Concentrations

The K West Basin contains approximately 4.2×10^6 L (1.1×10^6 gal) of water for cooling and shielding purposes. Table 3B-1 gives the maximum K West Basin water radionuclide concentrations allowed by the IWTS specification (Bergsman 1998). The IWTS will maintain general water concentrations of the radionuclides below the values listed in Table 3B-1. The dose conversion factors (DCF) are from the U.S. Environmental Protection Agency (EPA 1988) and allow the URD to be calculated. The URD given in Table 3B-1 is used in the consequence analysis for the spray release of K West Basin water.

Table 3B-1. K West Basin Water Radionuclide Concentrations.

Isotope	Concentration (Ci/L)	DCF (rem/Ci)	Dose per unit volume (rem/L)
^{90}Sr	5.00 E-07	2.39 E+05	1.20 E-01
^{90}Y	5.00 E-07	8.44 E+03	4.22 E-03
^{137}Cs	5.00 E-07	3.19 E+04	1.60 E-02
^{239}Pu (Total alpha)	4.00 E-08	4.29 E+08	1.72 E+01
		Total URD	1.73 E+01

DCF = dose conversion factor.
URD = unit release dose.

Table 3B-2 indicates the maximum radionuclides expected in K West Basin canister water and the calculated total URD used in the consequence analysis for the retrieval of high-cesium-content fuel. HNF-SD-SNF-TI-048, Rev. 0, *Analysis of Water from K West Basin Canisters (Second Campaign)* (Trimble 1997), provides estimated radionuclide concentrations. The IWTS specification (Bergsman 1998) states that the maximum amount of dissolved cesium in a canister is assumed to be 25 Ci. Table 3B-2 presents the maximum expected radionuclide concentrations for canister water, assuming that 25 Ci of cesium are present and that the other components are present in the same proportion as measured in the characterization study. The analytical results of the canister water characterization study (Trimble 1997) found that ^{241}Am was not present in the samples above the detection limit of about 3.78×10^{-4} Ci/barrel. A measurement of total alpha present in the samples was found to be about 5.1×10^{-5} Ci/barrel. For the purposes of this safety analysis, the measured alpha is assumed to consist of the individually measured plutonium concentrations plus the undetected americium. If the americium accounts for the remainder of the unidentified total alpha, the ^{241}Am concentration averaged about 42 μmCi/barrel.

Table 3B-2. K West Basin Canister Water Radionuclide Concentrations.

Isotope	Concentration (Ci/barrel)	Concentration$_{MAX}$ (Ci/canister)	DCF (rem/Ci)	Dose per canister (rem/canister)
^{3}H	5.49 E-07	2.35 E-02	9.62 E+01	2.26 E+00
^{60}Co	7.28 E-09	3.11 E-04	2.19 E+05	6.81 E+01
^{90}Sr	4.98 E-05	2.13 E+00	2.39 E+05	5.09 E+05
^{90}Y	4.98 E-05	2.13 E+00	8.44 E+03	1.80 E+04
^{137}Cs	5.85 E-04	2.50 E+01	3.19 E+04	7.98 E+05
^{238}Pu	2.30 E-06	9.83 E-02	3.92 E+08	3.85 E+07
$^{239/240}Pu$	6.15 E-06	2.63 E-01	4.29 E+08	1.13 E+08
^{241}Am	4.25 E-05	1.82 E+00	4.44 E+08	8.08 E+08
			Total URD	9.61 E+08

DCF = dose conversion factor.
URD = unit release dose.

3B3.2.3 K West Canister Sludge Radiological Characteristics

The canister sludge for the K West Basin is assumed to have the same nuclide mixture as K West fuel (Rittmann 1998). The K West fuel safety or regulatory assessment design basis feed (Mark IA assembly with 16.72 percent ^{240}Pu) was used to estimate the total activity in the canister sludge (Bergsman 1998). The unit doses from the worst-case fuel are calculated in Table 3B-3. The fuel activity information from HNF-SD-SNF-TI-059, *A Discussion of the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site* (Rittmann 1998), is reproduced in the second column of Table 3B-3. The unit activity per liter of sludge derived in column 3 of Table 3B-3 is based on the assumption that 6.2 m^3 (220 ft^3) of sludge represents 16.2 MTU (Bergsman 1998). The unit doses per liter of sludge released, shown in column 5 of Table 3B-3, are calculated by multiplying the DCF in column 4 by the derived unit activities in column 3. The unit doses in Table 3B-3 are used to conservatively calculate worst-case release consequences from accidents involving sludge.

Table 3B-3. Estimated K West Basin Canister Sludge Radionuclide Composition. (2 sheets)

Isotope	Total activity in design basis fuel (Ci/MTU)	Activity per liter of sludge (Ci/L)	DCF (rem/Ci)	Dose per unit volume (rem/L)
^{3}H	2.61 E+01	6.82 E-02	9.62 E+01	6.56 E+00
^{60}Co	2.09 E+00	5.46 E-03	2.19 E+05	1.19 E+03
^{90}Sr	6.93 E+03	1.81 E+01	2.39 E+05	4.33 E+06
^{90}Y	6.93 E+03	1.81 E+01	8.44 E+03	1.53 E+05

Table 3B-3. Estimated K West Basin Canister Sludge Radionuclide Composition. (2 sheets)

Isotope	Total activity in design basis fuel (Ci/MTU)	Activity per liter of sludge (Ci/L)	DCF (rem/Ci)	Dose per unit volume (rem/L)
^{137}Cs	9.66 E+03	2.52 E+01	3.19 E+04	8.04 E+05
^{154}Eu	1.13 E+02	2.95 E-01	2.86 E+05	8.44 E+04
^{155}Eu	1.06 E+01	2.77 E-02	4.14 E+04	1.15 E+03
^{234}U	3.84 E-01	1.00 E-03	1.32 E+08	1.32 E+05
^{235}U	1.27 E-02	3.32 E-05	1.23 E+08	4.08 E+03
^{238}U	3.31 E-01	8.65 E-04	1.18 E+08	1.02 E+05
^{238}Pu	1.33 E+02	3.48 E-01	3.92 E+08	1.36 E+08
^{239}Pu	1.73 E+02	4.52 E-01	4.29 E+08	1.94 E+08
^{240}Pu	1.37 E+02	3.58 E-01	4.29 E+08	1.54 E+08
^{241}Pu	6.82 E+03	1.78 E+01	8.25 E+06	1.47 E+08
^{241}Am	4.34 E+02	1.13 E+00	4.44 E+08	5.02 E+08
			Total URD	1.14 E+09

DCF = dose conversion factor.
MTU = metric ton of uranium.
URD = unit release dose.

3B3.2.4 Ion Exchange Module Radiological Characteristics

Currently, the ion exchange modules (IXM) are changed out before they reach 80 to 90 percent of the maximum transuranic isotope loading of 100 nCi/g. An IXM module weighs approximately 20,000 kg (44,000 lb). This results in a maximum of approximately 1.7 Ci of transuranic isotopes per IXM. Another criterion (based on a dose rate) is the changeout of IXMs when the ^{137}Cs loading is 300 Ci. Both criteria are assumed to be met simultaneously by loading the IXM with 1.7 Ci of transuranic isotopes and 300 Ci of ^{137}Cs. Also, the IXM is assumed to be loaded with ^{90}Sr and ^{90}Y at a ratio comparable to the ratios of canister water shown in Table 3B-1. The resulting loading on a single IXM is summarized in Table 3B-4.

Table 3B-4. Maximum Isotopic Loading for One K West Ion Exchange Module.

Isotope	Ci per IXM	DCF (rem/Ci)	Dose per IXM (rem/IXM)
^{90}Sr	1.80 E+02	2.39 E+05	4.30 E+07
^{90}Y	1.80 E+02	8.44 E+03	1.52 E+06
^{137}Cs	3.0 E+02	3.19 E+04	9.57 E+06
^{239}Pu (representing transuranic isotopes)	1.70 E+00	4.29 E+08	7.29 E+08
		Sum	7.83 E+08

DCF = dose conversion factor.
IXM = ion exchange module.

3B3.2.5 K West Annular Filter Backwash Radiological Characteristic

Rittmann (1998) gives the assumed fuel composition and the calculated URD used in the accident consequence analyses for the filter backwash scenario (Rittmann 1998). This composition and resultant URD are expected to be conservative. The inventory composition in the filter could be adjusted to allow additional transuranic isotopes (up to 10 times) to accumulate in the filter as oxide. This oxide will likely have released its soluble fission products, such as cesium. The composition in this case would have a reduced concentration of cesium, while essentially maintaining the concentrations of the transuranic isotope species. Because the transuranic isotopes account for more than 99 percent of the total URD (Rittmann 1998), an adjusted filter inventory would have a similar but slightly lowered URD.

3B4.0 DESCRIPTION OF HAZARDOUS MATERIALS

3B4.1 FUEL CHEMICAL COMPOSITION

The K East and K West Basins contain primarily irradiated N Reactor fuel. This fuel is primarily made up of two hazardous elements; uranium and zirconium. The following discussion is based on information contained in the *Purex Technical Manual* (RHO 1983).

The N Reactor fuel is composed of metallic uranium fuel elements clad in Zircaloy-2. The assemblies are fabricated in two basic designs, Mark IV and Mark IA, differentiated primarily by diameter and ^{235}U content. Both are tube-in-tube designs. The two fuel assemblies have different diameters and come in various lengths.

The use of zirconium-beryllium braze rings to close the fuel is unique to N Reactor fuel (RHO 1983, Schulz 1972). This construction appears to have contributed to cladding fires ignited by mechanical shock when N Reactor fuel was processed by shear-leach methods (Schulz 1972). As each fuel element was fabricated, it was stamped with an identification code that indicated the composition, length, and cladding thickness of the inner and outer components. As the fuel was loaded into storage after being irradiated, the identification code for each element was recorded on a bucket-loading summary, which was used to plan and document each change.

Uranium burns in air at 150 °C to 175 °C, with formation of U_3O_8. When finely powdered, it decomposes slowly in cold water and more quickly in boiling water (Merck 1989). When finely divided, uranium is pyrophoric (CRC Press 1986). Massive uranium burns steadily at 700 °C (Benedict et al. 1981).

The powder form of zirconium has a very low ignition temperature and is very explosive when mixed with oxidizing agents. On prolonged heating, the compact form of zirconium combines with oxygen, nitrogen, carbon, and the halogens (Merck 1989). When finely divided, zirconium may ignite spontaneously in air, especially at high temperatures (CRC Press 1986).

3B5.0 ACCIDENT ANALYSIS METHODOLOGY

The radiological dose and toxic chemical exposure effects of the postulated accidents were evaluated to determine the acceptability of the risk involved in the proposed operations. This requires an estimate of the radiological dose and toxic chemical concentrations at the receptors' locations caused by the accidental releases. No use of toxic chemicals has been identified for the IWTS. The accident consequences were compared with their respective risk evaluation guidelines (Sellers 1997) to determine a final list of safety-class and safety-significant structures, systems, and components.

Inhalation dose consequences from airborne hazardous materials depend on several variables:

- Quantity of hazardous material released
- Resuspension rate or aerosolization of radionuclides and/or toxic materials from respirable particles
- Dispersion of airborne particles before they reach exposed individuals
- Duration that individuals are exposed to the particles, breathing rates, and other factors.

The base methodology for calculating radiological consequences for accidents analyzed in this document is described in HNF-SD-SNF-TI-059 (Rittmann 1998). Release fractions for radiological agents are calculated using both computer calculational techniques and engineering hand calculations, as described in section 3B5.1, or by using bounding estimates that have been substantiated by experimental data.

The following section describes the generation of the source terms and the calculational methods used to determine radiological consequences from the postulated accidents. The radiological risk guidelines are presented in section 3.4 and the safety-class criteria and safety-significant criteria are presented in Appendix 4B.

3B5.1 RADIOLOGICAL INVENTORY AND SOURCE TERM DEVELOPMENT

The source term is the amount of radioactive material, in grams or curies, released to the air. The initial source term is the amount of radioactive material driven airborne at the accident source. The initial respirable source term, a subset of the initial source term, is the amount of radioactive material driven airborne at the accident source that is effectively capable of being inhaled. The airborne source term is typically estimated using the following equation (DOE 1994):

$$\text{Source term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF}$$

where

MAR	=	material at risk (Ci or grams)
DR	=	damage ratio
ARF	=	airborne release fraction (or airborne release rate for continuous release)
RF	=	respirable fraction
LPF	=	leak path factor.

The material at risk (MAR) is the initial amount of material available for release; the damage ratio is the fraction of the MAR actually affected by the accident-generated conditions. In most of the accidents considered in this analysis, the MAR accounts for the damage ratio. For example, the MAR for discussions of basin radionuclides would theoretically be the entire 1.2×10^6 L (3.2×10^5 gal), while the accident scenario may only involve the equivalent of 120 L (32 gal) of basin liquid. Rather than go through the more rigorous discussion of 1.2×10^6 L as the MAR and a damage ratio of 1.0×10^{-4} to determine the 120 L (32 gal) of actual material involved in the accident, this document defines the 120 L (32 gal) of liquid actually involved in the accident as the MAR.

The airborne release fraction is the coefficient used to estimate the amount of a radioactive material suspended in air as an aerosol and thus available for transport. For discrete events, the airborne release fraction is a fraction of the material affected. For mechanisms that continuously act to suspend radionuclides, an airborne release rate is required.

The respirable fraction is the fraction of airborne radionuclide particles that can be transported through air and inhaled into the human respiratory system. It is commonly assumed to include particles of 10 µm aerodynamic equivalent diameter and less.

The leak path factor is the fraction of the radionuclides in the aerosol transported through some confinement deposition or filtration mechanism, such as high-efficiency particulate air filters, in which the aerosol is depleted before transport and inhalation. Because no specific depletion mechanisms can be quantified and no high-efficiency particulate air filtration system is available, this analysis will consider the leak path factor to be 1; no further discussion of leak path factor is provided.

3B5.2 ATMOSPHERIC TRANSPORT

Atmospheric transport calculations estimate the air concentration resulting from atmospheric discharges of radionuclides and the resultant transport and dilution with meteorological conditions. These air concentrations are used to calculate radiological doses. The atmospheric dispersion factor (χ/Q') represents the dilution of an airborne contaminant from atmospheric mixing and turbulence. The χ/Q' s were previously calculated for acute (short-term) releases and a formula was developed for calculating releases lasting more than 2 hours (Rittmann 1998) for the onsite and offsite receptors. Values used in the current analyses are shown in Table 3B-5. Credit is taken for plume meander for all releases with durations longer than 1 hour.

Table 3B-5. Acute Maximum 99.5 Percent Sector Atmospheric Dispersion Factors.

Receptor location	χ/Q' (s/m^3)			
	30 min	1-2 hour	12 hour	24 hour
100 m radius (100 m E) (onsite)	7.32 E-02	1.24 E-02	6.28 E-03	—
Hanford Site boundary (offsite) (12,040 m W)	3.58 E-05	2.60 E-05	—	5.32 E-06
Near river bank (480 m NW)	2.15 E-03	5.55 E-04	—	1.76 E-04

3B5.3 RADIOLOGICAL DOSE CALCULATIONS

The major radioactive exposure pathway for the identified accidents is inhalation of radioactive material. Although dose contributions could originate from the submersion pathway, the dose from the inhalation pathway is much larger than the contribution from the submersion pathway, as discussed in WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (DESH 1998).

Potential doses from the ingestion pathway are not included in the comparison to risk guidelines, because U.S. Department of Energy, Richland Operations Office, state, and federal emergency preparedness plans are in place to limit ingestion in case of an accident.

The dose conversion factors for inhalation from EPA-520/1-88-020 (EPA 1988) are used to calculate the radiological doses. The plutonium is assumed to be in the oxide form. To calculate the effective dose equivalent in rem, the following relationship is used:

$$D = ST \times \chi/Q' \times BR \times URD$$

where

D	=	dose (rem)
ST	=	amount of respirable material released (grams or liters)
χ/Q'	=	appropriate dispersion factor
BR	=	breathing rate (3.3×10^{-4} m^3/sec)
URD	=	unit release dose.

3B6.0 REFERENCES

Benedict, Manson, Thomas, Pigford, and Levi, 1981, *Nuclear Chemical Engineering*, Second Edition, McGraw-Hill Book Company, New York, New York.

Bergsman, K. H., 1993, *Hanford Irradiated Fuel Inventory Baseline*, WHC-SD-CP-TI-175, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Bergsman, K. H., 1998, *Specification for Design Fabrication, Testing, and Technical Support for the K West Basin Water Treatment System*, HNF-S-0564, Rev. 1A, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

CRC Press, 1986, *Handbook of Chemistry and Physics*, 67th Edition, CRC Press, Incorporated, Boca Raton, Florida.

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DOE, 1994, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, DOE-HDBK-3010-94, Vol. I, U.S. Department of Energy, Washington, D.C.

Duncan, D. R., 1997, *Spent Nuclear Fuel Project Technical Databook*, HNF-SD-SNF-TI-015, Rev. 2, Fluor Daniel Hanford, Inc., Richland, Washington.

EPA, 1988, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, EPA-520/1-88-020, U.S. Environmental Protection Agency, Washington, D.C.

Merck, 1989, *The Merck Index*, Eleventh Edition, Merck & Co., Inc., Rahway, New Jersey.

RHO, 1983, *Purex Technical Manual*, RHO-MA-116, Rockwell Hanford Operations, Richland, Washington.

Rittmann, P. D., 1998, *A Discussion of the Methodology for Calculating Radiological and Toxicological Consequences for the Spent Nuclear Fuel Project at the Hanford Site*, HNF-SD-SNF-TI-059, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Schulz, 1972, *Shear-Leach Processing N-Reactor Fuel, Cladding Fires*, ARH-2351, Atlantic Richfield Hanford Company, Richland, Washington.

Sellers, E. D., 1997, *Risk Evaluation Guidelines (REGs) to Ensure Inherently Safer Designs* (Letter 97-SFD-172 to H. J. Hatch, Fluor Daniel Hanford, Inc., dated August 26), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Trimble, D. J., 1997, *Analysis of Water from K West Basin Canisters (Second Campaign)*, HNF-SD-SNF-TI-048, Rev. 0, Fluor Daniel Hanford, Inc., Richland, Washington.

Willis, W. L., and A. N. Praga, 1998, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities*, HNF-SD-SNF-TI-009, Rev. 1, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 INTRODUCTION

This chapter provides details of the safety-class structures, systems, and components (SSC) and safety-significant SSCs necessary for in the K West Basin integrated water treatment system (IWTS) to ensure protection of the public, onsite workers, and the environment. The chapter also describes the attributes required to support the safety functions identified in the hazard and accident analyses and subsequent derivations of the candidate technical safety requirements (TSR) (associated with IWTS equipment and operation) for the facility. The following information is included in this chapter:

- Description of safety-class and safety-significant SSCs, including the safety functions performed
- Identification of support system safety-class and safety-significant SSCs depended on to carry out safety functions
- Identification of the functional requirements necessary for the safety-class and safety-significant SSCs to perform their safety functions, and the general conditions caused by postulated accidents under which the safety-class and safety-significant SSCs must operate
- Identification of assumptions needing TSR coverage.

4.2 REQUIREMENTS

The facility standards and criteria that apply to the IWTS are found in HNF-SD-SNF-RD-001, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document* (Watson 1998). The standards and requirements applicable to the IWTS equipment are found in WHC-S-0564, *Specification for Design Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment System* (Bergsman 1998).

4.3 SAFETY-CLASS STRUCTURES, SYSTEMS, AND COMPONENTS

This section discusses safety-class engineered features used in the design of the IWTS equipment to ensure protection of the public, onsite workers, and the environment. The safety-class determinations in this analysis are in accordance with the criteria identified in Appendix 4A. The selection of safety-class SSCs is based primarily on their particular importance to defense in depth. Safety-class SSCs prevent or mitigate releases to the public that would otherwise exceed the offsite radiological risk guideline; they also prevent accidental criticality.

The criteria for safety-class determination of SSCs as applied to the IWTS equipment are presented in Appendix 4A, Table 4A-1.

All dose consequences for the K West Basin IWTS are below the offsite risk evaluation guidelines for the corresponding frequency of each accident. Therefore, no numeric requirements other than those for criticality protection are associated with any safety-class designation. The safety-class equipment designations for the K West Basin IWTS are presented in Table 4-1.

4.3.1 Knockout Pot Vessels

4.3.1.1 Safety Function. The IWTS knockout pot vessels are designated as safety-class SSCs for criticality prevention through geometry control as defined in section 6A2.2.2 and in the criticality safety evaluation report, HNF-SD-SNF-CSER-011, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems Subproject A.9* (Erickson 1998).

4.3.1.2 System Description. The knockout pots are cylindrical vessels constructed of 16-in. schedule 10 stainless steel pipe. They are designed to a critically safe geometry. Figure 2-4 is a sketch of the knockout pot. The knockout pots are designed and built in accordance with Section VIII of the *Boiler and Pressure Vessel Code* (ASME 1995).

4.3.1.3 Functional Requirements. The knockout pot vessels are passive devices required to maintain geometry control during normal conditions and potential 1.8 m (6-ft) drop accidents. The safety class features are the inside diameter, height, and wall thickness. The maximum inside diameter of the knockout pot is 40.11 cm (15.79 in.), the minimum wall thickness is 0.58 cm (0.23 in.), and the maximum height is 86 cm (34 in.). A 1-in. space between knockout pots in a square lattice is required for criticality purposes. The construction of each knockout pot physically ensures that the spacing requirement is met. Initial placement of knockout pots in the modified racks ensures that they are positioned in a square lattice. A single line arrangement is a subset of a square lattice arrangement.

4.3.1.4 System Evaluation. The knockout pots may be moved underwater when an inventory is present in the pots. A drop analysis demonstrates that the structural integrity of the knockout pots meets their functional requirements. The drop analysis is based on a maximum lift height of 1.8 m (6 ft). A special lifting device (similar to the canister lifting hook) is used to ensure that lift heights stay within the allowable limits (see section 4.3.3).

4.3.1.5 Controls (Technical Safety Requirements). The knockout pot vessels are passive barriers and will be listed as design features in the TSRs.

4.3.2 Knockout Pot Screens

4.3.2.1 Safety Function. The IWTS knockout pot screens are designated as safety-class SSCs for criticality prevention as defined in section 6A3.3 and in the criticality safety evaluation report (Erickson 1998). These screens provide the particle-size protection for the annular filter vessels and the particulate settlers. Therefore, these screens protect against a potential above-water criticality in the filters.

Table 4-1. Safety-Class Equipment List for K West Basin Integrated Water Treatment System.

Equipment		Safety function	Design basis accident	Functional requirements	Performance criteria requiring TSR coverage
Knockout pot	Vessels	Prevent criticality	Criticality/load drop	Geometry Control: Physical dimensions. Physical Strength: Withstand drop loads without failure.	None
	Screens	Prevent criticality	Criticality	Limit particle size in downstream equipment.	None
	Lifting hook	Prevent criticality/maintain basin integrity	Criticality/load drop	Lifting height restriction.	None
Particulate settler	Vessels	Prevent criticality	Criticality	Geometry Control: Physical dimensions.	None
Annular filter	Vessels	Prevent criticality	Criticality	Geometry Control: Physical dimensions.	None

4.3.2.2 System Description. The knockout pot screens are located in the top of the cylindrical knockout pots; the water must pass through them before exiting the knockout pot top discharge. The 500-μm mesh stainless steels screens are designed to limit the size of particles that pass through the knockout pots to downstream equipment. These screens are built to ASME (B31.1).

4.3.2.3 Functional Requirements. The screens are required to have the specified 500 μm mesh. The 500 μm designation is nominal with "tolerances" allowed to 550 μm without exceeding evaluated limits. The criticality analysis is conservatively based on the 550 μm uranium metal. The screens must be strong enough to withstand the forces from pressure buildup resulting from filter plugging.

4.3.2.4 System Evaluation. The knockout pot screens are required to have the dimensions of the mesh verified before construction acceptance.

4.3.2.5 Controls (Technical Safety Requirements). The knockout pot screens are passive barriers and will be listed as design features in the TSRs.

4.3.3 Knockout Pot Lifting Hook

4.3.3.1 Safety Function. The safety function of the knockout pot lifting hook is to limit the drop height for the knockout pot as defined in section 3.4.2.6.5. This ensures that the maximum drop height for a knockout pot is bounded by the drop analysis to prevent damage to the knockout pot and perforation of the basin floor.

4.3.3.2 System Description. The knockout pot lifting hook is a lifting device similar to the existing canister lifting hook (DESH 1998).

4.3.3.3 Functional Requirements. The knockout pot lifting hook functional requirement is to be long enough to prevent raising a loaded knockout pot above the 1.8 m (6 ft) lifting height limit to limit drop height to the analyzed value. Testing of the knockout pot lifting hook shall verify that the maximum lift height of the bottom of a knockout pot is no more than 1.8 m (6 ft) above the basin floor under any conditions.

4.3.3.4 System Evaluation. The knockout pot lifting hook will be designed to be long enough to prevent raising a knockout pot above the maximum drop height analyzed. Suitable design allowables are applied to the design to ensure that it will prevent failure with maximum knockout pot loading.

4.3.3.5 Controls (Technical Safety Requirement). The knockout pot lifting hook is a passive component and will be listed as a design feature in the TSRs. The K Basin configuration management program will ensure that the design features are not inadvertently changed. Facility procedures will provide adequate controls over knockout pot movements to ensure that only knockout pot lifting hooks are used to lift and move loaded knockout pots. No additional or special controls are required.

4.3.4 Particulate Settler Vessels

4.3.4.1 Safety Function. The IWTS particulate settler vessels are designated as safety-class SSCs for criticality prevention through geometry control as defined in section 6A2.3 and in the criticality safety evaluation report (Erickson 1998).

4.3.4.2 System Description. The settler vessels (Figure 2-5) are nominally 20-in., schedule 10 stainless steel pipes. They are arranged in an array of 10 pipes configured as two side-by-side stacks of 5 pipes 15 cm (6 in.) apart. The particulate settler vessels are described and built in accordance with the *Boiler and Pressure Vessel Code* (ASME 1995).

4.3.4.3 Functional Requirements. The settler vessels are required to maintain geometry control during normal conditions and all credible accidents. The safety-class features are the inside diameter, length, and wall thickness. The maximum inside diameter of the vessel is 50.27 cm (19.79 in.), the maximum length is 4.9 m (16 ft), and the minimum vessel wall thickness is 0.58 cm (0.23 in.).

4.3.4.4 System Evaluation. The settler vessels are passive devices designed to adequately meet the functional requirements.

4.3.4.5 Controls (Technical Safety Requirements). The particulate settler vessels are passive barriers and will be listed as design features in the TSRs.

4.3.5 Annular Filter Vessels

4.3.5.1 Safety Function. The annular filter vessels are designated as safety class for criticality prevention through geometry control as defined in section 6A2.4 and in the criticality safety evaluation report (Erickson 1998).

4.3.5.2 System Description. The annular filter vessels have a tank-in-tank design. The tank-in-tank design is required for criticality safety with the inner tank normally empty. The filter vessels are constructed of stainless steel. The inner tank diameter is nominally 1 m (3 ft-4 in.) and the outer tank diameter is nominally 1.8 m (6-ft). The space between the inner and outer tanks contains approximately 2.55 m^3 (90 ft^3) of filter media. The filter vessels are designed and built in accordance with the *Boiler and Pressure Vessel Code* (ASME 1995). Figure 2-6 is a sketch of the annular filter vessel.

4.3.5.3 Functional Requirements. The annular filter vessels are designed with dimensions required to maintain geometry control. The safety class features are the key diameters, wall thicknesses, and inner vessel offset. The minimum outside diameter for the inner vessel is 100.97 cm (39.75 in.) and the maximum inside diameter of the outer vessel is 180.66 cm (71.125 in.). The minimum wall thickness for both the inner and outer vessels is 1.27 cm (0.50 in.). The maximum inner vessel offset is 1.111 cm (0.4375 in.). The filter vessels must be positioned within the vessel enclosure to maintain the minimum distances from the floor, walls, and each other, as depicted in Figure 2-7. Enclosure wall dimensions shown in Figure 2-7 are maximum dimensions.

4.3.5.4 System Evaluation. The annular filter vessels are passive components that will perform their geometry-control function as designed.

4.3.5.5 Controls (Technical Safety Requirements). The annular filter vessels are passive barriers and will be listed as design features in the TSRs.

4.4 SAFETY-SIGNIFICANT STRUCTURES, SYSTEMS, AND COMPONENTS

This section discusses safety-significant engineered features used in the design of the IWTS equipment to ensure protection of the public, onsite workers, and the environment. The selection of safety-significant SSCs is primarily based on their particular importance to defense in depth. Safety-significant SSCs prevent or mitigate releases of radiological materials to onsite workers and releases of toxic chemicals to the offsite public and onsite workers.

The criteria for safety-class determination of SSCs as applied to the IWTS equipment are presented in Appendix 4A, Table 4A-1.

The potential to exceed the safety-significant criteria for exposure to facility workers exists; however all dose consequences for the K West Basin IWTS are below the risk evaluation guidelines for the corresponding frequency of each accident. Certain SSCs will be designed to meet safety-significant requirements for purposes of mitigation and defense in depth. The safety-significant equipment designations for the K West Basin IWTS are presented in Table 4-2.

4.4.1 Filter Vessel Radiation Monitoring System

4.4.1.1 Safety Function. The safety-significant function of the filter vessel radiation monitoring system is to limit the source term allowed in the annular filter vessels as defined in section 3.4.2.2.5. If the radiation monitor is not operating, the IWTS will not operate.

Table 4-2. Safety-Significant Equipment List for K West Basin Integrated Water Treatment System.

Equipment		Safety function	Design basis accidents	Functional requirements	Performance criteria requiring TSR coverage
Instrumentation and control	Filter vessel radiation monitor(s)	Limit source term for safety analysis basis	Filter vessel backwash spray release	Alarm before limit	None

4.4.1.2 System Description. The filter vessel radiation monitoring system design details are not yet determined.

4.4.1.3 Functional Requirements. The filter vessel radiation monitoring system will alarm before more than 200 Ci of cesium are detected in a filter vessel.

4.4.1.4 System Evaluation. A functionality test will be performed to ensure that the radiation monitoring system will detect appropriate levels of cesium in each annular filter vessel.

4.4.1.5 Controls (Technical Safety Requirements). An administrative control will be considered for inclusion in the TSR document for operation of the radiation monitoring system.

4.5 REFERENCES

ASME, 1995, *Boiler and Pressure Vessel Code*, Section VIII, "Pressure Vessels," American Society of Mechanical Engineers, New York, New York.

ASME B31.1, 1995, *Power Piping*, American Society of Mechanical Engineers, New York, New York.

Bergsman, K. H., 1998, *Specification for Design Fabrication, Testing, and Technical Assistance for the K West Basin Water Treatment System*, WHC-S-0564, Rev. 1A, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc. Richland, Washington.

Erickson, D. G., 1998, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems*, Subproject A.9, HNF-SD-SNF-CSER-011, Rev. 1, Fluor Daniel Northwest, Inc., for the Fluor Daniel Hanford, Inc., Richland, Washington.

HNF-PRO-097, *Engineering Design and Evaluation*, Fluor Daniel Hanford, Inc., Richland, Washington.

Watson, D. J., 1998, *SNF K Basins and Cold Vacuum Drying Standard Requirements Identification Document*, HNF-SD-SNF-RD-001, Rev. 1, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

APPENDIX 4A

SAFETY CLASSIFICATION CRITERIA

This page intentionally left blank.

APPENDIX 4A

SAFETY CLASSIFICATION CRITERIA

Safety-class determinations in this analysis are made in accordance with the criteria and requirements specified in the following paragraphs and shown in Table 4A-1. Table 4A-1 is adapted from HNF-PRO-704, *Hazard and Accident Analysis Process*.

The two safety-class designations are safety class and safety significant. The selection of safety-class and safety-significant structures, systems, and components (SSC) is based primarily on their importance to defense in depth. Safety-class SSCs prevent accidental nuclear criticality or prevent or mitigate releases to the public that would otherwise exceed the offsite radiological risk guideline.

Safety-significant SSCs prevent or mitigate releases of radiological materials to onsite workers and releases of toxic chemicals to the offsite public and onsite workers. This includes barriers that are judged to substantially contribute to defense in depth independent of quantitative analysis. Safety significant also applies to general services-designated equipment that plays no significant safety role but could degrade the safety functions of safety-class or safety-significant SSCs if not restrained during accidents. This is referred to as a "3 over 1" issue; the "3" refers to the older safety-class 3 designation (equivalent to general services under the current classification system) and the "1" refers to the older safety class 1 designation (safety class under current classification system). Safety significant also describes worker safety SSCs that protect facility workers from serious injury caused by other than standard industrial hazards (those not controlled by institutional safety programs). Institutional safety programs include safety training, radiation protection, environmental protection, as-low-as-reasonably-achievable, emergency planning, operational assurance, industrial safety, fire protection, and industrial hygiene.

REFERENCE

HNF-PRO-704, *Hazard and Accident Analysis Process*, Fluor Daniel Hanford, Inc., Richland, Washington.

Table 4A-1. Safety Structure, System, and Component Criteria.

	Structures, systems, and components	Safety SSC designation
1.	Prevent or mitigate offsite dose in excess of 5 mSv (500 mrem) TEDE.	SC
2.	Place or maintain an operating process in a safe condition that prevents or mitigates offsite dose in excess of 5 mSv (500 mrem) TEDE.	SC
3.	Monitor the release of radioactive materials to the environment during and after accidents in which the monitor's output initiates the emergency response plan or operator actions to place the operating process in a safe condition in accordance with criterion 2.	SC
4.	Maintain double contingency protection against an accidental nuclear criticality.	SC
5.	Support the safety function of a safety-class SSC. This includes control and monitoring functions (e.g., operating air, electrical power, instrumentation).	SC
6.	Prevent or mitigate a radiological dose or chemical exposure that challenges the risk evaluation guidelines.	SS
7.	Place or maintain an operating process in a safe condition that prevents or mitigates consequences that exceed criterion 6.	SS
8.	Prevent or mitigate exposure in excess of 50 mSv (5 rem) TEDE or an airborne chemical concentration in excess of ERPG-2 to facility operators who are relied on to achieve the safe condition of criterion 2 or 7.	SS
9.	Monitor the release of radioactive and/or hazardous materials to the environment during and after accidents in which the monitor's output initiates the emergency response plan or operator actions to place the operating process in a safe condition in accordance with criterion 7.	SS
10.	Support the safety function of a safety-significant SSC. This includes control and monitoring functions (e.g., operating air, electrical power, instrumentation).	SS
11.	Prevent or mitigate an acute fatality to a facility worker or serious injury to a group of workers, except where the SSCs are controlled through an implemented institutional safety or radiation protection program.	SS
12.	Provide defense-in-depth prevention or mitigation of an uncontrolled release of radioactive and/or hazardous material deemed significant in the safety analysis.	SS

Notes:

1. Consider initiating events with a frequency greater than 10^{-1} per year to be planned events and mitigate their consequences to within normal operational limits.
2. Where a postulated accident can cause multiple system failures, evaluate bounding consequences at a common receptor location. Select safety SSCs and determine residual consequences for the purpose of designating other structures or systems.
3. For criterion 6-10, the previous designation was SC-2 except for cases where SC-1 designation was applicable to the prevention or mitigation of toxic chemical exposures in excess of the offsite risk guidelines.
4. Designate SSCs that may prevent the adequate function of safety SSCs through physical interaction (e.g., seismic event, pipe whip, jet impingement, water damage, environmental changes) at the same level of importance as those potentially affected SSCs.
5. Water treatment systems that use chlorine are considered to pose a risk commonly accepted by the public provided their design is consistent with public water treatment plants. Do not designate such systems as SC or SS.
6. See Section 2.4 of HNF-PRO-704 for the procedural steps that this table supports. In May 1995, this procedure descoped environmental and standard industrial SSCs from designation as safety SSCs. These and other balance-of-plant SSCs are considered to be "general service" SSCs.

ERPG = emergency response planning guideline.
SC = safety class.
SS = safety significant.
SSC = structure, system, and component.
TEDE = total effective dose equivalent.

5.0 TECHNICAL SAFETY REQUIREMENTS

Technical safety requirement information will be provided in the update of the K Basins safety analysis report (DESH 1998). Chapters 3.0 and 4.0 address candidates for technical safety requirements, but until operations of K Basin systems and added subproject systems can be integrated, specifying actual technical safety requirements is not appropriate. No TSRs have been identified for the installation of the Integrated Water Treatment System. The passive safety-class SSCs identified in Chapter 4 represent the design features as defined in DOE Order 5480.22. The filter vessel radiation monitoring will be considered for inclusion in the administrative controls.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

6.0 PREVENTION OF INADVERTENT CRITICALITY

The criteria used in the criticality program and the engineered and administrative controls to be used for prevention of criticality accidents are consistent with those currently defined in Chapter 6 of the K Basins safety analysis report (SAR) (DESH 1998). Potential changes to the program required for integrated water treatment system (IWTS) operation will be addressed in the upgraded K Basins SAR. No changes have been identified to date. The IWTS criticality-related accidents and an evaluation of accident scenarios are provided in Appendix 6A.

See WHC-SD-WM-SAR-062, *K Basins Safety Analysis Report* (DESH 1998), for an overview of the organizational structure and interfaces and the technical and administrative practices of the criticality protection policy and programs for the K Basins. These program requirements will be applied to IWTS equipment and operations. The addition of the IWTS equipment will not change this section in the K Basins SAR.

6.1 OVERVIEW OF IWTS CRITICALITY ANALYSIS

The IWTS operations in the K West Basin were evaluated for potential nuclear criticality accidents and found to be safe and within the limits established for the IWTS operations to meet nuclear criticality safety criteria. The buildup of sludge containing fissile material was evaluated and the fissile material configurations were found to be critically safe for all credible postulated event sequences and material arrangements.

Many geometric configurations that could possibly lead to a criticality event under credible normal, abnormal, and accident conditions are analyzed in the criticality safety evaluation report, HNF-SD-SNF-CSER-011, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems Subproject A.9* (Erickson 1998). The analyses in Erickson (1998) establish the criticality safety design limits, their bases, and the parameters to be applied to the following items for prevention of criticality.

- K West Basin Integrated Water Treatment System annular filter vessel and enclosure
- Ion exchange modules
- Piping
- Knockout pot storage array and knockout pot lifting
- Integrated Water Treatment System particulate settlers.

The principal criticality prevention criterion is that the effective neutron multiplication (criticality) factor (k_{eff}) shall not exceed 0.98 ($k_{eff} \leq 0.98$) for IWTS operations, including allowances for all uncertainties. A k_{eff} of less than or equal to 0.98 means that the system has at least a 2-percent margin of reactivity, which has been determined to be satisfactory for this application.

6.1.1 Summary of Conservatism

The IWTS criticality safety analysis was performed to develop parameters for design and to ensure that the vessels as designed would be safely subcritical under all circumstances. Normal operating condition analyses were not performed. At the time this analysis was started, much information about the nature of the operations was not known. The total mass and volume of sludge that comes from the fuel repackaging operations is not known and was conservatively estimated.

Because of the stated purpose of the analysis, only worst case conditions were analyzed. It was understood that all operations under normal expected conditions would be significantly less reactive. The following are some of the more significant conservatisms used in the analysis for each vessel of concern.

- Knockout Pots

  — The knockout pots analyses assumed worst case materials and moderation. This means the pieces entering the knockout pots were assumed to be maximum sized (0.762 cm [0.30 in.]) and have the optimum packing fraction (0.25) (Erickson 1997) resulting in optimal moderation. Under normal conditions pieces of various sizes are expected to enter the knockout pots and the packing fraction will be significantly higher (0.6 or higher). The system will normally be significantly undermoderated.

  — The knockout pots were analyzed in essentially an infinite array (six by five). In actual operation, the knockout pots will be in a single-line array. This will reduce interaction significantly, which will reduce system reactivity. Also, a design change added spacing bands to the knockout pots because the basin fuel racks could not be counted on to ensure spacing under all postulated accident scenarios.

  — Unirradiated uranium metal was assumed to be the only material present. In reality, because the fuel is irradiated, pieces of uranium metal may be present, but uranium oxide, fuel cladding, fission products, and other materials also will be present. These other materials act as poisons to the system and will effectively lower the system reactivity.

- Particulate Settlers

  — The particulate settler analysis assumed worst case materials and moderation. In this case, that meant the pieces entering were all maximum sized (550 μm, maximum output from knockout pots). A packing fraction of 0.25 is used to give optimal moderation. Under normal conditions, only particulates of sizes less than 500 μm are expected to reach the particulate settlers and the packing fraction will be significantly higher (0.6 or higher). The 500 μm screens in the knockout pot typically will remove particles smaller than 500 μm. The system will normally be significantly undermoderated.

— The assumption of the larger particulates (550 μm), based on worst case particles getting through the knockout pot screens, has a significant effect on system reactivity.

— The particulate settlers were assumed to fill completely. The volume of sludge placed into the particulate settlers was completely independent of the total quantity of material available in the basin. This also ignores the effectiveness of the knockout pots in removing significant quantities of material.

— Unirradiated uranium metal was assumed to be the only material present. In reality, because the fuel is irradiated, pieces of uranium metal may be present, but uranium oxide, fuel cladding, fission products, and other materials also will be present. These other materials act as poisons to the system and will effectively lower the system reactivity.

- Annular Filter Vessels

— The annular filter vessel analysis assumed worst case materials and moderation. In this case, that meant the pieces entering were all maximum sized (550 μm, maximum output from knockout pots). A packing fraction of 0.25 is used to give optimal moderation. Under normal conditions, particulate less than 500 μm is expected to be contained in the knockout pots and remaining particles larger than approximately 50 μm will be removed from the stream by the particulate settlers. Only particulate under approximately 50 μm is expected to be accumulated in the annular filter vessels. The packing fraction will be significantly higher (0.6 or higher). The system will normally be significantly undermoderated.

— The particulate settlers are expected to remove particles 50 μm and larger. The assumption of the larger particulates (550 μm), based on worst case particles getting through the knockout pot screens and particulate settlers, have a significant effect on system reactivity.

— The annular filter vessels were assumed to fill completely. In actuality, alarm set points for both pressure drop and dose rate will signal the need for a backwash. This is expected to occur when the vessels are about 0.5 percent full. Also, the mass-volume of sludge placed in the annular filter vessels did not consider the total quantity of material available in the basin and ignored the material retained by the particulate settlers and the knockout pots.

— Unirradiated uranium metal was assumed to be the only material present. In reality, because the fuel is irradiated, pieces of uranium metal may be present, but uranium oxide, fuel cladding, fission products, and other materials also will be present. These other materials act as poisons to the system and will effectively lower the system reactivity.

6.1.2 Summary of Conclusions

Conservative assumptions were made for determining worst-case normal and accident conditions. The double contingency criterion requires at least two unlikely, independent, and concurrent changes in process conditions before a criticality is possible. A contingency is a possible but unlikely change in a condition or control identified as an important factor in preventing a nuclear criticality accident. For any single contingency, the system will still be acceptably safe (i.e., k_{eff} less than 0.98, accounting for the uncertainties). The analysis shows that the double contingency principle is met, and concurrent changes in process conditions are necessary before a criticality accident is possible. The analysis established the need for some safety-class equipment and some controls on fuel handling.

The underwater storage and handling of fissionable material at the K Basins facility does not require a criticality alarm or criticality detection system in accordance with DOE Order 5480.24. The operational 4.9 m (16 ft) nominal water level provides sufficient shielding to personnel (Schwinkendorf 1991).

The K West IWTS process equipment was analyzed in Erickson (1998). The analysis covered the criticality safety of the piping, the knockout pots, the particulate settler tubes, the annular filter vessels, and the ion exchange modules. The analysis concluded that the IWTS equipment remained safely subcritical for all normal and credible off-normal situations. Therefore, a criticality is not credible and a criticality alarm system is not required per the criterion in HNF-PRO-546, *Criticality Alarm System*, Section 1.4.1.

6.1.3 Physical Limits

The IWTS piping is critically safe because its maximum dimension is 10.2 cm (4 in.). Piping dimensions up to 48 cm (19 in.) are shown to be critically safe for the fuel composition in K West Basin (Schwinkendorf 1995). No additional requirements are placed on piping for criticality safety.

The knockout pots must be spaced at least 2.54 cm (1.0 in.) from each other, surface-to-surface, and must be arranged in a square lattice (a single line arrangement is a subset of the square lattice). These requirements may be met with any combination of spacing bands, locator racks, or other methods. The wall thickness of the knockout pots are minimum dimensions; and the inside diameter and height are maximum dimensions as described in Chapter 4.0.

The particulate settler tubes are critically safe for sludge particles up to 550 μm because of the tube dimensions and the spacing provided by the support materials in the event of a collapse. Safety-class filter screens are required on the outlet of all knockout pots to limit particles to this size. The minimum wall thickness and maximum inside diameter and length of the particulate settlers are controlled dimensions, as described in Chapter 4.0.

For the filter vessel geometry established in this evaluation, the size of sludge particles entering the filter vessel is limited to 500 μm or less. This also requires all inlet streams to be positively controlled, such as with safety-class knockout pot screens, to limit particles to this size. Dimensions as described in Chapter 4.0 are the minimum inner tank outside diameter and filter-vessel wall thicknesses, and the maximum outer tank inside diameter and inner tank offset. The vessel spacing dimensions are the minimum allowable without further analysis. The dimensions of the filter vessel enclosure shown in Figure 2-7 are maximum dimensions. Because of the large filter vessel enclosure vent openings and the steel cover, water flooding was not considered to be credible and was not analyzed. However, the vent openings must be inspected before first use to ensure that the openings will not obstruct water flow from the enclosure.

6.1.4 Summary of Controls

Fuel canisters or other containers of fissionable material shall not be moved over the knockout pot array pending further analysis of fuel spilled from canisters into the array. This shall be controlled via administrative prohibitions and mechanical stops to prevent canister movement over the knockout pots.

The IWTS IXMs have been shown to be critically safe even if the inlet plutonium concentration is increased by two orders of magnitude over that discussed in Erickson (1994).

6.1.5 Safety Class Equipment for Criticality Prevention

In summary, K West IWTS piping components and vessels have been analyzed to address the criticality concern. Criticality is not a concern for the K West IWTS piping because of the small size of the pipe.

The criticality analysis for the K West knockout pot storage array indicates that criticality is not a concern for a six-by-five array of knockout pots, provided spacing between the pots is maintained at greater than 2.54 cm (1 in.), surface to surface.

The analysis results indicate that the particulate settlers located in the weasel pit will remain subcritical for particulate sizes up to 550 μm during normal and credible off-normal conditions. This particle size shall be ensured by requiring safety-class filter screens on the knockout pot outlet. The filter vessels were shown to remain subcritical for all particle sizes below 550 μm.

The IWTS IXMs have been shown to be critically safe by imposing very conservative operating conditions.

6.2 REFERENCES

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Erickson, D. G., 1994, *Criticality Safety Evaluation of the 100K Area Ion Exchange Modules and Ion Exchange Columns,* WHC-SD-NR-CSER-011, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Erickson, D. G., 1997, *CSER 97-005: Feasibility Study of the Criticality Safety of the 100 K East Basin Weasel Pit for Fuel Retrieval Sludge*, HNF-SD-SQA-CSA-530, Rev. 0, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Erickson, D. G., 1998, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems, Subproject A.9*, HNF-SD-SNF-CSER-011, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Schwinkendorf, K. N., 1991, *K Basin Criticality Accident Analysis,* WHC-SD-NR-CSA-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Schwinkendorf, K. N., 1995, *Criticality Safety Evaluation Report for Spent Nuclear Fuel Processing and Storage Facilities*, WHC-SD-SNF-CSER-005, Westinghouse Hanford Company, Richland, Washington.

APPENDIX 6A

ANALYSIS OF INTEGRATED WATER TREATMENT SYSTEM CRITICALITY-RELATED ACCIDENTS

This page intentionally left blank.

APPENDIX 6A

ANALYSIS OF INTEGRATED WATER TREATMENT SYSTEM CRITICALITY- RELATED ACCIDENTS

6A1.0 INTRODUCTION

The criteria used by the criticality safety program and the engineered and administrative controls to be used for preventing criticality accidents are defined in U.S. Department of Energy (DOE) Order 5480.24. As an operating organization with greater than exempt quantities of fissionable material in its custody, the Spent Nuclear Fuel Project management is responsible to ensure that the material is controlled in accordance with those requirements.

The criticality safety analyses associated with the Integrated Water Treatment System (IWTS) during normal operations and accident conditions are summarized in the following paragraphs. The criticality safety impacts of incidents associated with IWTS operation other than those associated with normal handling and storage in the basins are addressed in this appendix. The normal IWTS equipment inventory loading has been evaluated for potential nuclear criticality accidents and found to be safe and within the nuclear criticality safety criteria and limits established for the IWTS operational activity. The basis of the nuclear safety limit at the K Basins facility while the fuel is under water is that the neutron multiplication factor, k_{eff}, will remain below 0.98 for all postulated accidents. A k_{eff} of less than or equal to 0.98 means that the system has a 2-percent margin of reactivity that has been determined to be satisfactory for this application.

The internal volumes and/or diameters of the five IWTS components of interest (the knockout pot storage array, the annular filter vessels and enclosure, the ion exchange modules [IXMs], the particulate settlers, and the interconnecting piping) were evaluated for the maximum safe parameters for unirradiated 1.25 wt% ^{235}U enriched fuel. Because unirradiated fuel is more reactive than that same fuel would be after irradiation, these parameters are conservative from a standpoint of nuclear criticality safety.

MCNP, the Monte Carlo computer code for neutron photon transport, Version 4A (Breismeister 1993), was used for all criticality calculations except those involving the IXMs and the piping.

For all calculations involving particulate, the optimum moderating conditions were used. HNF-SD-SQA-CSA-530, *CSER 97-005: Feasibility Study of the Criticality Safety of the 100 K East Basin Weasel Pit for Fuel Retrieval Sludge* (Erickson 1997), showed that a packing fraction of 0.25 gave the highest reactivity for small uranium metal particles.

Preventing accidental formation of critical masses in the IWTS equipment is based primarily on mass limits and on confining the fuel in a critically safe geometry. Furthermore, the control is based on the double contingency criterion as stated in HNF-PRO-537:

"Process designs shall incorporate sufficient factors of safety to require at least two unlikely independent and concurrent changes in process conditions before a criticality accident is possible. Protection shall be provided by either (a) the control of two independent process parameters (which is the preferred approach if practical) or (b) a system of multiple (at least two) controls of a single parameter. In all cases, no single credible failure shall result in the potential for a criticality accident."

For conservatism, the safety analyses were based on unirradiated fuel (initial enrichment) critical mass parameters and optimal configurations.

A series of scenarios that are associated with IWTS operation and have a potential for accidental nuclear criticality were evaluated for the criticality safety analysis associated with in-basin fuel handling and operation. In all instances, at least two unlikely, independent, and concurrent changes (contingencies) in processing and/or operating conditions must occur before a credible criticality accident is possible. Incredible single-contingency accidents also were analyzed. The accidents analyzed are presented in section 6A2.0.

6A2.0 CRITICALITY-RELATED ACCIDENT SCENARIOS

6A2.1 PIPING

The 10.2 cm (4-in.) backwash-feed pipe is evaluated by applying the available handbook subcritical limit on diameter of an infinitely long cylinder for low-enriched uranium uranium-water systems. For this 10.2 cm (4-in.) pipe, the uranium system is assumed to be heterogeneous uranium metal with an enrichment of 1.25 wt%, because using the maximum enrichment of the fuel in K West Basin at zero exposure is conservative. For a 1.25 wt% enrichment of uranium metal pieces in water, the maximum diameter of an infinitely long, critically safe cylinder is about 42 cm (16.5 in.).

Schwinkendorf (1995) determined that a safe diameter for cylinders containing scrap enriched to 1.25 wt% ^{235}U is 48.26 cm (19 in.) using a criticality limit of 0.98 for k_{eff}. Because all K West Basin IWTS piping is less than 10.2 cm (4 in.) in diameter, this piping is geometrically favorable. A criticality could occur only in piping of this diameter if the enrichment were increased significantly beyond 5 wt%, which is not possible with the material currently in the K West Basin.

6A2.2 KNOCKOUT POT STORAGE ARRAY

The maximum outer dimensions of an individual knockout pot were used in the analysis. The steel of the knockout pots is modeled as being 0.584 cm (0.23 in.) thick. A single case also was run with the steel thickness reduced to 0.48 cm (0.19 in.) to account for possible corrosion or fabrication tolerances. The knockout pots will not fit into the existing basin fuel storage enclosures without the enclosures being modified, but several possibilities exist for situating the knockout pots. Therefore, spacing between knockout pots was varied to determine the minimum surface-to-surface space needed for criticality safety. Approximately 20 knockout pots may be needed. Therefore, a four-by-five single-layer array of knockout pots was modeled. For conservatism and comparison, 30 knockout pots in a 6-by-5 single-layer array also was modeled. The six-by-five array was used for most other calculations because the results showed a slightly higher reactivity than for the four-by-five array.

6A2.2.1 Knockout Pot Contingencies

The criticality contingency scenarios identified for the knockout pots are as follows.

- A knockout pot is accidentally dropped on top of the array of knockout pots.
- A spill of material from a knockout pot onto the knockout pot array was considered. The knockout pots are constructed of stainless steel and are designed as Section VIII pressure vessels (ASME 1995). Therefore, the knockout pots will not lose integrity during the short time they are used.
- A fuel-canister-handling exclusion zone will be in effect around the knockout pot array. The exclusion zone will consist of an administrative prohibition and mechanical stops to prevent canister movement over the knockout pots.

6A2.2.2 Knockout Pot Evaluation and Results

6A2.2.2.1 Assumptions. The assumptions for the evaluation of the knockout pot storage array include the following.

- All calculations assume that the fissionable material is unirradiated 1.25 wt% ^{235}U enriched fuel. This is conservative because the reactivity of the fuel is reduced as exposure is increased and all fuel is exposed.
- All calculations assume that the fissionable material is uranium metal with a density of 19.05 g/cm^3. This is conservative because much of the fuel is oxidized, especially the small particulates. These small particulates likely will be oxides or will oxidize quickly once formed.

- For all calculations, the particles in the vessels are assumed to all be of maximum size and optimally moderated. This is very conservative for the following reasons.
  - — All particulates are unlikely to be of the maximum size.
  - — Small particles are less reactive than large particles.
  - — No mechanism has been identified to support the optimum lattice spacing.
- All fuel fission products and fuel cladding are ignored.
- The neutron-absorbing effects of internal or external structures, other than the specific verified vessel materials, are ignored.
- All materials are evaluated at a temperature of 300 K.
- The model uses optimal particle spacing. Optimal particle spacing probably cannot be achieved. Also, the particles are expected to settle rapidly in each pot during operation or during or after transport in the basin. The optimal particle spacing is conservative and covers any possible disturbance of the pot load, including a seismic event or incorrect valving.
- A particle size of 0.762 cm (0.3 in.) is assumed for all evaluations. This was shown (Schwinkendorf 1995) to be the most reactive particle size for the fuel stored in the K West Basin.
- The inlet elbow on the knockout pot was not included in the model. This is conservative because its omission allows the pots to be packed more closely than would otherwise be possible.

6A2.2.2.2 Knockout Pot Models. The storage array of the knockout pots was modeled using MCNP 4A (Breismeister 1993). Each pot was modeled as a right circular cylinder. By using the lattice structure option in MCNP 4A, both a four-by-five (Table 6A-1, case k-n-1a) and a six-by-five array (Table 6A-1, cases k-n-2a to k-n-2c and cases k-n-6a and k-n-6b) of knockout pots were modeled. The surface-to-surface spacing between pots was varied from touching to 5.08 cm (2.0 in.) apart. The model used had 60 cm (24 in.) of concrete for the floor and a 60 cm (24-in.)-thick water reflector on all other sides. This model is conservative; because of handling constraints, it is expected that the knockout pots will be stored in single-row arrays, with at least one empty enclosure row separating knockout pot rows.

Case k-n-6b was run with the knockout pot wall thickness reduced from 0.584 cm (0.23 in.) to 0.48 cm (0.19 in.) thick to account for any manufacturing defects or possible corrosion effects.

Because the knockout pots will be placed into the basin near full fuel canisters, the normal condition analysis also included a case (k-n-5a) with the knockout pots near an array of canisters full of unexposed Mark IA fuel.

For the off-normal analysis, the entire six-by-five array of knockout pots was modeled as being two layers tall. This accounts for any handling of either knockout pots or fuel canisters over or around the array and the accidental dropping of a knockout pot onto the array. The two-layer-tall model is very conservative because only one knockout pot would be allowed to be lifted over the array at a time, so only one location could be two layers tall. These results can be found in Table 6A-1, cases k-o-3a and k-o-3b. Two cases, one with a six-by-five-by-one array and a single row on the top layer (k-o-4a) and one with a six-by-one-by-two array (k-o-5a) of knockout pots, were completed to show how conservative the model used is.

6A2.2.2.3 Knockout Pot Results. The results of the MCNP 4A runs for the normal and off-normal cases are shown in Table 6A-1. As can be seen from the results in Table 6A-1, the size of the knockout pot array does not have a significant effect on the system reactivity. This would suggest that the six-by-five array is essentially infinite. The results also show that a small change in the wall thickness has very little effect on the overall system reactivity. The small reactivity reduction seen between cases k-n-2b and k-n-5a is not statistically significant. The results also show that the knockout pots are significantly more reactive than the fuel canisters, so the off-normal model of two-layers-tall knockout pots is bounding and conservative. The comparison between the original dimension base case (k-n-2b) and the two cases with the worst case dimensions (k-n-6a and k-n-6b) show that the final design with the thicker steel actually is safer from a criticality standpoint.

6A2.2.2.4 Knockout Pot Design Features (Passive and Active) and Administratively Controlled Limits and Requirements. The knockout pots must be spaced at least 2.54 cm (1.0 in.), from each other, surface-to-surface, and must be arranged in a square lattice. These requirements may be met using any combination of spacing bands, locator racks, or other methods. The wall thickness of the knockout pots is minimum dimensions, and the diameter and height are maximum dimensions.

Fuel canisters or other containers containing fissionable material (other than knockout pots) shall not be moved over the knockout pot array pending further analysis of fuel spilled from canisters into the array. This shall be controlled via administrative prohibitions and mechanical stops to prevent canister movement over the knockout pots.

Table 6A-1. Results of Criticality Analysis for Knockout Pots.

Case name	Model description	$k_{calc} \pm \sigma_{calc}$	k_{eff}
k-n-1a	4 x 6 x 1 array, surface-to-surface spacing = 0.0 cm	0.9816 ± 0.0011	0.992
k-n-2a	6 x 5 x 1 array, surface-to-surface spacing = 0.0 cm	0.9853 ± 0.0013	0.996
k-n-2b (base case)	6 x 5 x 1 array, surface-to-surface spacing = 2.54 cm	0.9575 ± 0.0012	0.968
k-n-2c	6 x 5 x 1 array, surface-to-surface spacing = 5.08 cm	0.9344 ± 0.0014	0.945
k-n-3a	Single knockout pot, full reflection	0.9057 ± 0.0013	0.916
k-n-4a	k-n-2b, but 0.457 cm (0.180-in.) wall thickness	0.9552 ± 0.0012	0.966
mkia-3	10 x 20 array of Mark IA fuel canisters	0.6903 ± 0.0019	0.701
k-n-5a	k-n-2b with mkia-3	0.9563 ± 0.0012	0.967
k-n-6a	Like k-n-2b, but worst-case radial dimensions and thicker steel (0.23 in.)	0.9502 ± 0.0013	0.961
k-n-6b	Like k-n-6a, but original steel thickness (0.19 in.)	0.9592 ± 0.0013	0.970
k-o-3a	k-n-2b, but 6 x 5 x 2 array	0.9659 ± 0.0012	0.976
k-o-3b	k-n-2c, but 6 x 5 x 2 array	0.9446 ± 0.0013	0.955
k-o-4a	k-o-3a, but single row on top layer	0.9565 ± 0.0013	0.967
k-o-5a	k-o-3a, but 6 x 1 x 2 array	0.9400 ± 0.0013	0.951

6A2.3 INTEGRATED WATER TREATMENT SYSTEM PARTICULATE SETTLERS

The particulate settlers are made of 10 stainless steel pipes, each 50.8 cm (20 in.) in diameter and 487.7 cm (16 ft) long. Under normal conditions, the minimum spacing between the pipes is 15.24 cm (6 in.), and the minimum spacing between the pipes and the two side walls is 8.9 cm (3.5 in.). The actual distance from the concrete floor to the bottom row of the array is 30 cm (12 in.); the normal model's use of 8.9 cm to the reflecting concrete floor is an additional conservatism. Outlet screens on the knockout pot discharge limit the size of the particles entering the settling tubes to 550 μm or less. The methodology employed in evaluating these particulate settlers is similar to that used for the filter vessel enclosure and the knockout pots.

6A2.3.1 Particulate Settler Contingencies

The criticality contingency scenarios identified for the particulate settlers are as follows.

- An event is postulated that relocates all 10 pipes from their normal position to a closely packed array at the bottom of the pit. The minimum critically acceptable spacing is determined to compare with the minimum spacing between particulate settlers that the structural steel supports maintain.

- An event is postulated where a single tube leaks all its particulate matter into a hemisphere at the bottom of the pit. For conservatism, this event is postulated to occur when all the settler tubes are filled with optimally moderated particulate. The material in the hemispherical pile at the bottom of the pit is not optimally moderated because no mechanism has been identified to support the particle spacing necessary for optimal moderation. A conservative packing fraction of 0.52 is used, based on the largest allowed particle in a cubic lattice. This is conservative because particles would fall into a more compact lattice than a cube, with a correspondingly higher packing fraction.

6A2.3.2 Particulate Settler Evaluation and Results

6A2.3.2.1 Assumptions. The specific assumptions for the evaluation of these particulate settlers include the following.

- All calculations assume that the fissionable material is unirradiated 1.25 wt% ^{235}U enriched uranium fuel. This is conservative because the reactivity of the fuel is reduced as exposure is increased and all fuel is exposed.

- All calculations assume that the fissionable material is uranium metal with a density of 19.05 g/cm^3. This is conservative because much of the fuel is oxidized, especially the small particulates. These small particulates likely will be oxides or will oxidize quickly once formed.

- For all calculations, the particles in the vessels are assumed to all be of maximum size and optimally moderated. This is very conservative for the following reasons.

  — All particulates are unlikely to be of the maximum size.

  — Small particles are less reactive than large particles.

  — No mechanism has been identified to support the optimum lattice spacing..

- All fuel fission products and fuel cladding are ignored.

- The neutron-absorbing effects of internal or external structures, other than the specific verified vessel materials, are ignored.

- All materials are evaluated at a temperature of 300 K.

- The model uses the optimal particulate spacing packing fraction of 0.25 (Erickson 1997). This is conservative because it is unlikely that optimal particle spacing can be achieved during the normal operation of the settlers. The pipe diameter change from the 10.2 cm (4-in.) inlet pipe to the 50.8 cm (20-in.) settler tube will cause the flow rate to be reduced by a factor of at least 25. This is designed to settle particles greater than 50 µm. However, instances such as pump malfunction or tube blockage may increase flow rate to the settlers that causes disturbances in the system such that the optimal spacing between particles can be achieved.

- A particle size of 550 µm (to account for the statistical variations in the manufacture of the knockout pot outlet screen) is used for all evaluations.

- Both the floor and two side concrete walls are assumed to be 61 cm (24 in.) thick. In addition, a 61 cm (24-in.)- thick water reflector is assumed above the top of the topmost settlers and along the ends of the pipes.

- Each settler tube is assumed to contain approximately 4,500 kg (9,920 lb) of uranium, for a total of 45,000 kg (99,200 lb) of uranium in all 10 settler tubes. This is extremely conservative. This mass is more than 5.5 times the design-basis sludge mass and almost three times the safety-basis sludge mass.

6A2.3.2.2 Particulate Settler Models. Three basic MCNP models were used in the evaluation of the particulate settlers. The first model portrayed the settler configuration under normal conditions. The other two models were used to analyze the two abnormal conditions described in section 6A2.3.1.

Ten evenly spaced 50.8 cm-diameter pipes were represented in the first (normal) model (cases c-n-1a). All 10 tubes were completely filled with sludge at optimal geometry in the model. For the assumed particle size of 550 µm, the optimal packing fraction of 0.25 yields a center-to-center spacing of 0.0704 cm (0.03 in.). All materials in this model are identical to those used in the model of the knockout pot array.

The second model was constructed to assess the consequences of a postulated off-normal event in which the structural material supporting and separating the 10 full tubes collapses completely. The result is a closely packed array at the bottom of the pit. Because of the quantity of structural material present in the weasel pit with the particulate settling tubes, a closely packed array with no clearance between tubes could not form. Thus, six variants of the second model were constructed to determine the relationship between tube spacing and the reactivity of the array. All six model variations have five rows of two pipes, with the bottom row resting on the concrete floor. In all cases, the two pipes in each row touch, while the minimum surface-to-surface spacing of tubes between rows varies from zero to 6.9 cm. For each center-to-center distance, the array is in the most compact arrangement of the 10 cylinders, which is the most reactive configuration. Letting the cylinders fall into the weasel pit without restriction would make a less compact, and therefore less reactive, arrangement. The results from these cases (c-o-4a to c-o-4f and c-o-3b) are shown in Table 6A-2.

The case (c-n-1b) using the final worst case dimensions also was analyzed.

Table 6A-2. Results of the Criticality Analysis for Particulate Settlers.

Case name	Model description	$k_{calc} \pm \sigma_{calc}$	k_{eff}
c-n-1a (base case)	Normal position with tubes full	0.9244 ± 0.0014	0.935
c-n-1b	Like c-n-1a, except worst-case radial dimensions and thicker steel (0.23 in.)	0.9237 ± 0.0014	0.934
c-o-2b	One tube spilled onto pit floor, other tubes full	0.9377 ± 0.0014	0.948
c-o-4a	No spacing between rows	0.9903 ± 0.0012	1.001*
c-o-4b	0.9 cm, surface-to-surface spacing between rows	0.9822 ± 0.0011	0.993*
c-o-4c	1.7 cm, surface-to-surface spacing between rows	0.9768 ± 0.0013	0.987*
c-o-4d	3.5 cm, surface-to-surface spacing between rows	0.9663 ± 0.0012	0.977
c-o-4e	5.2 cm, surface-to-surface spacing between rows	0.9566 ± 0.0013	0.968
c-o-4f	6.9 cm, surface-to-surface spacing between rows	0.9562 ± 0.0013	0.967
c-o-3b	Infinite spacing between rows (two tubes at bottom)	0.9479 ± 0.0013	0.959

*Structural supports for particulate settlers will prevent a close-packed array.

The third model was constructed to evaluate a postulated off-normal event in which one full tube in an upper row lost all its contents. The most reactive sludge configuration that could result from this event would be a hemisphere on the weasel pit floor between the bottom rows of tubes. In the case of the sludge spill, no mechanism keeps the sludge in an optimally spaced condition. Therefore, the sludge on the floor of the pit was modeled with a packing fraction of 0.52, which results from modeling the particulates in a square lattice with minimum spacing. This is conservative because a higher packing fraction would be expected in reality. A square lattice would collapse into a close-packed triangular pitch lattice. The bottom row of the particulate settlers was modeled as being 30.48 cm (12 in.) above the concrete floor.

A portion of the hemispherical pile of sludge is displaced by the bottom two tubes. The radius of the hemisphere that conserves the assumed uranium mass in one full tube (4500 kg [9,920 lb]), has a packing fraction of 0.52, and accounts for the displacement by two tubes is 65.1 cm. This result can be found in Table 6A-2 (case c-o-2b).

6A2.3.2.3 Particulate Settler Results. The results of the MCNP 4A runs for the normal and abnormal cases of the particulate settlers are shown in Table 6A-2. For the normal condition, even with the tubes full (when the maximum estimated fill volume is about one-half full) and the contents optimally moderated (case c-n-1a), the k_{eff} value is 0.935, well under the criticality limit of 0.98. With the contents of one tube added to the MCNP model as a hemispherical mass on the pit floor, k_{eff} increases to 0.948, but is still safely subcritical.

For the postulated case where the pipe support structures collapse and each pair of pipes is in contact, computed k_{eff} values are under the limit only if the effective minimum spacing between pipe rows is greater than 3.5 cm (1.4 in.). With all the structural steel present, the effective spacing between tubes would never be that small, even if the support structure fails.

The present rows of tubes are spaced 15.2 cm (6 in.) apart vertically and a seismic analysis shows that the support structure does not fail. The support structure is composed of a vertical web along the tube centerline between the tubes, steel beams at right angles to the tube centerline, and the equivalent of 'tube sheets' for the tubes. Therefore, a scenario that displaces or removes enough seismically qualified steel structure to allow the tubes to come within 3.5 cm (1.4 in.) of each other is not considered credible. The spacing for at least four tubes in a parallel arrangement must be reduced from 15.2 cm (6 in.) to less than 3.5 cm (1.4 in.) to exceed the maximum allowable reactivity and to less than 1.27 cm (0.5 in.) to approach criticality.

The results of this spacing analysis show a structure requiring extreme deformation to exceed safe criticality configuration with no projected accidents to impose forces that would inflict such deformation.

The comparison between the original dimension base case (c-n-1a) and the case with the worst case dimensions (c-n-1b) show that the final design with the thicker steel is not statistically different from a criticality standpoint and still meets the criticality safety limit.

6A2.3.2.4 Particulate Settler Design Features (Passive and Active) and Administratively Controlled Limits and Requirements. The particulate settler tubes are critically safe with sludge particles up to 550 μm because of their dimensions and the spacing provided by the support materials in the event of a collapse. This requires 500 μm safety-class filter screens on the outlet of all knockout pots to limit particles to this size. The wall thickness of the particulate settlers are minimum dimensions, and the diameter and length are maximum dimensions.

6A2.4 K WEST INTEGRATED WATER TREATMENT SYSTEM ANNULAR FILTER VESSEL AND ENCLOSURE

The sand and garnet filter vessels are surrounded with a rectangular shield enclosure. The current shielding requirements for the vessels include various combinations of steel, lead, and concrete. A top shield of 2.54 cm (1-in.) steel minimizes the release of upward radiation. The dimensions of the filter vessels and enclosure, including the minimum filter vessel wall thickness of 1.27 cm (0.5 in.), use conservative tolerances.

Sufficient internal volume is provided above the filter media for sludge to mix with water during the backwash cycle. Thus, during backwash, the water flowing into the filter will suspend the sludge particles from the bed, increasing the chance for the particles and water to establish an optimum condition for criticality. Although sludge particles greater than 50 μm are not expected in the filter vessels, for consistency, a particle size of 550 μm was used in the criticality analysis.

It is assumed that the sludge suspended during the backwash will yield the highest reactivity. This is because, during this process, the particle spacing will be increased to such a distance that moderation should be adequate to increase the system's reactivity. The evaluation of this backwash case will bound the conditions during normal operation.

6A2.4.1 Annular Filter Vessel Contingencies

The criticality contingency scenarios identified for the filter vessels and enclosure are as follows.

- The center void region of the inner tank is normally empty. A contingent condition is to have water added to the inside of the tank.
- If particles larger than 550 μm enter the filter vessel through a short circuit from other feed streams (e.g., the Cold Vacuum Drying Facility) or a ruptured outlet screen in the active knockout pot, reactivity would be higher than in a vessel with only smaller particles. This is not considered a credible event because at least two systems (the knockout pot outlet screen and the particulate settlers) would have to fail before the event could occur. Criticality specifications for the cold vacuum drying process will ensure the double contingency against a backwash introducing particles larger than 550 μm into the filter vessels. The filter vessels are analyzed with particles larger than 550 μm to ensure a margin of safety beyond that required for the allowed particle size.
- The vessel was modeled as being filled with sludge to different heights up to the maximum possible. At the maximum possible height, the vessel would contain a large fraction of the sludge expected from all the canisters. This is not considered credible because differential pressure alarms and high-dose-rate alarms would both be activated long before this could occur. This analysis shows that even filled with sludge, the criticality limits are met.

6A2.4.2 Annular Filter Vessel Evaluation and Results

6A2.4.2.1 Annular Filter Vessel Assumptions. The assumptions for the evaluation of the filter vessels include the following.

- All calculations assume that the fissionable material is unirradiated 1.25 wt% ^{235}U enriched uranium fuel. This is conservative because the reactivity of the fuel is reduced as exposure is increased and all fuel is exposed.
- All calculations assume that the fissionable material is uranium metal with a density of 19.05 g/cm^3. This is conservative because much of the fuel is oxidized, especially the small particulates. These small particulates likely will be oxides or will oxidize quickly once formed.

- For all calculations, the particles in the vessels are assumed to all be of maximum size and optimally moderated. This is very conservative for the following reasons.
  - All particulates are unlikely to be of the maximum size.
  - Small particles are less reactive than large particles.
  - No mechanism has been identified to support the optimum lattice spacing.
- All fuel fission products and fuel cladding are ignored.
- The neutron-absorbing effects of internal or external structures, other than the specific verified vessel materials, are ignored.
- All materials are evaluated at a temperature of 300 K.
- Optimally spaced uranium particles are assumed based on the most reactive packing fraction, 0.25 (Erickson 1997). This assumption is conservative because the likelihood of all the particles being suspended in water above the bed at an optimal condition is remote, even during the backwash cycle.
- A right cylindrical geometry was used to model the filter vessel. The actual elliptical shape of the filter vessel will yield a lower reactivity.
- A particle size of 550 μm is used for all evaluations.
- It is also assumed that approximately 6450 kg (14,220 lb) of uranium will be in each annular filter vessel, for a total of 19,350 kg (42,660 lb) of uranium in all three vessels. This is extremely conservative. This mass is more than twice the design-basis sludge mass and more than the safety-basis sludge mass. This is after the knockout pots and settler tubes presumably have removed all the large particulates.

6A2.4.2.2 Annular Filter Vessel MCNP Models. MCNP, the Monte Carlo computer code for neutron photon transport (Breismeister 1993) was used to model the filter vessel and enclosure, including all three filter vessels. The sludge, structural steel, and concrete were modeled using the materials documented in Appendix A of HNF-SD-SNF-CSER-011, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment System* (Erickson 1998). The filter medium was modeled as a homogenous mixture of 61.3 vol% sand and garnet and 38.7 vol% water. In the models of normal conditions, the inner tank was dry.

Two models were used in the criticality analysis of the filter vessels under normal conditions. Both models are extremely conservative. In the first model (a-n-1a), all the uranium (6,450 kg per vessel) was suspended in a 76.8 cm-thick water layer above the sand and garnet filter material. In the second model (a-n-2 series of cases), 2560 kg of the 6450 kg uranium was embedded in the filter material. Embedding the 2560 kg of uranium in the filter material reduced the height of the uranium-water layer to 46.4 cm. Several variations of the second model were analyzed. These variations differed in the concentration and depth of the layer containing uranium in the filter. The concentration and depth were changed consistently in each variation to conserve the uranium mass (2560 kg) in the layer.

Of the abnormal conditions postulated, only the one where water flooded the inner vessel required computer modeling for assessment. The analysis (case a-o-1a) shows that, because of its isolating effects, adding water to the inner vessel reduces reactivity.

Several cases with more credible quantities of particulates also were run for comparison. Case a-n-1d used 28 kg of sludge in a layer; case a-n-1b used 500 kg of sludge in a layer. Both results show how conservative the normal analysis is. The 500 kg case bounds the 205 kg quantity of particulate (adjusted for oxidized fuel) used in the unmitigated bounding accident analysis shown in Chapter 3.

The two cases (a-n-1g and a-n-1h) using the final worst case dimensions for wall thickness and inner vessel offset also were analyzed.

6A2.4.2.3 Annular Filter Vessel Results. The results of all calculations are shown in Table 6A-3. As expected, the most reactive configuration is the one with all the uranium dispersed optimally in water above the filter material. The value of k_{eff} for this case is 0.976, which is below the k_{limit} value of 0.98. When 2560 kg of the 6450 kg uranium inventory used in all cases was relocated to the top portion of the filter media, k_{eff} was lower by at least 2 percent. The thickness of the uranium layer in the filter media was extended to identify any maximum in the reactivity caused by the change in the uranium concentration.

6A2.4.2.4 Filter Vessel Design Features (Passive and Active) and Administratively Controlled Limits and Requirements. For the filter vessel geometry established in this evaluation, the size of sludge particles entering the filter vessel should be limited to 550 μm or less. This requires all inlet streams to be positively controlled, such as with safety-class filter screens, to limit particles to this size. Critical dimensions include a minimum outside diameter of the inner tank, a maximum inside diameter of the outer tank, minimum filter vessel wall thicknesses, and a maximum inner vessel offset. The vessel spacing dimensions shown in Figure 2-7 are the minimum allowable without further analysis. The dimensions of the vessel enclosure walls shown in Figure 2-7 are maximum dimensions. Because of the large filter vessel enclosure vent openings and the steel cover, water flooding was not considered to be credible and was not analyzed. However, the vent openings must be inspected before first use to ensure that the openings will not obstruct water flow from the enclosure.

6A2.5 ION EXCHANGE MODULES

Erickson (1994) investigated the potential for an unsafe accumulation of plutonium in the K Basin ion exchange modules (IXM). They found that for an assumed average inlet concentration of 1.5×10^{-6} g/L plutonium and an incredible constant 95 percent holdup efficiency over the life of the IXM, it would take about 42 years to accumulate enough plutonium to reach a calculated k_{eff} of 0.95. The analysis ignored the neutron-absorbing effects of the other materials that would be mixed with the plutonium in the IXMs, which would be substantial. The flow rate through the IWTS IXMs will be similar to that through the IXMs analyzed in Erickson (1994).

Table 6A-3. Results of Criticality Analysis for the Annular Filter Vessel.

Case name	Model description	$k_{calc} \pm \sigma_{calc}$	k_{eff}
a-n-1a (base case)	6450 kg uranium in 76.8 cm-deep sludge-water layer[a]	0.9615 ± 0.0012	0.972
a-n-1g	Like a-n-1a, but worst-case radial dimensions and thicker steel	0.9649 ± 0.0013	0.976
a-n-1h	Like a-n-1g, except vessels offset 1.1113 cm	0.9639 ± 0.0012	0.975
a-n-1d	28 kg uranium in 0.334 cm-deep sludge-water layer	0.1198 ± 0.0006	0.131
a-n-1b	500 kg uranium in 5.96 cm-deep sludge-water layer	0.5441 ± 0.0017	0.555
a-n-2c	Uranium in 21.8 cm layer of filter media[b]	0.9314 ± 0.0014	0.942
a-n-2b	Uranium in 30.5 cm layer of filter media[b]	0.9378 ± 0.0015	0.948
a-n-2e	Uranium in 50.8 cm layer of filter media[b]	0.9417 ± 0.0013	0.952
a-n-2f	Uranium in 76.2 cm layer of filter media[b]	0.9416 ± 0.0013	0.952
a-n-2g	Uranium in 127.0 cm layer of filter media[b]	0.9389 ± 0.0012	0.949
a-o-1a	Same as case a-n-1a, but with water filling the center annulus	0.9572 ± 0.0012	0.968

[a] a-n-1a series of cases had no uranium in the filter media.

[b] Cases with uranium in the filter media had 2560 kg uranium in a layer at the top of the filter material and 3890 kg uranium in a 46.4 cm-deep sludge-water layer above the filter material. Total uranium mass in these cases was 6450 kg, the same as in case a-n-1a.

An IWTS IXM is expected to operate for only about 1 month because of the expected transuranic concentration and the corresponding operating limits. Even if the average inlet plutonium concentration increased by two orders of magnitude, the IWTS IXMs would not be on line long enough to pose a criticality hazard.

6A3.0 INTEGRATED WATER TREATMENT SYSTEM CRITICALITY DESIGN FEATURES AND ADMINISTRATIVELY CONTROLLED LIMITS AND REQUIREMENTS

6A3.1 PIPING

For a 1.25-percent enrichment of uranium metal pieces in water, the maximum diameter of an infinitely long, critically safe cylinder is about 42 cm (16.5 in.). The IWTS piping is critically safe because its maximum dimension is 10.2 cm (4 in.). No additional requirements are placed on piping for criticality safety.

6A3.2 KNOCKOUT POT ARRAY

The knockout pots must be spaced at least 2.54 cm (1.0 in.), surface-to-surface, from each other and must be arranged in a square lattice. These requirements may be met with any combination of spacing bands, locator racks, or other methods. The wall thickness of the knockout pots are minimum dimensions, and the diameter and height are maximum dimensions as described in Chapter 4.

Fuel canisters or other containers containing fissionable material shall not be moved over the knockout pot array pending further analysis of fuel spilled from canisters into the array. This shall be controlled via administrative prohibitions and mechanical stops to prevent canister movement over the knockout pots.

6A3.3 PARTICULATE SETTLERS

The particulate settler tubes are critically safe for sludge particles up to 550 μm because of the dimensions of the tubes and the spacing provided by the support materials in the event of a collapse. Safety-class filter screens are required on the outlet of all knockout pots to limit particles to this size. The wall thickness of the particulate settlers as described in Chapter 4 are minimum dimensions; The diameter and length are maximum dimensions.

6A3.4 ANNULAR FILTER VESSELS

For the filter vessel geometry established in this evaluation, the size of sludge particles entering the filter vessel is limited to 500 μm or less. The dimensions described in Chapter 4 are the minimum dimensions for the inner tank diameter and filter vessel wall thicknesses and the maximum dimensions for the outer tank diameter and inner vessel offset. The vessel spacing dimensions are the minimum allowable without further analysis. The dimensions of the vessel enclosure shown in Figure 2-7 are maximum dimensions.

6A3.5 ION EXCHANGE MODULES

The IWTS IXMs have been shown to be critically safe even if the inlet plutonium concentration is increased by two orders of magnitude over that discussed in Erickson (1994).

6A4.0 REFERENCES

ASME, 1995, *Boiler and Pressure Vessel Code*, Section VIII, "Pressure Vessels," American Society of Mechanical Engineers, New York, New York.

Breismeister, J. F., Editor, 1993, *MCNP – A General Monte Carlo N-Particle Transport Code, Version 4A*, LA-12625, Los Alamos National Laboratory, Los Alamos, New Mexico.

DOE Order 5480.24, 1992, *Nuclear Criticality Safety*, U.S. Department of Energy, Washington, D.C.

Erickson, D. G., 1994, *Criticality Safety Evaluation of the 100K Area Ion Exchange Modules and Ion Exchange Columns*, WHC-SD-NR-CSER-011, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Erickson, D. G., 1997, *CSER 97-005: Feasibility Study of the Criticality Safety of the 100 K East Basin Weasel Pit for Fuel Retrieval Sludge*, HNF-SD-SQA-CSA-530, Rev. 0, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Erickson, D. G., 1998, *Criticality Safety Evaluation Report for the K West Basin Integrated Water Treatment Systems, Subproject A.9*, HNF-SD-SNF-CSER-011, Rev. 1, Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

Schwinkendorf, K. N., 1995, *Criticality Safety Evaluation Report for 300 Area N Reactor Fuel Fabrication and Storage Facility*, WHC-SD-NR-CSER-010, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

7.0 RADIATION PROTECTION

As part of the design package, Chem Nuclear reviewed the adequacy of the integrated water treatment system (IWTS) design features used to protect personnel from radiological exposure and documented this in the as low as reasonably achievable (ALARA) section of the design report (Bergsman 1997). The evaluation considered exposure to workers from operation and maintenance activities associated with the IWTS equipment. Based on the results of the estimated exposures, the design was evaluated to see whether design or operating improvements could be made that would reduce worker dose.

The design features that minimize worker dose were identified as the following:

- The minimum water cover maintained over most of the IWTS equipment and fuel-handling activities

- Shielding provided for the piping, booster pump, and filter vessels based on cesium content

- Remote-handling devices for operator use in the basin

- The positive exhaust path for gases

- The design requirements that minimize dose during maintenance of IWTS equipment, such as use of quick disconnects and design features that facilitate decontamination efforts.

- The administrative control features that minimize dose include rotation of in-basin workers and application of standard ALARA principles to minimize time in the basin, movement to low-dose areas when work tasks permit, and an approach to maintenance that minimizes repair of low-cost replaceable components.

The evaluation concludes that the IWTS equipment does not contribute significantly to the overall dose rate profile for the basin and that the IWTS design with the recommended administrative controls will provide individual dose uptakes for the IWTS operations that are as low as reasonably achievable. Inclusion of the IWTS subproject will not require changes in Chapter 7 of the K Basins safety analysis report (DESH 1998).

REFERENCES

Bergsman, K. H., 1997, *K West IWTS Design Report* and *K West IWTS Design Drawings*, EDT 621526, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

8.0 HAZARDOUS MATERIAL PROTECTION

The existing Hazardous Material Protection Program is described in Chapter 8 of the K Basin safety analysis report (DESH 1998) and will be applied to the integrated water treatment system (IWTS) installation and installation testing. Potential changes to the Hazardous Material Protection Program will be addressed in the upgraded K Basin safety analysis report activities to be performed at a later date. No potential changes have been identified as part of the ongoing IWTS activities.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

9.0 RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

The integrated water treatment system (IWTS) subproject will increase the number of ion exchange modules used in the K Basin. Although this is not a new waste stream, it will increase the number of spent ion exchange modules that are handled. The radioactive waste in the form of sludge from the basin will be handled by the sludge removal subproject.

IWTS installation and installation testing will adhere to the requirements of the K Basins Radioactive and Hazardous Waste Management Plan as described in Chapter 9 of the K Basins safety analysis report (DESH 1998). Potential changes to the program required for IWTS operation will be addressed in the upgraded K Basins safety analysis report. No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

10.0 INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

The initial testing, in-service surveillance, and maintenance program provisions will be applied, as appropriate, to the integrated water treatment system (IWTS) equipment. Three types of testing will be done before startup of the IWTS. They are factory acceptance testing, construction acceptance testing, and preoperational acceptance testing. The factory acceptance test shall demonstrate to the satisfaction of the project design authority that the designed equipment can perform its intended function during all expected operating modes. The major pieces of designed equipment include the knockout pots, settler tanks, and annular filters. The construction acceptance test shall demonstrate that the installation matches the design and that all equipment is functional. The preoperational acceptance test shall demonstrate that the design and installation are operable and can perform their intended functions. Initial system testing, in-service surveillance, and maintenance will be described in the upgraded K Basins safety analysis report (DESH 1998).

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

11.0 OPERATIONAL SAFETY

The operational safety program provisions will be applied to the integrated water treatment system (IWTS) equipment. Fire hazards to the worker are being addressed in a revision of the fire hazards analysis (FHA) (DESH 1998a). A list of IWTS combustibles consisting mostly of wire insulation and other incidental materials was provided to the cognizant engineer for incorporation into the next revision of the FHA. The IWTS will not affect the conclusions of the draft FHA. Changes to the program required for IWTS operation will be addressed in the upgraded K Basins safety analysis report (DESH 1998). No changes have been identified to date.

REFERENCES

DESH, 1998a, *Fire Hazards Analysis for the K Basins Facilities at 100 K Area*, HNF-SD-SNF-FHA-001, Rev. 1, Draft, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

DESH, 1998b, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

12.0 PROCEDURES AND TRAINING

All integrated water treatment system (IWTS) installation and installation testing activities will be performed in accordance with written procedures. Procedures will be developed and maintained in accordance with the program described in the K Basins safety analysis report (DESH 1998). Personnel performing IWTS installation and installation testing will be trained and qualified for the tasks they are performing. Revisions to the procedure and training program necessary to support operation of the IWTS will be described in the upgraded K Basins safety analysis report.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

13.0 HUMAN FACTORS

No human factors apply to the integrated water treatment system (IWTS) safety-class structures, systems, and components because all IWTS safety-class structures, systems, and components are passive devices. However, human factors were considered in the design of IWTS equipment to ensure that human–machine interfaces do not pose operational or ergonomic problems. Potential changes will be addressed in the upgraded K Basins safety analysis report. No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

14.0 QUALITY ASSURANCE

Integrated water treatment system (IWTS) installation and installation testing will be performed in compliance with the existing K Basin Quality Assurance Program. Changes to the program required for IWTS operation will be addressed in the upgraded K Basins safety analysis report (DESH 1998). No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev, 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

15.0 EMERGENCY PREPAREDNESS PROGRAM

The existing K Basin emergency preparedness program will be applied during installation and installation testing of the integrated water treatment system (IWTS). Changes to the program required by IWTS operation will be addressed in the upgraded K Basin safety analysis report (DESH 1998). No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

16.0 PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

The design of the integrated water treatment system (IWTS) equipment considered the decontamination and decommissioning of the equipment. The items considered in the IWTS equipment design included provisions for access to accumulated sludge in the knockout pots and particulate settlers for future sludge removal. Other provisions include access for cleaning process piping, waterproof equipment, lack of crevices, ledges, and protrusions in welded structures, lifting lugs on all assemblies, and adequate clearance for transfer of equipment. The decontamination and decommissioning considerations for purchased equipment were incorporated into the procurement specifications.

Chapter 16 of the K Basins safety analysis report (DESH 1998) will be upgraded as required. No changes have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

17.0 MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

Integrated waste treatment system (IWTS) installation and installation acceptance testing will be performed under the management, organization, and institutional safety provisions described in the existing K Basins safety analysis report (DESH 1998). Changes to the program required for IWTS operation will be addressed in the updated and upgraded K Basins safety analysis report. No changes to accommodate IWTS have been identified to date.

REFERENCE

DESH, 1998, *K Basins Safety Analysis Report*, WHC-SD-WM-SAR-062, Rev. 3C, DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

This page intentionally left blank.

ATTACHMENT

ACCEPTANCE OF THE SAFETY ANALYSIS DOCUMENTS FOR THE FUEL RETRIEVAL SYSTEM, HNF-2032, REV. 0, AND K-WEST INTEGRATED WATER TREATMENT SYSTEM, HNF-SD-SNF-SAD-002, REV.2

This page intentionally left blank.

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

98-SFD-169

AUG 3 1 1998

Mr. R. D. Hanson, Acting President
Fluor Daniel Hanford, Inc.
Richland, Washington 99352

Dear Mr. Hanson:

CONTRACT NO. DE-AC06-96RL13200 - ACCEPTANCE OF THE SAFETY ANALYSIS DOCUMENTS (SADs) FOR THE FUEL RETRIEVAL SYSTEM (FRS), HNF-2032, REVISION (REV.) 0, AND K-WEST INTEGRATED WATER TREATMENT SYSTEM (KW-IWTS), HNF-SD-SNF-SAD-002, REV.2

References: (1) FDH letter to E. D. Sellers, RL, from N. H. Williams, "Fuel Retrieval System Safety Analysis Document," (FDH-9854896), dated June 11, 1998.

(2) FDH letter to E. D. Sellers, RL, from N. H. Williams, "Integrated Water Treatment Safety System Safety Analysis Document," (FDH-9855063), dated June 11, 1998.

This letter provides conditional approval of the FRS and IWTS safety basis documentation transmitted to the U.S. Department of Energy (DOE), Richland Operations Office (RL) in References (1) and (2). The RL evaluation of these documents is contained in Enclosure 1, "Safety Evaluation Report (SER) for the SNF Fuel Retrieval Sub Project Safety Analysis Report, HNF-2032 Rev. 0, and K-West Basin Integrated Water Treatment System Subproject Safety Assessment Document, HNF-SD-SNF-SAD-002." The SER states that the SADs and the SER comprise an acceptable safety basis for construction and pre-operational testing of the FRS and KW-IWTS systems subject to the conditions of approval are stipulated in Enclosure 1.

Design and safety assumptions contained in the SADs are expected to be controlled as stipulated in paragraph 4.f.(8). (c). 3, Attachment 1, to DOE Order 5480.23, Nuclear Safety Analysis Reports. Design changes must be screened against the SADs and this SER for their impact on the safety basis, and no design changes that would invalidate an assumption, analysis, commitment, or a conclusion in the safety basis shall be made without approval by RL.

Mr. R. D. Hanson -2-
98-SFD-169

In preparation of the SER, RL assessed reviewer comments and contractor responses. A summary of the identified issues is provided in Enclosure 1. Major issues requiring management attention are identified below:

- The Hazard and Accident Analysis Out-of-Date – The hazard and accident analysis presented do not accurately represent the current hazard baselines – The hazards identification and analysis presented in the FRS and IWTS SADs summarized the results of the HAZOP/other analysis conducted during preliminary hazards assessments. These hazards analyses do not reflect the results of system design changes as the design evolved. Additionally, the hazards analysis contains controls, design features, and commitments to emergency response actions which are generic and cannot be understood and in some case are obsolete.

- Hazard and Accident Analysis Omissions – No IWTS drop analysis or seismic analysis for safety class systems, components, or structures (SSC) were provided or referenced in the SAD as required by DOE Orders 5480.23 and 6430.1A. Additionally, the radiation hazard imposed by the proximity of the settlers to the pool surface under fuel basin water loss accident scenarios was not identified or assessed in the SAD. Safety analysis contained in the current K Basin Authorization Basis could potentially be invalidated relative to radiation exposure, basin manning, and emergency recovery actions.

- Adequacy of Base Information – There was a lack of, or omission of, base information in the areas required to be addressed by DOE Order 5480.23. These areas included: 1) human factors; 2) initial testing, in-service surveillance, and maintenance; and, 3) identification of what specific requirements from S/RID, which were applied, what specific DOE Order 6430.1A design requirements were applied, and identification and qualification of safety margins in accident analysis to account for uncertainties as required by DOE Order 5480.23, Item (4), d. (1). In general complaince to applicable codes, standards, and requirements was not adequately described in the SAD nor was it able to be confirmed by FDH.

The RL observations listed above require management attention to strengthen the process for preparing nuclear safety basis documentation. RL requests continued dialog on these observations such that any identified management actions necessary can be implemented prior to submittal of Final Safety Analysis Reports (FSARs) for the Spent Nuclear Fuels (SNF) Project.

Any commitments contained in the contractor responses to RL review comments on the SADs (Appendix C to the SER) are expected to be tracked to closure. Some comments are noted to remain open until closed in the FSAR. RL requested and received excellent contractor support on the review activities in order to meet the document approval dates in the RL review plan.

RL appreciates the teamwork and professionalism of the contractor in their support of the RL review team.

If any direction is provided by a Contracting Officer's Representative (COR) which your company believes exceeds the COR's authority, you are to immediately notify the Contracting Officer and request clarification prior to complying with the direction.

Mr. R. D. Hanson
98-SFD-169

AUG 31 1998

If you have any questions regarding this matter, please call me or Robert M. Hiegel, RL Spent Nuclear Fuels Project Division, on (509) 376-1062.

Sincerely,

C. A. Hansen, Assistant Manager
for Waste Management

SFD:RMH

Enclosure (as stated)

cc: C. B. Aycock, DESH
R. G. Morgan, DESH
R. W. Rasmussen, DESH
A. W. Segrest, DESH
T. J. Hull, EH-34, HQ
J. D. Thomspson, FDH
N. H. Williams, FDH

Department of Energy

Richland Operations Office

Safety Evaluation Report

For the

"SNF Fuel Retrieval System
Safety Analysis Document," HNF-2032 Rev. 0

And

"K West Basin Integrated Water Treatment System
Safety Analysis Document," HNF-SD-SNF-SAD-002,
Rev. 2

Approved by Charles A. Hansen / 8/31/98
Charles A. Hansen
Assistant Manager for Waste Management
Richland Operations Office

FRS/IWTS Safety Analysis Document Review Team

Sidney J. Altschuler
DOE-RL/TPD

Sidney J. Altschuler

Richard P. Denise
GSSC

Robert M. Hiegel for

Michael C. Humphreys

Michael C. Humphreys
DOE-RL/Nuclear Safety
Advisor

F M Roddy

F. M. Roddy
DOE-RL/Radiation Control
Advisor

Robert M. Hiegel

Robert M. Hiegel
Review Team Leader
DOE-RL/SFD

Guy E. Bishop, III
DOE-RL/SFD

G. D. Barton for

Dennis C. Humphreys
DOE-RL/SOD

Gregory Z. Morgan

Gregory Z. Morgan
DOE-RL/SFD

Dale H. Splett

Dale H. Splett
DOE-RL/SFD

Contents

EXECUTIVE SUMMARY

The Safety Analysis Documents (SADs) are new documents prepared to establish the safety basis for a decision to allow procurement, fabrication, installation, and pre-operational testing of these two new systems. As such, the SADs should provide the same information as expected in a preliminary safety analysis report (PSAR). The DOE review process for these SADs was in accordance with an approved Safety Analysis Review Plan and included an acceptability review, followed by a detailed technical review against the standards of DOE Order 5480.23.

The Review Team found that the SADs for both the FRS and IWTS are conditionally acceptable. It is evident that a significant effort was made to deliver a quality product. Nonetheless, the Review Team could not arrive at the same conclusions as presented in the documents in some cases. As a result, the Review Team concluded that the hazard and accident analysis did not provide sufficient documentation and basis to conclude the review acceptance criteria[1] had been fully met. This conclusion indicates that there is some risk to the project in proceeding. This is primarily due to a lack of base information either referenced or provided by the SADs.

The hazard and accident analysis is fundamental to establishing a sound safety basis. The hazard analysis provided in the SADs for both the FRS and IWTS was not maintained current with the design as the design evolved. The significance of this issue cannot be overstated, as the hazard analysis is used to pinpoint weaknesses in the design or operation of a facility that could lead to accidents.[2] Failure to assure an iterative safety analysis/design process can allow new hazards or design weaknesses to be introduced, via design changes, which are not adequately assessed. Conclusions reached by safety analysis may not be valid if the hazards analysis does not reflect the actual design.

Other significant issues identified during the review are summarized below and are discussed in more detail in the Review Results section of this report.

- Evidence was not provided to demonstrate that applicable requirements of HNF-SD-RD-001 (S/RID) have been systematically identified and applied to the FRS and IWTS designs.
- General Design Criteria specified by DOE Order 6430.1A, which apply to safety class components (including applicable codes and standards) were not identified, nor was evidence provided that they had been fully applied to the FRS or IWTS designs.
- The margins existing between design requirements and safety basis limits were not

[1] DOE-STD-1104-96, paragraph 2.2

[2] DOE-STD-3009-94, page xvi.

consistently documented as required by DOE Order 5480.23, item (4)d(1).

- Drop analysis and seismic analysis results were not provided in the IWTS SAD, nor were applicable references provided.
- A critical evaluation of the proposed design, operation, and test program to assess conformance with safety design objectives and verify projections of residual risks should be provided.
- The manipulator support structure tethers should be classified as safety class or show that drop consequences are acceptable, or request a deviation from DOE Order 6430.1A.
- Design and analysis of the knockout pot screen design must either (1) demonstrate that failure of the safety function is incredible or is bounded by the criticality analysis, or (2) provide safety-class monitoring of the safety function.
- New hazards resulting from the settler height should be addressed, including reviewing and revising, as necessary, the current TSR restrictions on Basin unmanning.

As written, the SADs do not fully meet DOE Order 5480.23 based on the preparation and review standards[3]. However, given the conditions of approval specified herein, the SADs for the FRS and IWTS provide a suitable safety basis for a programmatic decision to authorize assembly, installation, and testing of the FRS and IWTS. It must be emphasized that this does not replace the USQ screening / evaluation process that still must be completed prior to performing any of these activities at the K Basins.

[3] DOE-STD-3009-94 AND DOE-STD-1104-96

MISSION

The K Basins were constructed in the 1950s, and are beyond their design life. They store about 2100 metric tons of spent nuclear fuel, approximately 400 yards from the Columbia River. The current K Basin mission is to provide continued safe storage of the fuel currently located in the KE and KW Basins, to clean and repackage the fuel in new storage containers (multi-canister overpacks), and to load the repackaged fuel in a shipping cask for transport to the cold vacuum drying facility, where the water will be removed prior to shipment to the new interim dry storage facility in the 200 Area (Canister Storage Building). The mission includes subsequent removal of sludge and contaminated water. This mission is expected to require approximately 10 years to accomplish, with completion of K Basin activities by the year 2008. After that time, the basins will be transferred to a decommissioning and decontamination status.

The Fuel Retrieval System (FRS) and the Integrated Water Treatment System (IWTS) are major modifications to the K Basins, and are necessary to support the mission of the Spent Nuclear Fuel Project (SNFP).

REVIEW SCOPE AND METHODOLOGY

Review Scope

It is important to note that this SER does not modify the currently approved authorization basis for K Basin operations. The FRS and IWTS represent major modifications to the K Basins. The Safety Analysis Documents under review were therefore prepared to serve the same function as a PSAR, i.e. to provide the safety basis for the decision to authorize construction and pre-operational testing of these systems, not to authorize operation of these systems. The existing authorization basis for K Basin will be modified, by incorporating the FRS and IWTS SAD information, prior to operation of these systems. The USQ Process is the mechanism relied upon to assure construction and pre-operational testing activities in the basins will be conducted within the existing K Basin authorization basis.

The FRS and IWTS SADs describe the activities necessary to remove the fuel from canisters in K West Basin, clean and sort the fuel, and place the fuel and scrap into Multi-Canister Overpack (MCO) baskets. This includes the system needed to maintain water clarity and low dose rates from the water. These SADs do not address K Basin modifications required for placing the MCO baskets into the MCO for transfer from the Basins. This will be addressed in the SAD for the Cask Loadout System.

Review Plan

The review was conducted in accordance with a review plan as required by RLP 5480.23. The RL review plan implemented RLP 5480.23, following the guidance of DOE Standard 1104-96, "Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports".

Team Composition

A RL SAR Review Team was formed. Members of the Review Team were selected based on their technical qualifications, experience, and familiarity with the subject matter. The team was comprised of personnel from the RL Spent Nuclear Fuels Project Division (SFD), both the technical integration and support team and the operations team, as well as support from the General Support Services Contractor (GSSC), criticality analysis support, hoisting and rigging, and two senior technical advisors. Appendix A contains concise individual Curriculum Vitae describing the technical and professional credentials of each member of the team.

Reviews Conducted

A Tier I review was conducted by the contractor for both FRS and IWTS. Following completion of that review and submittal of the documents to RL, an acceptance review was conducted by RL, in accordance with the Review Plan. The purpose of the acceptance review was to determine 1) that all pertinent matters in the technical review criteria had been addressed sufficiently to justify the expenditure of resources on a technical review, and 2) that the contractor Tier 1 review was satisfactorily completed, e.g. management review and approval, and closure of RCR comments had been performed satisfactorily. The conclusion of the acceptance review was that these criteria had been met, and the detailed Tier 2 technical review was initiated.

RLP 5480.23 does not require a Tier 3 technical review. However, the Independent Review Panel (IRP) conducted a Tier 3 review on the FRS SAD, and submitted comments for disposition. The IRP consists of three persons of outstanding credentials and represents extensive experience in the nuclear industry from both a DOE and NRC perspective. The IRP did not request review of the IWTS SAD, and therefore no Tier 3 review was conducted for the IWTS SAD.

Application of Graded Approach

A graded approach was applied in evaluating acceptance of these documents. The graded approach for document acceptance focused on the following considerations: 1) major safety issues relative the IWTS and FRS must have been considered and adequately addressed; 2) the fact that most of the systems, components, and structures, (SSC) have already been procured and fabricated, such that the a significant part of the programmatic risk has already occurred; and 3) the overall need to preclude unnecessary delays which could adversely impact the major SNF Project objective to expeditiously remove the SNF and sludge from the K Basins. The acceptance of the documents based on the graded approach should not be construed as meaning the documents fully meet expected and necessary safety basis information. In fact, under normal circumstances, the documents would have required modifications prior to acceptance. Under the graded approach used by the Review Team, approval is based upon management acceptance of the conditions of approval and the increased project risk.

Review Comments and Closure

The RL SAD Review Team members identified 366 comments, which were consolidated and screened for safety significance. A significant effort was made by the Review Team to reduce redundant comments and provide only relevant comments. Editorial comments were deleted and only provided informally to FDH for consideration, with no response required. After screening, a total of 141 Review Team comments were transmitted to FDH for resolution. Resolutions to the Review Team comments were proposed by FDH personnel and transmitted to RL. The comment resolutions did not close all of the identified issues. Open comments will be tracked to closure. The completed RCRs are included as Appendix C to this report.

Comments received from the IRP on the FRS SAD were transmitted separately to FDH for disposition. The completed RCRs and IRP comments with contractor responses are included as Appendix C to this report. Editorial comments identified during the review are not included in Appendix C.

REVIEW RESULTS

Although the IWTS and FRS SADs provide a reasonable description and safety analysis for these proposed K Basin modifications, there was a lack of necessary base information in some areas. These omissions prevented the Review Team from being able to conclude that the described safety basis was fully adequate to support a programmatic decision for authorization of construction and pre-operational testing for the FRS and IWTS.

The Review Team found the information provided in the SADs for the FRS and IWTS does not fully meet the approval basis contained in DOE-STD-1104-96, Review and Approval of Nonreactor Nuclear Facility Safety Analysis Reports. There are five areas that a SAR review and approval should focus on according to DOE-STD-1104-96. These are:

- Base Information;
- Hazard and accident identification;
- Safety structures, systems, and components (SSCs);
- Derivation of technical safety requirements (TSRs); and
- Programmatic control

The safety basis for a decision to authorize construction and pre-operational testing focus primarily on the first three of these five areas.

Common Results and Conclusions

Base Information

The Review Team could not conclusively determine that the FRS and IWTS were designed to be built, operated, and shut down in accordance with applicable codes, standards, and requirements specified by the K Basin S/RIDs based on the information provided or referenced in the IWTS and FRS SADs. This was primarily due to a lack of base information, which is expected to be provided in accordance with DOE Orders and Standards for the preparation and review of safety analysis documents. For example, evidence was not readily available that a systematic review had been conducted to identify and document the applicable DOE codes, standards, and requirements that should be applied to the FRS and IWTS. DOE-STD-3009-94 clearly indicates in the content guidance that chapter sections should list the codes, standards, regulations and DOE Orders, which are required for establishing the safety basis. According to DOE-STD-3009-94, the intent of this is to provide only the requirements that are specific for each chapter and pertinent to the safety analysis and not a comprehensive listing of all industrial standards, or codes or criteria. This information was not provided as intended by the standard as the SADs only referenced S/RIDs and the design specification. These references did not specifically identify the pertinent codes, standards, regulations and DOE Orders, which are required for establishing the safety basis as intended by DOE-STD-3009-94. This type of information must be included in order to provide a safety basis which is fully adequate to support a decision by DOE to authorize procurement, construction or installation of SSCs.

Hazards and Accident Analysis

The Hazards Analysis does not fully reflect actual final design, and the SAD does not clearly bin hazards to ensure that all the hazards are correctly evaluated and analyzed in the accident analysis. Although the actual risk is unknown, it is judged to be relatively low and major modifications to the FRS and IWTS are not anticipated. Completion of an update to the hazards evaluation and analysis should be accomplished expeditiously to minimize project risk.

The criticality analysis was determined to be adequate. The analytical approach taken contains substantial conservatism, however. The potential for reducing the level of conservatism, and thereby eliminating the need for safety class equipment and associated operational controls, will be given further consideration during review of the final safety analysis submittal prior to system operation.

Safety structures, systems, and components (SSCs)

General Design Criteria specified by DOE Order 6430.1A which apply to safety class components (including applicable codes and standards) were not identified, nor was evidence provided that they had been fully applied to the FRS or IWTS designs. Order 6430.1A requires analyses which are documented and auditable; this documentation has not been provided.

Contractor criteria for safety class items could not be confirmed to be in compliance with DOE requirements. Specifically, Tables provided in the IWTS and FRS SADs reference HNF-PRO-704 for safety classifications. This procedure may not comply with DOE Order 6430.1A requirements in that 1) equipment which prevents accidents with off site potential is allowed to be safety significant rather than safety class, 2) toxic material releases do not result in safety class designation, and 3) environmental degradation is not considered for designation of safety class or safety significant equipment. The use of this procedure in producing the SADs is not accepted as a resolution of the classification issues. Issues with the procedure will be resolved outside the scope of this SER.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

Information provided in Chapter 10 of the SADs on initial testing, in-service surveillance, and maintenance did not meet the required content of DOE Order 5480.23, paragraph 4f(3).(d)15. Chapter 4 of each SAD does contain some information regarding planned testing of the safety functions, however the information provided is incomplete. The final modification to the K Basins SAR incorporating this safety analysis information must fully address the testing of safety functions.

The information provided on human factors design does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. The discussion provided leaves the reader with a concern that there may be a lack of understanding relative to the timing, scope, and importance of Human Factors in facility safety. Clearly, this effort must be incorporated into the system design process and is required by DOE Order 6430.1A, section 1300-12. Compliance with this requirement has not been demonstrated and must be met. Delaying this effort to the K Basin SAR is not consistent with DOE 6430.1A requirements.

The SADs do not address the potential reduction in visibility in the basins, as the FRS stirs up sub-micron material, which the IWTS may be unable to adequately treat. This reduction in visibility may require operators to stay in the basins longer, to perform their jobs. Meanwhile, the material is radioactive and will be closer to the surface of the basin water, so the dose rate will rise. Longer exposures at higher dose rates may be a significant operator dose concern. The understanding of the Review Team's is that the decision has been made to proceed with design of additional filtration capability, which should alleviate this concern.

Common Conclusions

Special Conditions Of Approval

COM-1 The plan for testing of safety functions shall ensure an appropriate initial testing, in-service surveillance, and maintenance program, and shall be provided to RL for review early enough for RL input to be effective in ensuring proper design of those safety functions.

COM-2 A human factors review effort shall be performed, documented, and the results incorporated into the system design for both FRS and IWTS as required by DOE Order 6430.1A, section 1300-12. Any deviations from 1300-12 shall be justified and approved as required by 6430.1A.

SER Requirements For K Basin SAR

- A final (updated) HAZOP analysis shall be provided for the K Basin SAR. Any administrative controls or mitigating features identified in that revision must be recognized as authorization basis commitments, and be recognized, described, and controlled as such. It would be prudent to perform an early evaluation of design changes not considered in the original HAZOP to minimize project risk.
- The K Basins SAR shall document the margins between design requirements and the safety basis limits.
- The HNF-SR-RD-001 and DOE Order 6430.1A requirements, codes, and standards applicable to FRS/IWTS shall be identified in the K Basins SAR as required by DOE Order 5480.23 and the implementing standards.
- Crane and hoist controls for FRS / IWTS shall be provided in the K Basin SAR as directed in RL letter 98-SFD-026.
- Means to track and assure compliance with the multitude of operational commitments shall be provided.

Fuel Retrieval System Results

Base Information

One reviewer noted that system complexity may result in substantial down time due to equipment failures and malfunctions. The FRS functional requirements do not specify the use of manual methods and tools as an alternative to automated system operation. This comment has been provided to the RL project manager for consideration and will be handled outside this review scope.

Hazards and Accident Analysis

The analysis for manipulators throwing fuel clear of the water appears to have an error, in that the manipulators can lift fuel higher than assumed. Dose rates from lifted fuel may exceed those reported in the SAD.

Safety structures, systems, and components (SSCs);

The manipulator tether support system is intended to prevent the manipulator trolley support frame from falling and damaging safety related equipment, a safety related table (for criticality prevention) and the basin floor. The SAD acknowledges that under the current requirements, this equipment is required to be safety class. However, the basin floor is not only a safety class component, it is the primary confinement barrier. This confinement barrier must remain fully functional following any credible DBA as required by DOE Order 6430.1A, 1300-1.4.2. The tethers should be classified as safety class or show that drop consequences are acceptable, or request a deviation from DOE Order 6430.1A.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

No additional issues.

FRS Conclusions

Special Conditions Of Approval

FRS-1 The estimated weights of FRS equipment approaching the Table 3-10 limits contained in the K Basin SAR shall be confirmed and used for the installation USQ review.

FRS-2 Installation of the manipulator support structure tethers is withheld pending 1) contractor confirmation that the tethers will be classified as safety class, or (2) RL review of analysis justifying the safety significant designation by demonstrating that the upgrade to safety class would not entail significant reduction of risk. If (2) is chosen, a deviation request to DOE Order 6430.1A is required, or manipulator support structure drop consequences must be shown to be acceptable.

FRS-3 Approval of installation of the fuel manipulators is withheld pending 1) RL review of analysis which demonstrates that the consequences of the manipulator fuel handling accident remain acceptable, or 2) contractor confirmation to RL that safety significant interlocks for the fuel manipulators will be installed

SER Requirements For K Basin SAR

- FRS manipulator rail stops and interlocks shall be listed as defense in depth items.

Integrated Water Treatment System Results

Base Information

No additional issues.

Hazards and Accident Analysis

Appendix 3A HAZOP Analysis appears to be an initial analysis that has not been updated to the final IWTS design. Although the final IWTS design has been described and analyzed in the SAD, equipment descriptions and functions in the HAZOPS that are not consistent with chapter 2 and 3 need to be deleted or revised. Additional information may also be required. A final (updated) HAZOP analysis is required for the K Basin SAR.

The hazards analysis also needs to be updated to consider the increased hazard resulting from the proximity of the settlers to the pool surface, i.e. uncovery of a substantial source of radiation at a higher pool elevation, hence shorter time duration, than currently considered. This situation applies during fuel basin water loss accident scenarios, and has the potential to impact current authorization basis assumptions and conclusions relative to radiation exposure, basin manning, and emergency recovery actions. The SAD indicates that sludge settler tank uncovery and fire due to basin drain down is beyond extremely unlikely and beyond design basis because it would take at least five days to uncover the top two settlers at the maximum allowable post seismic leak rate. The classification as BDBA should be reconsidered, or additional information provided which justifies the classification. The reconsideration and justification should take into account the already-analyzed basin corner cracking and leakage as a result of the basin DBE, the effects of drain valve leakage, and the accepted reliable response times for emergency actions to remediate basin leakage.

Safety structures, systems, and components (SSCs):

The SAD states that the Knockout Pot screens are designed to meet safety-class specifications. Section 4.3.2.3 states that the screens must be strong enough to withstand the forces from pressure buildup resulting from filter plugging. Section 4.3.2.4 states that the Knockout Pot screens are required to have mesh dimensions verified before construction acceptance. The revised K Basin SAR should also identify the testing performed to confirm the structural adequacy of the screen to resist pressure buildup loads, and the testing which confirmed that the mesh structure maintained its safety function (specified spacing et. al.) during operation. Additionally, the design must (1) demonstrate that failure of the safety function is incredible, or (2) demonstrate that the consequences of credible failure modes are bounded by the criticality analysis; or (3) provide safety-class monitoring of the safety function.

The Radiation Monitoring System limits the consequences of spray leaks through control of the source term available for release. These instruments do not identify the occurrence of a spray leak event, however. Re-evaluation of spray leaks and required safety related equipment for detection of such leaks shall be provided by October 16, 1998.

Derivation of technical safety requirements (TSRs)

No identified issues.

Programmatic control

No additional issues.

IWTS Conclusions

Special Conditions Of Approval

IWTS-1. Approval of installation of the following IWTS components is withheld pending the conditions delineated below:

a. Knockout Pots
   (1) RL review of seismic analysis showing that the knockout pots will perform their safety class function (criticality geometry) during and following the DBE.

(2) RL review of analysis demonstrating that either a) failure of the knockout pot screen safety function is not credible, or b) the consequences of credible failure modes are bounded by the criticality analysis, or c) the safety basis and safety classification for equipment required for failure monitoring.

b. Settlers - RL review of analysis which evaluates the impact of the hazards resulting from the settler height on the existing authorization basis. This analysis shall include, but not necessarily be limited to, the following:
(1) Evaluation of the impact of the drain valve USQ and JCO on the settlers, as well as the impact of the settlers on the USQ and JCO.
(2) Impact on the adequacy of current TSR restrictions on basin manning.
(3) Appropriate drop analysis and/or installation controls for settler equipment.
(4) Seismic analysis showing that the settlers will perform their safety class function (criticality geometry) during and following the DBE.

c. Annular Filters – RL review of seismic analysis showing that the annular filters will perform their safety class function (criticality geometry) during and following the DBE.

d. Radiation Monitoring System – Completion of design and RL review of a submittal of design related safety analysis information.

IWTS-2 The safety significant function of the Radiation Monitoring System for the IWTS shall not rely on the computer control system, unless that system is designed and certified to be safety significant.

IWTS-3 Re-evaluation of spray leaks and required safety related equipment for detection of such leaks shall be provided to DOE by October 16, 1998, and the results incorporated in the K Basins SAR.

SER Requirements For K Basin SAR

No Additional Issues.

APPENDIX A
CURRICULA VITAE

PURPOSE

This Attachment contains the technical and professional credentials of the Review Team as they relate to the review.

THE TEAM MEMBERS

Sidney J. Altschuler

B.Ch.E. Chemical Engineering, The Cooper Union for the Advancement of Science and Art
M.S. Nuclear Engineering, University of California - Berkeley
Eng.Sc.D. Nuclear Engineering, Columbia University
Registered Professional Engineer

Dr. Altschuler has 21 years experience in the nuclear criticality safety. He has authored twelve papers in this field, eight of which were published in Nuclear Technology.

As a Research Physicist at the Rocky Flats Division of Dow Chemical (1970-75), he used the Monte Carlo codes KENO and O5R and was co-developer of the Surface Density vs. Unit Shape Factor Method. In 1979 he joined Rockwell Hanford Operations Criticality Engineering and Analysis Group as a Staff Engineer. He was Criticality Safety Representative for the Z Plant complex from 1981-85. His duties which continued as a Principal Engineer for Westinghouse Hanford included writing and reviewing analyses (CSERs, CPSs, and postings) and providing technical support for Hanford facilities which stored, handled, packaged, and processed fissile material, including PUREX, Plutonium Finishing Plant, Plutonium Recycle Facility, K and N Basins, WRAP, SP-100, HWVP, and the Process Facility Modification.

In 1995, Dr. Altschuler joined the Quality, Safety and Health Division of RL where he is responsible for oversight of the contractors' nuclear criticality safety programs.

Grant D. Baston

B.S. Physics, University of Wyoming
MBA, University of Hartford
Senior Reactor Operator License, 1968, 1972, 1974

Mr. Baston has more than 35 years experience in the design of fast breeder reactors, the startup and operation of commercial BWRs and PWRs, and the operation of defense production reactors. Mr. Baston's commercial experience includes plant startup test engineer, plant operation management, quality program management, materials management, Chairing Nuclear Review Board activities, and directing emergency response teams. Mr. Baston's defense production experience includes reactor physics engineer and operations management at the Hanford KE Reactor. Mr. Baston is currently working on the Spent Nuclear Fuel Project as a contractor to RL.

Guy E. Bishop, III

B.S. Aeronautical Engineering, Virginia Polytechnic Institute

Mr. Bishop has 21 years of nuclear experience. This includes completion of naval nuclear power school training and qualification in several naval installations as engineering officer of the watch, reactor engineer at a medium size commercial boiling water reactor, and operations shift supervisor at a large commercial boiling water reactor.

Mr. Bishop has extensive experience in core analysis, operations, safety analysis, and engineering in commercial nuclear power plants, and has held a senior reactor operator license. He has extensive experience within DOE in safety analysis, having served as chairman for line reviews of several other safety analysis reports. He has extensive knowledge regarding safety analysis techniques, requirements, industry standards, and worker protection issues and is familiar with all areas of safety analysis reports.

Richard P. Denise

B.S. Nuclear Engineering, North Carolina State University
Registered Professional Engineer
Patentee on Nuclear Reactors
Retired Senior Executive, U.S. Government
Certified Instructor in DOE Conduct of Operations

Mr. Denise has more than 40 years experience in the design, construction, operation, management, and regulation of complex nuclear facilities including commercial nuclear power reactors, defense production reactors, fuel fabrication facilities, chemical processing facilities for nuclear fuel, and fuel storage facilities. He has extensive senior executive experience in the management of production facilities for DOE, and in the regulation of commercial facilities for the NRC.

Mr. Denise's experience includes an assignment of five years at the K Basins in support of the RL spent nuclear fuel program. During this assignment at K Basins, a detailed knowledge and understanding of the K Basins design, operations, safety basis, fuel handling, and characteristics of the fuel was acquired. This detailed special expertise on K Basins, augmented by the other extensive technical capabilities, was utilized as a member of the Independent Technical Assessment Team.

Robert M. Hiegel

B. S. Mechanical Engineering, University of Washington

Mr. Hiegel has over 30 years total engineering experience in the nuclear industry for the Department of Energy and the Department of the Navy . His nuclear experience at DOE has included managing the design, construction and testing of nuclear facilities, and nuclear safety overview of reactor and nuclear facility operations. He is currently responsible for managing a team of engineers overviewing the development of the safety analysis for the Spent Nuclear Fuel Project. He has had experience in both chairing and participating in major operational readiness reviews, safety analysis reviews, safety audits and appraisals. He was the Project Manager for a Major System Acquisition, the Hanford Environmental Project and was the Deputy Project Manager for the Shippingport Station Decommissioning Project. Robert s experience also includes over 13 years experience in the nuclear program at Pearl Harbor Naval Shipyard and Puget Sound Naval Shipyard where he performed radiological engineering and project management assignments for maintenance and modifications to nuclear reactor systems and components on nuclear submarines.

Dennis C. Humphreys

Mr. Humphreys has over 26 years experience in the maintenance, operation, testing, defueling, refueling, and overhaul of naval nuclear power plants. This included 16 years as a certified Nuclear Shift Test Engineer in the Nuclear Engineering Department, at Mare Island Naval Shipyard. He also has 1 -years experience in management and oversight of the Hanford Site.

Mr. Humphreys has been with the Department of Energy for approximately 2.5 years. He has been a member of at least 7 full and partial Conduct of Ops and Maintenance Assessments, including the team leader for the Maintenance Team for the Characterization Project Assessment. He also was a member of the DOE Team involved with the assessment of the BHI Readiness Evaluation Team at 100N for the removal of high energy components from the basin. Mr. Humphreys has completed EM-25 Operations Assessment Training. His duties and responsibilities include the application of engineering theories and principles in the evaluation and approval of reports and other technically related subjects and documents at Hanford. While working with DOE he successfully passed the Engineering in Training (EIT) Exam for the State of Washington. Mr. Humphreys is a member of the Site Operations Division's Operations and Maintenance Management Team for Richland Operations Office. Two of his areas of responsibility include Hoisting and Rigging and configuration management.

Mr. Humphreys has been the RL Hoisting and Rigging Program Manager for the past 2.5 years. He has been trained in rigging and handling procedures and is a SME for the Site Hoisting and Rigging Manual. His sixteen years at Mare Island Naval Shipyard included familiarization with Crane and Rigging Safety and Operations. He is in charge of and a voting member of the Site Hoisting and Rigging Safety Committee.

<u>**Michael C. Humphreys**</u>

B.S. Chemical Engineering, Washington State University
M.S. Nuclear Engineering, University of Washington

Mr. Humphreys has over 17 years experience in fuels and reactor engineering, reactor systems testing, operational readiness, and operation support of Boiling Water Reactors. As an employee of a commercial nuclear utility he served as a fuels engineer, reactor engineer, Shift Technical Advisor, lead reactor engineer, and simulator engineer. He has 5 years experience as an independent consultant to commercial industry utilities and to the Department of Energy in the areas of safety analysis, fuel design, simulator nuclear physics and thermal hydraulics design, plant design basis training development, BWR incore refueling, and plant procedure support. He is the owner and developer of the COSMOS refueling software package, currently being used to prepare incore shuffle sequences by approximately 15 U.S. and European Boiling Water Reactors. Mr. Humphreys has been with the Department of Energy for approximately 1 1/2 years. During that time, he has served as the RL site representative for development and implementation of the DOE/RL Integrated Safety Management System (ISMS). Responsibilities include coordination with the DOE Safety Management Implementation Team and oversight of the Fluor Daniel Hanford ISMS implementation effort, including preparation for and conduct of the K Basins Phase I Verification. Other duties include review of safety analysis reports, establishing nuclear safety policy and resolution of nuclear safety concerns.

<u>**Gregory. Z. Morgan**</u>

B.S. Mechanical Engineering, University of New Mexico

Mr. Morgan has over 15 years experience in engineering, design, analysis, testing and operational readiness of nuclear reactors and nuclear facilities. As an employee of a nuclear utility he was a senior scheduling engineer, saving a week on the critical path for a refueling outage. As a Department of Energy employee he has analyzed the safety of six nuclear reactors, new and old tritium facilities, nuclear waste tanks, and a spent fuel facility. He has led an operational readiness review, and managed teams which finalized safety analysis reports and restarted a troubled nuclear reactor.

Francis M. Roddy

B. S. Physics , Villanova University, 1965
M. S. Physics, University of Illinois, 1971
US Navy Nuclear Power School, US Navy Nuclear Prototype A1W @ INEEL
Registered Professional Nuclear Engineer (2 states)
Certified Health Physicist

Mr. Roddy has more than 33 years of experience in the design, construction,, operation, management, repair, and regulation of nuclear facilities including US Navy nuclear propulsion plants, commercial nuclear power reactors, spent fuel storage facilities, radwaste storage facilities, radwaste burial sites, and DOE facilities. He has been associated with the K Basins for 1.5 years while serving as the Senior Technical Advisor for Radiological Controls for AMW. He has written Safety Analyses Reports for 12 commercial nuclear power plants and has reviewed safety analyses documents for 15 DOE facilities. He has performed on ORR teams for 8 DOE facilities.

Dale H. Splett

Bachelor of Science, Electrical Engineering, Seattle University, 1990

Mr. Splett was a Naval nuclear operator from 1972 to 1978, and has a total of over 20 years experience in repair and engineering in Naval nuclear power plants. He joined DOE in 1994. He has worked in K Basins Spent Nuclear Fuel since then. His responsibilities include project management and operations.

APPENDIX B
DOCUMENTS REVIEWED

1. *Spent Nuclear Fuel Project K Basins Technical Safety Requirements*, WHC-SD-SNF-TSR-001, Revision 0B Submittal, dated

2. *Safety Requirements (TSR's)- 100-KE and 100-KW Fuel Storage Basins*, WHC-SD-SNF-TSR-001, Revision 0

3. DOE Standard "Review and Approval of Non Reactor Nuclear Facility Safety Analysis Reports", DOE-STD-1104-96

4. "Preparation Guide for US DOE NonReactor Nuclear Facility Safety Analysis Reports", DOE-STD-3009-94

5. *Technical Safety Requirements*, DOE Order 5480.22, dated February 25, 1992

6. *Nuclear Safety Analysis Reports*, DOE Order 5480.23, dated April 10, 1992

7. *Justification For Continued Operations - 105 K East and K West Basins - Limited Activities To Preclude Damage To Basin Drain Valves, Plan and Schedule Of Proposed Recovery Actions*, FDH-9762048 R11, Dated March 10, 1998 (and Revs 2, 5, 7, 8 and 10).

8. *Summary of Phase 1 Task Completion 105 K Basin Floor Drain Valves*, HNF-2222, dated February 9, 1998

APPENDIX C
COMPLETED REVIEW COMMENT RECORD FORMS

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Comment Key: Comments are evaluated as falling into the following omission categories, taken from DOE Std 1104-96: (1)- failure to address hazardous material or energy releases w significant consequences to the public, worker, or environment that will otherwise be left w/o coverage; (2)- technical errors that invalidate major conclusions relevant to the safety basis; (3)- failure to cover topical material required by DOE orders (eg, 6430.1A, 5480.23) or guidance on SAR's. All comments (unless identified as not requiring a response) adversely impact the adequacy of the facility safety basis/documentation.		Comment/Disposition Status (Column 16.) Key: O/SER - COMMENT NOT ACCEPTED, ISSUE ADDRESSED IN SER OA - COMMENT NOT ACCEPTED, ACTION REQUIRED CA - COMMENT ACCEPTED, ACTION REQUIRED C - COMMENT ACCEPTED, NO FURTHER ACTION REQUIRED	AUG 28 1998
	Executive Summary:			
1	Tables ES-4 and 5: 4 items remain in draft form. These should be converted to final as soon as practicable.	Y	The reference to draft documents was made to assure that the latest design information was reviewed for SAD development. The SAD is a commitment document rather than an implementation document. Implementation was identified where available, even in draft form, due to the maturity of the design.	CA
	Chapter 2, "Facility Description":			
	General Comments:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
2	The Contractor has not systematically 1) Identified which 6430.1A design requirements apply to which safety class components, and 2) documented how these requirements were applied to a safety class system or component, and 3) demonstrated / documented the existing margin between design requirements and Authorization Basis limitations. For example, corrosion allowances (6430.1A, Section 0262) to be used for the various safety class equipment to be placed in the basins are not specified. What is the corrosion allowance assumed for the knockout pots? The assumption may be that, for the stainless steel equipment and short duration of expected operation, negligible corrosion will occur. Where is application of this requirement documented? No reference appears to identify the actual design values for the wall thickness or vessel diameter, to allow the review to confirm the margin between the allowable design dimensions and the SAD limits for vessel diameter and wall thickness. (3) Additionally, chapter 4.0 , 4.3.1.4, p. 4-2, does not identify these dimensions as items which will be verified upon receipt, prior to acceptance, although the design authority for ITWS did indicate that will occur. (3) (3)	Y	The safety functions and performance functions listed in Table 4-1 and code requirements in Section 4.3 are applicable to the IWTS safety class components. As noted SC components are passive and made of stainless steel. Their safety function is assured by the verification of dimensions, prototypical testing (screens), preoperational testing (pressure tests). Acceptability of corrosion is provided by information in the current K basin SAR Section 2.6.3, <u>Water Chemistry</u>, 2nd paragraph. Section 4 specifies the dimensions for safety function compliance, and they will be verified prior to equipment installation or upon receipt.	O/ SER
3	What is the temperature effect of operating the submersible pumps in the basin? The electrical energy dissipated by the pump motor winding resistance will all go into the basin water as heat. During the factory acceptance test the temperature rise in the tank of water with one submersible pump was significant. During IWTS basin operations essentially three heaters will be installed in the basin water. Have the effects on the current K basin temperature limits been analyzed?	Y	Evaluation of the thermal effects of submersible pumps in the basin was made. Additional chiller capacity was not required for added basin heat load from submerged pumps. Fuel removal continually reduces heat load. Start up during summer, would extend time required to lower pool temperature, but doesn't affect ability to maintain temperature.	C
* 4	<u>Section 2:</u> The system description does not adequately describe the computer system which controls the IWTS. Normal operations of the IWTS are computer controlled. This includes automatic shutdown of the system in response to abnormal or out of spec conditions. This is a significant characteristic of this system with potential system wide ramifications. For example, during the factory acceptance test complete system shutdown occurred while the operator was merely navigating through the computer display screens. (It is expected that this particular software problem will be resolved prior to basin operations.) The system description describes in detail the mechanical aspect of the IWTS, but except for scattered references to the various control functions and alarms it does not address the computer system, which is the direct operation interface with the IWTS. Section 2 should contain a description of the IWTS computer control interface. (3)	Y	The control system described is not a safety class or safety significant system that needs to be addressed in detail in the SAR or SAD. The hazard analysis addressed failure consequences which would bound the consequences of control system failures. This position assumes that the safety significant radiation monitor safety functions are not part of the computer control system.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 5	Section 2: Relative to the application of identified codes and standards, this chapter, or other chapters in this document do not adequately demonstrate commitments to identified standards and requirements which are applicable to IWTS equipment. Primary focus is on safety class SSCs. Clear statements should be provided to demonstrate and confirm that the IWTS SSCs comply with all applicable codes and standards. This would include items such as seismic and safety class requirements contained in DOE Order 6430.1A for safety class SSCs.	Y	SC and safety significant SSCs identified in Section 4 are in compliance with 6430.1A.	O/ SER
6	Section 2: The annular filter tanks, which had previously not met the double contingency criterion, now meet the criterion. The inner region is best left empty with its drain open so that any inleakage of fissile material will be automatically removed from the system. Describe how the IWTS will be operated to assure fissile material will be removed from the inner region.	Y	The inner tank has an open pipe drain. This feature will be identified in the K Basin FSAR.	CA
* 7	Section 2.2: This section states that the facility standards and criteria that apply to the IWTS are found in HNF-SD-RD-001, and that the specific standards and requirements that apply to the IWTS equipment are found in HNF-S-0564. Provide evidence to validate this statement, e.g., the results of a systematic review which identified that all applicable standards and requirements for IWTS SSCs from HNF-SD-RD-001 are contained in HNF-S-0564.	Y	All of the applicable standards and requirements for IWTS SSCs from HNF-SD-RD-001 are not contained in HNF-S-0564 (other than by reference), however the appropriate standards and requirements and application of these standards and requirements were evaluated by qualified multi-disciplinary personnel during the several design reviews. There were no open standards or requirements issues identified at those reviews.	O/ SER
	Specific Comments:			
8	2.2, p. 2-1: The applicable codes and standards are not listed, but referenced (HNF-S-0564). These codes and standards must be incorporated into the applicable K Basin SAR revision, and not referenced.	Y	The appropriate code and standard requirements will be addressed in the K Basin FSAR.	CA
* 9	Page 2-3: Section 2.5.1.1: The weights of various in-pool components should be included and verified as part of the system description. This is critical information needed for USQ screening for determining compliance with Table 3-10 of the K Basin SAR. (3)	Y	Weights will be verified prior to lifting over the basin. USQs for installation will determine compliance with existing K Basin SAR. The K Basin FSAR will address or reference specifics of compliance.	CA
10	Page 2-4: Section 2.5.1.2.1: A description is needed to describe how the knockout pots are vented and where the vented hydrogen is directed to, to help understand how potential radiological and combustion hazards are controlled. Although some information is in Table 3A, it should be included in this section. (3)	Y	The vent is to the basin when they are in storage. No consequences are anticipated. An increase in hydrogen can result from the additional surface area due to fuel breakage from FRS operations. Consequences of plugged vent, hydrogen buildup and subsequent opening is addressed in the current SAR Section 3.4.3.5.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
11	Sections 2.5.1.2.1 and 4.3.2.1 state that the Knockout Pot screens are designed to meet safety-class specifications. Section 4.3.2.3 states that the screens must be strong enough to withstand the forces from pressure buildup resulting from filter plugging. Section 4.3.2.4 states that the Knockout Pot screens are required to have mesh dimensions verified before construction acceptance. The code or standard (such as ASME B31.1) used to specify allowable design stresses and loads for the screen should be identified.	Y	ASME B31.1 is identified as the standard for the screen in 4.3.2.2..	O/ SER
12	Section 2.5.1.2.3. The description of the annular filter vessels, and their depiction in figures 2-6 and 2-7, indicate that the outer vessel tanks are of solid construction except for inlet and outlet piping. In actuality these vessels have a series of handholes around their circumference, four each near the top and bottom of the vessel. The covers for these handholes are held in place by tightening a nut on a threaded clamp and are sealed by gaskets. The SAD does not address the probability or consequences of leakage through these handholes. Failure of a gasket, due to radiation exposure, mechanical damage, age or some other mechanism, may represent one of the most credible leak paths out of the system, and could result in drain down of a filter vessel.	Y	The filter vessels are ASME B&PV Code Section VIII code stamped vessels. The covers for the openings are integral parts of the vessel. Gasket material is environmentally qualified including radiation exposure levels. Expected gasket radiation dose for the duration of fuel removal is less than 10% of acceptable exposure. The SAD drawing will be updated to reflect actual configuration in the K Basin FSAR.	CA
13	<u>Page 2-6:</u> Section 2.5.1.7: Did not see excess water removal (or receipt from the CVD) in the hazards analysis. (3)	Y	Backflow through FRS pumps of CVD water is addressed as last item of Table 3A-1 Node 1 on page 3A-4, last item of Table 3A-2, Node 2 on page 3A-6, and last item of Table 3A-3, Node 3 on page 3A-8, next to the last item of Table 3A-5, Node 5 on page 3A-11. The K Basin FSAR will address excess water removal or provide reference to appropriate hazard analysis. Truck moves in basin for receipt of water from CVD will be controlled to existing K Basin SAR and TSR controls. Unloading hazards of the this water will be formally document in updated hazard analysis.	CA
* 14	<u>Page 2-6:</u> Section 2.5.2.1: What is the basis for the 50 # DP limit (given in 2.5.2.2)? Potential failure modes of the screen / knockout pot (bypass of screen) should be addressed. If no failures are credible, justification for such statements need to exist. If failure modes are credible, then TSR operability monitoring requirements (for sudden DP drop, or the DP limit) need to be specified, and this equipment needs to be safety class. (1)	Y	The 50# delta pressure is the maximum expected operating DP across the knockout pot screen to initiate pot replacement. It is not a safety parameter so no TSR controls are required. The screen which is a passive SC design feature must withstand discharge head of pump (125 psi).	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
15	Section 2.5.2.1 states the knockout pot and screen will capture particles larger than 500 micro-meters. Please clarify whether this is actually one quarter inch, which was believed to be referred to as the limit in earlier discussions regarding the screen limit. If 500 mm, please provide the basis for selecting this limit. (3)	Y	The 500 micron screen in the knockout pot is based on the particle size used in the criticality evaluation for the settlers and the filter vessels. Settler tank dimensions were restrictive for larger particles. The 1/4 inch is the size of the FRS screens upstream of the knockout pots which are critically safe for optimal sized particle.	C
16	Section 2.5.2.3: Provide the safety classification and basis for the vent system.	Y	The vent system is General Service and is required by the Washington Department of Ecology NOC (Notice of Construction). This design was evaluated for its hazards (no unique hazard identified) and will be formally documented for reference in the K Basin FSAR.	CA
17	Section 2.6; The IWTS has significant impacts on the confinement system. They should be described here, as committed to in the FRS SAD.	Y	The impacts to the confinement system (i.e. water) are the basin pump down potential due to the submerged pumps. This issue is addressed by the current SAR and TSR and only impacts unmanning durations.	C
18	Sections 2.7 and 4.4.1.1 state that if the radiation monitor is not operating the IWTS cannot and will not operate. This implies that prevention of IWTS operation without the radiation monitor is an engineered function of the control circuitry. However, 4.4.1.5 states that an administrative control will be considered for inclusion in the TSR for operation of the radiation monitoring system. If there is an interlock which prevents operation of IWTS without the radiation monitor operable, there should be a TSR addressing operability / surveillance requirements for this interlock. If no such interlock exists, the administrative control is probably appropriate. One or the other should apply, but not both. (2)	Y	The safety function requirements of the safety significant radiation monitor are defined. The system design is still in progress. A safety significant interlock or administrative control will be provided.	O/ SER
	Chapter 3, "Hazard and Accident Analyses":			
	General Comments:			
19	Chapter 3: Specify which hazards were eliminated from accident consideration due to being covered in general worker safety. (3)	Y	The update identified in response to item 21 will provide identification of specific ES&H program that addresses hazard, as appropriate.	CA
	Specific Comments:			

HNF-SD-SNF-SAD-002 REV 2

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
20	Page 3-2: Section 3.3.1.1: Voltage is a process parameter that was not considered in the hazards analysis. Time also is a process parameter that might need to be considered. Hazards analysis is incomplete. (1)	Y	The hazard analysis did not address electrical system explicitly. It was determined that no new hazards existed that were not already present and controlled by existing institutional safety codes and requirements. (i.e. NEC, OSHA, Hanford Hoisting and Rigging Manual, Hanford Radiation Protection Program, HAZCOM, etc).	C
21	Table 3-3, 3-4, and Appendix 3A: The purpose of the hazard and accident analysis process is to systematically identify hazards within an operation and describe the measures taken to eliminate, control, or mitigate the identified hazard. It is necessary to keep the hazard and accident analysis current as baseline information changes. Baseline information includes facility description and drawings, process and operational descriptions, hazardous material inventories, etc. Numerous comments were identified during the review indicating the hazards analysis, provided in the IWTS SAD, is not current. The Appendix 3A HAZOP Analysis appears to be an initial analysis that has not been updated to the final IWTS design. Although the final IWTS design has been described and analyzed in the SAD, equipment descriptions and functions in the HAZOPS that are not consistent with chapter 2 and 3 need to be deleted or revised. Additional info may also be required. A final (updated) HAZOP analysis, as described in HNF-PRO-704, is required for the K Basin SAR. Features required for accident prevention and features required for accident mitigation have been identified in chapter 3 in the SAD, but still need to be included in the updated HAZOP. Defense-in-depth and worker safety engineered features and administrative controls also need to be revisited in the HAZOP. Consequences and frequencies need to be re-evaluated considering information obtained during the accident analyses. There is concern that not all defense-in-depth features were adequately considered regarding safety classification. These features which include monitoring instrumentation and above water piping need to be reconsidered for significance and final classification. Justify the final classification in terms of requirements and guidelines. Examples of specific identified concerns have been provided separately for information.	Y	The evolving design has been and will be reviewed for new (unique) hazards. None have been identified to date. The hazard analysis will be updated as required for reference in the K Basin FSAR. Examples for updating include deleting old design information and addressing any design changes.	CA
22	What are the consequences of a basin pumpdown with the settlers installed? Can basin now be unmanned with pumps running? What controls are necessary? (1)	Y	This is addressed by the current K Basin TSRs, Section 3.4.3. The unmanning criteria of the TSR must be met. The unmanning criteria will be reviewed to determine if the early uncovering of the settler tanks impacts this criteria. The K Basin FSAR will provide the evaluation and/or criteria change.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
23	Table 3-4: The list of potential accidents does not list a case where the dose to operators increases and the loss of visibility severely affects operations due to the plume of sludge in the water. This potential accident should be assessed for inclusion in the list of potential accidents, if it was not, and evaluated accordingly.	Y	This is an operability concern and water quality issue. A single event would not significantly impact radioactive material content of the basin.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 24	Page 3-21: Table 3-10: The SPRAY analyses are central to establishing the adequacy of the worker protection features of the entire system. Additional information is required to demonstrate the adequacy of the analysis and the overall methodology. What is the optimum hole size, and is "optimum" determined as the fraction of release which is respirable, or is "optimum" that release which gives the highest respirable inventory and dose? What verification/validation has been performed for the SPRAY program? How do the results change if the release and exposures are for shorter times? (2)	Y	1) Optimum hole size is the size that gives the greatest respirable release rate and, therefore, the greatest receptor dose. This hole size does not give the necessarily give the greatest fraction of the release as respirable. 2) The SPRAY computer code quality assurance documentation may be found in "A Model for Predicting Respirable Releases from Pressurized Leaks," WHC-SD-GN-SWD-20007 (Hey and Leach 1994). The models used in the SPRAY code are based upon empirical correlations available from published literature. The SPRAY code was written to assist in determining optimum values for releases and for quickly and consistently calculating release rates. Independent validation was performed for the correlations used in the SPRAY model by taking data from other published sources and comparing it with the model predictions. Hand calculational checks were performed for several SPRAY code outputs to ensure that code outputs are correct. The code runs under DOS and should be compatible with any IBM-compatible personal computer running DOS Version 3.0 or later. 3) Shorter release times reduce the amount of respirable release in a way that is directly proportional to the total release time. However, the air transport factors increase for a shorter total release time because there is less wind dispersion. The air transport factors increase in a way that is proportional to the ratio of the logarithm of the two release durations. The total amount of respirable release is multiplied by the air transport factors to calculate the total dose. In general, the receptor dose will be greater for greater release times. The current methodology (HNF-SD-SNF-TO-059, Rev. 1) for calculating the air transport factor as a function of release duration will not produce a monotonically increasing total dose as a function of release and exposure. Artifacts of the model will, for some release durations between 0 and 24 hours, sometimes give an estimated dose that is slightly larger for lesser release times. This is due primarily to the fact that different breathing rates are applied after 16 hours and a constant air transport factor is applied for releases of duration less than one hour or between on and two hours.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 25	Section 3.4.3: page 3-38: The first paragraph indicates that this accident is beyond extremely unlikely and beyond design basis because it would take at least five days to uncover the top two settlers at the maximum allowable post seismic leak rate. The classification as BDBA should be reconsidered, or additional information provided which justifies the classification. The reconsideration and justification should take into account the already-analyzed basin corner cracking and leakage as a result of the basin DBE, the effects of drain valve leakage, and the accepted reliable response times for emergency actions to remediate basin leakage. The current analyses for these effects indicates that uncovering the top settlers would occur sooner than five days, and stopping leakage at the corners with structural damage may be difficult. The first sentence of the section indicates that this accident is a DBA rather than a BDBA. The word "beyond" should be inserted. The first sentence of the third paragraph uses the word "detonation", which should be changed to "deflagration" to be consistent with the rest of the text and Table 3-17. Page ES-viii, Table ES-2, may require revision based on resolution of comments on Section 3.4.3 questioning the validity of the accident classification as BDBA. (2)	Y	The corner leakage per Document HNF-SD-SNF-DA-012, Closure of Seismic Review Issues and Other Structural Safety Concerns for the 105 KE and 105 KW Spent Fuel Basins, is not a significant amount relative to the 50 gpm limit now in the SAR and cracking is only postulated to approximately 13 ft above the basin floor. The excessive drain valve leakage could impact the analysis but currently the plan is to preclude drain valve leakage through mitigation, determination of incredibility or engineer fixes. The location of the settlers in weasel pit does provide attenuation by weasel pit walls of radiation field if they do become uncovered, such that access concerns for mitigation efforts are minimized. Contained material could not be aerodynamically entrained.	O/ SER
	HAZOP Analysis, Appendix 3A:			
	General Comments:			
26	Table 3A-16: Should add to Table 3A-16, Node 17, consideration of an overheating/fire in the electric heaters.	Y	The vent system was evaluated for hazards, including the heater. No hazards were judged to be significant. The hazard analysis of this system will be formally documented for reference in the K Basin FSAR. 3A-16, Node 17, is the results for an earlier system design. Typically such designs have limited heater capacity to prevent overheating.	CA
27	Table 3B-5, Acute Maximum 99.5 Percent Sector Atmospheric Dispersion Factors: Provide the basis to believe that heavy PuO_2 particles will make it not only 100 meters but 7.5 miles in a dead calm (99.5% meteorology) especially within the first 30 minutes.	Y	We are using accepted accident release criteria, no credit is given for fallout.	C
	Chapter 4, "Safety SSC's":			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 28	Page 4-2: Section 4.3.1.3: The racks in the basins are safety class per the K Basin SAR. Modification of the racks is not described in the SAD, nor is it clear that there is any authorization documentation for rack modifications. The rack modification and analysis of the modification relative to the racks continuing to perform their safety function must be provided to DOE. It is also requested that the safety classification of the modified racks be clearly delineated including the basis and controls, if the racks are not maintained as safety class. (3)	Y	The rack modification involves cutting the center bar to allow room for the knockout pots. The knockout pots have built in spacers and are not dependent on the racks to maintain separation for criticality reasons. Therefore for the knockout pots the racks are not required to provide their indexing safety function. For existing canisters the cutting of the center bar would not impact the safety indexing function because no additional canisters would fit than is allowed with the center bar not cut. The adequacy of the modified racks is documented in HNF-SD-SNF-SARR-006, Evaluation of Safety Issues Associated with Damage or Removal of K Basin Storage Racks.	OA
* 29	Page 4-2: Section 4.3.1.4: The drop analysis for the pots was not referenced nor was it completed at the time the SAD was issued to DOE. This analysis should demonstrate compliance with safety class functional requirements. It is requested that FDH confirm the analysis is completed and issued, and that it demonstrates functional requirements are met. DOE requests that they be provided a copy of this analysis. (1)	Y	The intent of the SAD is to provide criteria not implementation details of the criteria. Because of the maturity of the design implementation details were provided or referenced when available. Drop analysis will be provided for DOE review where required by existing authorization basis and/or prior to installation of equipment. The upgraded K Basin SAR for fuel removal operations will provide details of compliance for safety class and safety significant SSCs.	CA
* 30	Page 4-5: Section 4.3.5: This section provides no functional requirements to withstand potential impacts of drops onto the annular filter vessels. Basin crane limitations for loads over the filter vessels are not described nor are there handling administrative controls identified. The safety class functions must be maintained under accident scenarios. Provide the basis why a load drop on the annular vessels is not a credible accident, and, if the accident is credible, provide reference to any drop analysis performed to show the annuler vessel safety function is maintained. (1)	Y	The location of the filter vessel enclosure is beyond the reach of the Transfer Area Crane trolley. Removal of access port during operation will be with mobile crane and will be subject to evaluation at that time. It should be noted that normal maintenance access would only occur after vessels have been backwashed to provide tolerable radiation levels. Criticality concerns and release consequences are much reduced or non-existent after vessels have been backwashed. The upgraded K Basin SAR for fuel removal operations will address as required.	CA
* 31	Section 4.4.1.2: DOE-STD-3009-94 guidance indicates that safety significant systems, structures, or components is to be described in this chapter. Section 4.1 of the SAD further states that Chapter 4 provides details of the safety significant SSCs. Only one safety significant SSC was identified in this chapter and the system description design details are not provided. It is reported that design details are not yet determined. Design details of this system should be provided for review, as this system is currently incomplete.	Y	The SAD is a criteria document not an implementation document as noted in response to item 29. The K Basin FSAR will provide implementation details.	O/ SER

HNF-SD-SNF-SAD-002 REV 2

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 32	Table 4-2: Section 4.4: This section states that certain SSCs will be designed to meet safety significant requirements for purposes of mitigation and defense-in-depth. It further presents safety significant equipment designations for K West IWTS in Table 4-2. Only one item is identified in the Table. According to DOE-STD-3009-94, page 8, SSCs which provide defense-in-depth are designated as safety significant. There are a number of SSCs that could be classified as safety significant, but have not been identified as such in Table 4-2, e.g., shielding, primary containment (pipes, IXM, etc.), computer controled interface between the radiation monitoring system and the IWTS, filter vessel temperature monitors, spray shielding, filter vent system, etc. It is requested that a careful review of these and other SSCs be made using DOE-STD-3009-94 criteria to assure the SSCs are properly classified as safety significant, and that Table 4-2 and Section 4.4 are modified to reflect any changes. (2)	Y	The hazard analysis performed for the SAD SSCs and the results are in compliance with the above definition of safety significant from STD-3009-94. For the examples cited there was no identified hazard that could result in fatalities or serious injuries, or excessive exposure.	O/ SER
33	Page 4A-3: Table 4A-1: This table shall be revised as required to be in compliance with DOE Order 6430.1A and DOE-STD-3009-94. Any affected SSC classification shall be identified and documented. (3)	Y	No changes are anticipated but table will be updated for any new safety significant items.	CA
	Chapter 5, "TSR's":			
	Chapter 6, "Prevention of Inadvertent Criticality":			
* 34	Page 6-5: Section 6.1.4: The summary of controls identifies that analysis has been performed for fuel spilled from canisters into the array of knockout pots, and identifies both administrative prohibitions and mechanical stops as controls to prevent canister movement over knockout pots. Provide the basis for not making the mechanical stops safety class or safety significant as defense-in-depth. (2)	Y	Mechanical stops will be used and are safety class with a safety function to have sufficient strength to stop movement of canisters past them. The upgraded K Basin SAR and Criticality Prevention Specifications for fuel removal operations will provide the implementation details as required.	CA
35	Section 6.1.4: second paragraph: States that IWTS IXMs have been shown to be critically safe even if inlet plutonium concentration is increased by two orders of magnitude over that discussed in Erickson (1994). The statement implies that it is not in Erickson 1994 itself. The statement should reference the document that substantiates this claim. Confirm this was based on Erickson (1998) and clarify in the K Basin SAR.	Y	Evaluation is in Erickson 1994. Statement was only made to identify conservatism. This will be clarified in the upgraded K Basin SAR for fuel removal operations.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
36	Page 6A-13: Section 6A2.4.1: This section identifies that the CVD process will ensure double contingency against a backwash introducing particles larger than 550 um into the filter vessels. This requirement is identified in section 6.1.3. Provide evidence that it is covered in the CVD SAR. (3)	Y	This issue is an interface item that is being formalized with CVD. Various solutions to the issue are viable.	CA
	Chapter 10, "Initial Testing, In-Service Testing, Maintenance":			
* 37	Chapter 10: General Comment: The information provided in Chapter 10 does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. Specific concerns include a lack of specific information on requirements, initial testing, in-service surveillance, or maintenance. Requirements such as those identified in HNF-S-0564, section 5.3 should also be considered for inclusion into this chapter.	Y	Details of initial testing, inservice inspection and maintenance is premature at this time. Commitment to existing programs addressing these items is appropriate based on Program Commitment guidance section of 3009-94. The upgraded K Basin SAR for fuel removal operations will provide more specific information for safety class and safety significant SSCs. The safety function of passive components are verified by code required inspections, factory acceptance testing, and receipt inspections. No inservice inspections or maintenance requirements for these items have been identified to date. Safety significant filter vessel radiation monitor will be lab or K Basin tested with check sources and periodically calibrated.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 38	Chapter 10: General Comment: The content of Chapter 10 of the Integrated Water Treatment System Safety Analysis Document is wholly deficient in meeting the scope and content requirements of DOE Order 5480.23 and DOE-STD-3009-94, and does not support a conclusion that the requirements of DOE Order 6430.1A, 1300 (testing of safety functions), have been or will be met. The submitted information simply states that there will be an appropriate initial testing, in-service surveillance, and maintenance program, and defers the provision of information until the upgraded K Basins SAR. Since this plan makes the information available to RL at the latest possible time, and is likely to make any RL input difficult to accommodate, it is not a satisfactory arrangement for making important safety information available. It is recognized that some of the testing, such as factory acceptance testing and construction testing, may have already been performed, and that other testing may still be in the planning stages. Since RL needs the utmost confidence in the equipment performance, FDH should provide that information on design and construction confirmation testing which is now available, and inform RL of the plan and schedule for preparing and providing the remaining information which is required by Chapter 10.	Y	See 37 above.	O/ SER
	Chapter 11, "Operational Safety":			
39	The operational Safety section of the K Basin SAR must include a description of the program to assure systematic identification and incorporation of the various operational commitments of the FRS SAD. A table listing all the various special operational commitments in the SAD is suggested. (3)	Y	Implementation of the specifics of Programmatic commitments (e.g. radiation protection, quality assurance, maintenance, etc.) are to be addressed external to the SAD and SAR as allowed by SAR PREPARATION CONCEPTUAL BASIS AND PROCESS, PROGRAMMATIC COMMITMENTS, of DOE STD-3009-94. Special operational commitments will be addressed or referenced in the K Basin FSAR	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Chapter 13, "Human Factors":			
* 40	Chapter 13: General Comment: The information provided in this chapter does not meet the guidance of DOE 5480.23, Attachment 1, or DOE-STD-3009-94 for content. The discussion provided leaves the reader with a concern that there may be a lack of understanding relative to the timing, scope, and importance of Human Factors in facility safety. Clearly, this effort must be incorporated into the system design process and is required by DOE Order 6430.1A, section 1300-12. Compliance with this requirement has not been demonstrated and must be met. Delaying this effort to the K Basin Safety Analysis Report is not consistent with DOE 6430.1A requirements. (3)	Y	The discussion in the SAD is not in conflict with the graded-approach guidance of STD-3009-94. The safety significant vessel monitor system was not addressed but is subject to human factor evaluation. However the human factor concerns for operator action to alarms do not require immediate actions (hours would be action requirements. Also operator action in response to alarm is not complex (shutdown and initiate backflush)	O/ SER
41	Chapter 13: No evidence that environmental factors were considered for impact on operators or equipment operation. Provide assessment. (3)	Y	Environmental factors have been evaluated and none have been identified for SC SSCs.	O/ SER

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
	Comment Key: Comments are evaluated as falling into the following omission categories. taken from DOE Std 1104-96: (1)- failure to address hazardous material or energy releases w significant consequences to the public, worker, or environment that will otherwise be left w/o coverage; (2)- technical errors that invalidate major conclusions relevant to the safety basis; (3)- failure to cover topical material required by DOE orders (eg, 6430.1A, 5480.23) or guidance on SAR's. All comments (unless identified as not requiring a response) adversely impact the adequacy of the facility safety basis/documentation.		Comment/Disposition Status (Column 16.) Key: O/SER - COMMENT NOT ACCEPTED, ISSUE ADDRESSED IN SER OA - COMMENT NOT ACCEPTED, ACTION REQUIRED CA - COMMENT ACCEPTED, ACTION REQUIRED C - COMMENT ACCEPTED, NO FURTHER ACTION REQUIRED	AUG 28 1998
	Executive Summary:			
1	Section E.8, Page xiii; Contrary to the SAD, USQ K-97-0265 is not "recently closed".	Y	Agree, the upgraded K Basin SAR for fuel removal operations will remove statement that USQ K-97-0265 is closed.	CA
2	Table E-1 lists the Guidelines for off site radiological consequences for accidents having frequencies from 1 E-02 to < 1 E -06 as 0.5 rem EDE. This is not consistent with the risk Evaluation guidelines of Table 3-1. When the SAD information is incorporated into the K Basins SAR, correct and consistent guideline values should be used.	Y	Agree, the upgraded K Basin SAR for fuel removal operations will provide the risk evaluation guidelines in the table and footnote the 0.5 rem which is the safety class threshold.	CA
	Chapter 2, "Facility Description":			
	General Comments:			
3	Provide the corrosion allowances used for the various equipment in the basins? (3)	Y	Corrosion is not considered an issue. Equipment in basin is predominately painted carbon steel. The fuel racks are unpainted carbon steel. Refer to Section 2.6.3 Water Chemistry 2nd paragraph of the existing SAR which provide data to indicate that corrosion is not an issue because of the short service time and low corrosion rates for carbon steel.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
4	Describe provisions for easy removal later on, or as required for maintenance (eg, the PCM)? See 6430.1A, section 1300-11.2. (3)	Y	The FRS maintenance strategy is documented in the Fuel Retrieval SubProject Maintenance Assessment, SNF-FRS-RPT-010. The strategy is largely driven by cost, personnel dose, and schedule considerations. The assessment recommended a strategy that is based upon direct replacement of modular components rather than repairing failed in basin units for all FRS systems with the exception of the manipulator systems (due to the high costs and long lead replacement times of manipulators). In support of this strategy, the following features have been incorporated into FRS design for in basin equipment: * In basin equipment prone to failure designed as modular units. * In basin components designed for remote, in place replacement using long handle tools or the manipulator. * Traditional remote handling features incorporated into design to expedite replacement times, such as use of acorn nuts designed for easy engagement and special anodized or painted finishes for ease of decontamination. * Failure prone items, to the extent practical, relocated to above water, hands on accessible locations. Servo valves, controller cards, etc. relocated to manipulator bridge are examples. * Maintenance agreements with off site vendors in progress for the manipulator system to expedite repair times and improve repair capability. Fundamental to the strategy is the procurement of equipment and systems that have an operating life of better than two years	C
* 5	Cannot determine that GFI (Ground Fault Interrupter) breakers have been used, as required by 6430.1A, section 1605-2.3. Contractor states issue is still "open". (1)	Y	GFIs will be incorporated as required by code.	C
	Specific Comments:			
6	2.2, p. 2-1. The applicable codes and standards are not listed, but referenced (WHC-S-0461). The applicable codes and standards need to be incorporated into the applicable K Basin SAR revision. (3)	Y	The precedent set by the K Basin SAR at RLs direction was to refer to the SRIDs document for identification of requirements. The SRIDs is approved by Site Manager, is treated as an authorization basis (AB) document. The intent is not to have two sets of requirements both approved as ABs creating the possibility of conflicts or inconsistencies. STD 3009-94 also states that SRIDs may be referenced. WHC-S-0461 has been cross-checked against the SRIDs by the system engineering process to assure all appropriate requirements were specified.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
7	Page 2-4: top of page: Found no mention of the "telescoping stiffbacks" discussed here as Defense in Depth feature for worker safety and may be safety-significant. However, this feature is no where mentioned as such in chapter 3. (3)	Y	The telescoping stiffback features is one of several pieces of "Equipment that prevents lifting the PCM wash basket and canisters out of the basin water" as defined in the 6th bullet on the page 3-11 list of defense in depth equipment. The telescoping stiffback. and its safety classification are also discussed in Section 3.4.2.2	OA
8	Section 2.5.1.1 states that canister hooks and stiffbacks are designed to prevent lifting canisters too close to the surface. This may be true for single canisters, but if canisters are engaged when racks are lifted, tilting of the racks can over-raise the canisters. This scenario is not analyzed in the SAD or the K Basin SAR. (1)	Y	The unmotorized hoists with unrestrained rollers will return the stiffback to a vertical lift position because of the horizontal load induced by the tilting of the rack. All lifts of canisters are under manual local control . Lifting of fuel close to surface by tilted rack would be detected by area radiation monitors before operator dose limits were exceeded. With operator presence, overload limits on hoists, and unrestrained rollers the probability of this accident extremely unlikely or incredible. The lifting of a canister is addressed in the K Basin SAR Section 3.4.2.6 -Canister Lift Overexposure. Will identify the rack scenario as another way for fuel to approach surface in FSAR in the upgraded K Basin SAR for fuel removal operations.	CA
9	Page 2-4: Section 2.5.1.2: 1st paragraph: Specify the decapping system material. carbon or stainless steel? (3)	Y	Carbon steel with exception of water wetted tools which are stainless steel.	C
* 10	Page 2-4: Section 2.5.1.2: 2nd paragraph: More detailed information is required on the vent system for canister decapping. (3) & (1) e.g. Where does the gas vent go to? Is this vent line included in the K Basins NEPA license, etc? What kind of monitor is on the vent line (for radiation or other)? See 6430.1A, sections 1589-99.0.1 and 1320-6.3.1. e.g. Where is this strainer? How would it be cleaned and what limits are on its accumulation of junk?	Y	The vent system is an ALARA feature as addressed here and in Section 7.0. DOE/RL 97-28, Radioactive Air Emissions Notice of Construction Fuel Removal for 105KW Basin does not require any abatement or monitoring for Kr. The system is routed to be vented near roof vent 10. The strainer is only a demister, junk should not be present. No additional detail is required.	C
11	Page 2-4: Section 2.5.1.2: 4th paragraph: How does the demister work w/o pads (as so stated in the Hazards Analysis)? (3)	Y	The Hazard Analysis reviewed a more complicated system, and this item is no longer part of the design. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 12	Page 2-4: The FRS system description on page 2-4, Section 2.5.1.2, and page 2-5, Section 2.5.1.3, needs to be strengthened to clearly identify the interfaces between the FRS and IWTS relative to high pressure water. If FRS includes any piping, pumps, ect., it should be identified as a potential hazard and evaluated. E.g. Describe what is the PCM made of (all parts), pressure the water jets operate at, the source of water, where the piping is (above waterline or below), how the jets are controlled, where everything is located (control station, hi press water pumps, etc), where the washed out sludge goes, and how sludge is removed.	Y	The FRS pumps which supply water to jets are located atop west basin divider wall and the water supply is from the IWTS treated water i.e. after filtration and ion exchange. Pumps and piping are designed to appropriate pressure system codes (ANSI B 31.3) as required by WAC. This provides for worker protection. Maximum pressure is 250 psi. Only pumps and their suction and discharge piping are above water. The consequences of a leak is essentially the same as for the existing recirculation or skimmer system , same radioactive source. The current K Basin SAR Section 3.4.2.11 Contaminated Building Atmosphere bounds spray leaks of the type addressed(basin water). The upgraded K Basin SAR for fuel removal operations will clarify interfaces. Personnel hazards from spray leaks will be addressed as part of the development of the hazards baseline to be prepared to cover all K Basin activities and update the existing hazards information.	CA
13	Page 2-5: Section 2.5.1.3: Describe purpose of torque limiter. Limiter appears to be a Defense-in-Depth item to prevent excessive breakage of fuel and therefore excessive contamination of the basins, radiation exposure, etc. (3)	Y	The purpose of the torque limiter is to prevent mechanical damage to the PCM gear box and is not to prevent fuel damage. Defense-in-depth is only required to be identified to prevent uncontrolled release.	C
14	Page 2-5: Section 2.5.1.3: Describe where the skid-mounted HP pump assembly and valves are located. (3)	Y	See 2nd paragraph, page 2-6. - The skid-mounted high-pressure pump assembly is positioned over the wall separating the center and west bays of the basin pool. The high-pressure pump provides the fuel flush nozzles with treated basin water from IWTS.	C
15	2.5.1.4, 2.5.2.4: Stuck Fuel Removal Equipment Description: Provide the dose consequences from sawing the fuel along with the canisters? Are special PPE needed for everyone in the basin?	Y	3.4.2.3 Fuel Assembly Burns Under Water, provides the evaluation of the worst case event. The event scenario, which is the same for decapping, primary cleaning, or removing stuck fuel, could initiate an energetic reaction of uranium hydrides, uranium, or zirconium cladding materials. Section. 3.4.3.9 **Confinement of Gaseous Radiolysis Products**, of the current K Basin SAR refers to Weber 1994 which a more detailed evaluation of the consequences of a burn of canister uranium fuel elements under water and concludes that the release to the site boundary is significantly less than acceptance criteria. Further there is no damage to the K Basin structure nor injury to personnel for credible events.	C
17	Page 2-6: 1st paragraph: It cannot be determined if there is any potential hazard, without defining what is meant by "treated" basin water. Please define this term and clarify if there are any differences radiologically between this term in K East and K West. (3)	Y	"Treated" basin water is water that has been filtered and deionized by the IWTS. KW will have less activity than KE.	C
18	Page 2-6: Section 2.5.1.5: 1st paragraph: Specify table material. (3)	Y	Table material is carbon steel and is to be painted.	C
19	Page 2-7: top of page: Need better explanation of purpose of the MCO baskets go/no-go gauge. (3)	Y	The go-no-go gauge is a pipe that assures the MCO baskets will fit in the MCO (non safety function) and that the fuel is confined to a safe geometry in the event of MCO basket rupture during a siesmic event or drop accident (safety function to prevent criticality) . Refer to section 4.3.2.2	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
20	Page 2-7: middle of page: • What fuel element "length requirements" are these? Could not find further mention of them anywhere. • What are these two other go/no-go gauges for? • Where are the test weights stored? Could not see them on Fig 2-11. • Is there only one lamp? Must there be a certain illumination of the work area, or will work be stopped to relamp? (3)	Y	Limit 11 from the CSER (contained in Appendix 6A of the SAD) addresses the length requirements • Assembled fuel assemblies can be no longer than longest allowed fuel. • MCO fuel or scrap basket loading/storage; see item 19 • Test weights are stored south of fuel basket loading station under monorail 27. • Yes, there is one lamp to back light the MCO basket to facilitate assembly loading which is easily re-lamped. Additional lighting is provided by the CCTV system.	OA
* 21	Page 2-8: Section 2.5.1.6: Specify how the environmental design requirements have been met to assure the effect of radiation on the hydraulic lines has been evaluated. (Radiation generally reduces rubber/plastic integrity.) (3)	Y	The following citations of the FRS procurement specifications highlight where environmental and radiation design considerations have been imposed upon the equipment vendors: * Performance Specification for the Manipulator Purchase. SNF-FRS-SPC-03 Section 5.3- Radiation, Section 3.2.5.1- Operating Environment * In-Pool Equipment Procurement Specification, SNF-FRS-SPC-007 Section 5.12- Radiation, Section 5.1.2.2- K Basin Operating Parameters (environment conditions) * Performance Specification for Closed Circuit Television. In Basin Lighting, and Equipment Operations Center. SNF-FRS-SPC-09, Section 3.2.2.1- Operating Environment, Radiation environment was not specified, since it was determined that replacement upon failure was the most economical approach .	C
* 22	Section 2.5.1.6 states that the control system is designed to prevent over lifting of the fuel. Please explain why there are no mechanical interlocks. Please explain what ensures "the manipulators are not capable of lifting fuel out of the basin water".	Y	As identified in Table 3.A.4, Item 4 page 3A-18 the physical reach capability of the manipulator is up 4.5 feet from surface of water. Control limits reach to 6 feet from surface of water. No other controls are necessary. A detailed explanation is provided in Appendix 3C pages 9 - 12.	O/ SER
23	Page 2-8: Bottom of page: The manipulator control system has been classified as GS in table 3-8. It appears the system should be classified as safety significant. Justify the classification.(3)	Y	The existing area radiation monitors provide the necessary protection for workers for lifting of SNF above the water. The failure of manipulator control system is evaluated in 3.4.2.1 Appendix 3C.	C
* 24	Page 2-9: 1st paragraph: The removable mechanical rail stops should be S/S, per its definition. (1)	Y	Manipulators operate at or below grating level. Failure of the end stops does not create an unacceptable load drop, or criticality concern or a worker safety issue.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 25	Page 2-9: 1st paragraph: The manipulator collision-avoidance system would at least be a Defense-in-Depth feature. (3)	Y	In accordance with DOE-STD-3009-94 "Systems, structures and components that are major contributors to defense in depth are designated as safety significant". While the collision avoidance system may be considered as a defense in depth measure to minimize equipment damage, it would not be considered as safety significant. This feature will be added to the defense in depth list recognizing it is capable of preventing a challenge to the basin floor or FRS safety class equipment due to a drop, but will be classified as general service since the drop is acceptable.	CA
26	Page 2-9: 2nd & 3rd paragraphs: The location of rooms 3 and 20A should be described. (3)	Y	See attached figure for location of room 3 and 20A	C
27	Page 2-11: Section 2.5.1.8: 2nd paragraph: Specify the material for the basket queue. (3)	Y	Basket queues are carbon steel (painted).	C
* 28	Page 2-12: Section 2.5.2.1: 3rd paragraph: Provide basis justifying why the telescoping stiffback is not SC for the same reason the MCO stiffback is SC. (1)	Y	The maximum amount of material that can be lifted out of the water by the telescoping stiff back (assuming failure of the stiffback) is the PCM wash basket (equivalent to 1 canister). Ignition of the scrap in the wash basket will not occur based on analysis demonstrating that a canister containing scrap would not reach ignition temperatures with the scrap canister insulated by sludge layer of 10 percent or less of the debris bed height (Porten and Crowe 1994). The PCM wash basket provides for higher heat transfer than the canister in sludge. Since the similiar analysis is not available for the MCO basket, the scrap in the over-lifted MCO basket is assumed to ignite. The release from this combustion exceeds the limit. The MCO basket stiffback also functions to limit drop height, which the telescoping stiffback need not do due to the mass difference. The release from the wash basket is aerodynamic entrainment from surface and the MCO basket release is fire driven which is much higher. This is the basis for differences in classification of MCO basket grapple and telescoping stiff back. Refer to Sections 3.4.2.1 & 3.4.2.2.	C
* 29	Page 2-13: Section 2.5.2.3: Unable to determine that the PCM is designed for easy withdrawal from the Basins, consistent w 6430.1A, section 1300-11.2. This is important as the PCM is probably the most likely thing to break down during operations and need removing for repairs. (3)	Y	The PCM is installed in pieces and assembled under water. The reverse process will be used to remove the PCM following completion of operations. Procurement specifications includes criteria and design features for remote maintenance. Factory Acceptance Tests require remote maintenance demonstration.	C
30	Page 2-14: Section 2.5.2.5: Provide additional description of the "wash basket" to better understand it's function. (3)	Y	The description in 2.5.1.3 **PCM Equipment Description** is considered adequate for safety evaluation.	OA
31	Section 2.5.2.5: Procedural controls and inspections necessary to control mixing tramp SNF with debris shall be described in the waste management section of the SAR to ensure commitments in this section are adequately controlled.	Y	This is a "debris removal" activity from the standpoint of waste management and is beyond the scope of this SAD.	C
32	Page 2-16: Top of page: Describe basis and safety significance of the 3" limit on scrap. (3)	Y	There is no safety significance. The limit is the size based on experience that is realistically expected to be capable of being reassembled as a fuel piece.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
33	Page 2-16: Section 2.5.2.6: 1st paragraph: 3rd, 4th sentences: Clarify how we ensure that the operating lever (of the MCO stiffback grapple) engages the ball detent grapple from the operating floor, looking down on the equipment? This is a critical operation. Suggest consideration in operating procedures to lift slowly while checking with a TV camera, as this would provide immediate visual evidence of attachment. (3)	Y	The MCO stiffback grapple has an indicator associated with the operating lever to indicate position of grapple which is not shown in the figure. This is not a safety concern since lifts or drop have been analyzed and do not present a problem.	OA
34	Page 2-16: Section 2.5.2.6: 3rd paragraph: Clarify: • How the empty MCO grapple is grappled to the MCO basket, how the hoist is then connected to the MCO grapple and how the positive engagement of the two (basket to the grapple, grapple to the hoist) is ensured, • What safety precautions are needed vis a vis hoist operation to ensure proper engagement of the empty MCO basket hoist to the flexible transfer crane, and • how verification is made that the empty MCO grapple is disengaged from the unloaded basket underwater. (3)	Y	See pages 2-11 through 2-12 for a description of the empty basket grapple. The FTC interlocks to monorail 27 with the same basic functional design as all other existing basin monorail interlocks. This is an appropriate level of detail for safety analysis.	OA
35	Section 2.6. Contrary to this SAD, the IWTS SAD does not develop "detailed changes to the K Basins SAR" for the confinement system design description.	Y	The intent was to refer to the IWTS discussion of changes to the "confinement system" due to the IWTS system which provides the water for the confinement system. This will be corrected in the upgraded FSAR.	CA
* 36	Page 2-18: Section 2.9.4: 2nd bullet: Provide basis justifying why these new interlocks are not safety class, per 6430.1A, section 1300-3.2. (1)	Y	Administrative controls for criticality prevention will ensure no fuel canisters are stored in the MCO basket movement path, so a criticality caused by a failure of the interlock and non-upgraded portion of the rails becomes a double contingency event. In addition weight/height for drops of MCO baskets are within K Basin SAR Table 3-10 limits. Therefore the consequences of the accidents associated with failure of the interlocks are acceptable and they need not be safety class.	CA
37	Page 2-18: Section 2.9.4: 2nd bullet: Describe the flexible transfer crane in more detail to allow an understanding of this equipment. (3)	Y	Since complete failure of the FTC is acceptable, more specific details are not required to estyablish the safety basis.	OA
38	Figure 2-3: Figure needs to be updated to describe what happens to the unstuck fuel elements, and to address incomplete information. (3)	Y	Appropriate Figures will be included in the updated K Basins SAR.	CA
39	Figure 2-6: There is not sufficient information in the figure or discussed in Section 2.5.1 to understand: • how the "telescoping hook" section works, • What the hook's capacity is, • What the spreader bar is for, and • How all of this works. (3)	Y	An appropriate level of detail for safety analysis has been provided to allow assessment of the safety analysis.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
40	Figure 2-12: Can the debris bins be loaded with fuel and go critical? CSER had no limits on the debris bins. (Is loading the bin w fuel bits a single contingency?) The plan view seems to show gaps between the pail and the two debris canisters where debris (or pieces of fuel elements) could fall to past the bins to the basin floor. (1)	Y	The criticality aspects of the debris baskets are addressed in **6A.3.7 Debris Handling Limits** as follows: - No limits. -Basis: Debris is defined as nonreactor-origin material, e.g., a wrench in a canister. Debris is separated from the fuel and reactor-origin material and placed in the debris bin until it is disposed of. The debris bin should not contain any fuel. The process table design includes a height difference between the debris bin and the table surface to prevent fuel pieces from inadvertently spilling into the debris bin. The table analysis demonstrated that, even if the debris bin were full of optimized scrap, it would not cause a criticality problem. Drops of the debris bin are bounded by canister drops. As-low-as-reasonably-achievable controls will be in place to protect workers handling debris.	C
41	Figure 2-14: Print is inadequate. Provide better print or additional print with clear details. Engineering print w parts listing is needed at a minimum. (3)	Y	The upgraded K Basin SAR will provide appropriate figures, it is inappropriate to provide engineering prints with detailed parts lists in the SAR.	CA
42	Figure 2-16: Print is inadequate. Provide better print with clear details. Engineering print w parts listing is needed at a minimum. (3)	Y	The upgraded K Basin SAR will provide appropriate figures, it is inappropriate to provide engineering prints with detailed parts lists in the SAR.	CA
	Chapter 3, "Hazard and Accident Analyses":			
	General Comments:			
43	How the hazards roll into the accidents is unclear. ie, Not clear that the hazards are bounded by the accidents. Part of the problem is that the hazards' risks (freq X consequence) were not calculated. Also, did not provide freq for the "what if" HA, so risks cannot be calculated for those hazards, anyway.) Provide clear connection (binning) between the hazards and the accidents. Must show that all hazards other than standard industrial hazards are picked up by the accident list. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
44	Could not see which hazards were eliminated from accident consideration due to being accepted industrial type hazards and covered in general worker safety. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
45	Environmental factors not considered for impact on operators or equipment operation. (Heat, humidity, etc). Provide assessment. (3)	Y	FRS safety class components are passive and painted structural steel. Environmental factors for the safety class equipment are negligible. Environmental factors that impact operations and equipment were considered.	OA
	Specific Comments:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
46	P. 3-2, 2nd paragraph. The SAD states that unmitigated onsite and offsite dose consequences for radiological material and toxic chemicals were calculated, as applicable. The consequences were compared with Table 3-1 to evaluate the risk level and establish the need for safety SSCs and TSRs. Since Table 3-1 shows the REGs, not the threshold for safety class of 500 mR for all event probability classes, this statement gives the impression that the requirements of 6430.1A (which by reference to the 5400 series establishes the threshold for safety class determination at 500 mr, independent of event probability) are not being met. In fact HNF-PRO-704 correctly applies this requirement in step 2.4.2.A.4, and this procedure was correctly followed, based on 3.4.2.1.5, which correctly identified the MCO basket stiffback grapple and the empty basket grapple as required to be safety class. Table 4A-1 should be revised to be consistent with Table 3-1.	Y	The safety class or safety significant classification was determined based on HNF-PRO-704 criteria. The acceptability of the accident analysis was then based on comparison to Table 3-1. Section 4.3 has the correct statements. The upgraded K Basin SAR will correct the text.	CA
47	Page 3-3: Section 3.3.1.1: 1st sentence is wrong. Hazards are things capable of causing harm to people, the facility, or the environment. Hazards cause the harm, and NOT accidents. Accidents are only triggers "releasing" the hazard from the SSC's containing them. Revise. (3)	Y	Agree, the upgraded K Basin SAR will correct.	CA
48	Page 3-5: top of page: The form used for the hazards analysis is not provided in Appendix 3A as stated. (3)	Y	The statement should say the "completed forms".	CA
49	Page 3-7: Tables 3-5 and 3-6: Tables do not appear complete as some items in Table 3A-2 were not picked up. Verify that all entries from the hazards analysis tables are picked up here. e.g. items 21,22,23,and 24 from Table 3A-2 should be in Table 3-5, and items 2,3,and 6 from Table 3A-2 should be in Table 3-6. (1)	Y	The tables are complete. Several items from Hazops were combined in the summary table.	C
50	Table 3-5 states that the table consists of 2 sheets. Either the statement is in error or one sheet of S2 and S3 items is missing.	Y	Agree.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 51	Section 3.3.2.3.2 indicates that safety significant equipment prevents uncontrolled drops of the manipulator support system. Table 3-7 indicates that the manipulator rail support structure tether system is classified as safety significant, along with a footnote which states that the tether system was classified, designed. and procured as safety significant based on the safety classification that existed at the time. and that under the current criteria, this would be a safety-class device. The manipulator tether support system is intended to prevent the manipulator trolley support frame from falling and damaging safety related equipment, a safety related table (for criticality prevention) and the basin floor. The SAD acknowledges that under the current requirements, this equipment is required to be safety class. However, the basin floor is not only a safety class component, it is the primary confinement barrier. This confinement barrier must remain fully functional following any credible DBA as required by DOE Order 6430.1A. 1300-1.4.2. The tethers should be classified as safety class. It is recognized that the tether system relies upon the K Basin building structure for support. (2)	Y	The tether system was designed and procured in accordance with the existing criteria at the time., The tether system is supported by a similar safety significant structure (building superstructure). Making the tether system safety class will not signifcantly reduce the overall risks since the weak link is likely the superstructure. The design includes significant margins and is judged to be acceptable as is. More specifically, the design and design reviews, procurement, installation and inspection would be would be no different for these items if they were designated as safety class, with the exception of some commercial grade dedication activities (likely a test of a sample assembly). FDNW applied procedures typically used for safety class construction for the procurement, material certifications, welding / inspections, records, etc. for the safety significant tether support system. All structural steel was procured as safety class. All welding was performed as safety class. All inspections performed as safety class. The cable was procured as commercial grade item, and pull tested to 125% of load equivalent to drop load (i.e., 2 x weight of support structure and live loads such as the manipulators and PCM drive system). ECN to original analysis which defined the loads is being investigated to validate pull test of cable. Some rework may be required if pull test must be repeated.	O/ SER
52	Page 3-14: Section 3.3.2.3.5: 1st paragraph: Which hazards were eliminated because of design or process changes or because another existing safety analysis bounded the hazard? These need to be listed. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
53	Page 3-14: Section 3.3.2.3.5: Revisit the listing of hazards brought forward to accident analysis after revising Tables 3-5 and 3-6 as needed (See comment # 49). Perform any additional accident selection and analysis necessary. Document results. (1)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
* 54	Page 3-15: 4th paragraph: Provide the rational describing why fuel elements were not used instead of fuel scrap for the analyses? (2)	Y	Scrap baskets have a higher potential to ignite, i.e has the largest surface to volume ratio, lower heat convection, and larger area for release calculations than fuel baskets.	C
* 55	Page 3-19: Section 3.4.2.1.5: The discussion provided in this section is confusing and would not lead to a classification of safety class for empty basket and stiffback grapples. The basis for the limit of .5 rem (5 mSv) as referenced in Table 4A-1 is also not clear. Provide clarification and basis for the .5 rem limit in Table 4A-1. Table 3-1 is the basis for safety classification on the SNF Project per DOE letter 97-SFD-172. (2)	Y	The safety classification is to prevent removal of a full basket of scrap from the water which would result in exceeding 0.5 rem off site. The empty basket grapple design prevents the possibility of remote (i.e., in-pool) engagement of a MCO basket, and prevents placement of fuel into an empty MCO basket while engaged. The MCO basket stiff back grapple is required to prevent lifting the MCO basket out of the water, and limit the lift height above the basin floor. This is addressed in section 4. The classification criteria is consistent with HNF-PRO-704 and DOE Order 6430.1A (1989).	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 56	Page 3-26: Section 3.4.2.4: There are no identified means preventing FRS equipment and operational loads from being brought over canisters of fuel. Controls must be established as TSRs to preclude this, as consequences have not been analyzed, nor is it clear that this is bounded by other accident analysis. (1)	Y	For installation the work package and USQ will assure controls are in place to prevent lifting the FRS equipment over fuel canister. Fuel will be relocated away from FRS equipment installation paths. Canisters will not be located in FRS operational load paths (in excess of canister weight loads) as required by CSER limit 6 which requires canisters be no closer than 6 feet from the load path.	C
57	Page 3-28: top of page: This tether system mentioned on this page was not mentioned/described in Chapter 2. Describe. (1)	Y	The tether is only a part of the manipulator support and is mentioned in Section 2.5.1.6, 2nd paragraph, first bullet.	OA
58	Page 3-28: 1st paragraph: State what this maximum lift height is. (3)	Y	The maximum lift height is shown on Figure 2-14.	OA
59	Page 3-29: Section 3.4.2.5.5: Page 3-31: Section 3.4.2.6.5: The summary of safety structures and components in section 3.4.2.5.5 is not complete, or is inconsistent with Table 6-3 which lists the MCO basket go/no-go gages and the process table bottom plate. Also the stiffback grapple listed in section 3.4.2.5.5 is not shown on Table 6-3. (3)	Y	The MCO basket go-no-go gauge will be added to the process table bullet in section 3.4.2.5.5 and 3.4.2.6.5, and the stiff back grapple will be added to Table 6-3 when the K Basin SAR is upgrade for fuel removal operations	CA
60	Page 3-29: Section 3.4.2.5.5: 2nd paragraph: Didn't see the limit on moving loaded MCO baskets in the CSER. This limit is not mentioned in Chapter 6. (3)	Y	Limit 12 of Section 6 addresses limits on moving loaded MCO baskets.	OA
61	Page 3-30: Section 3.4.2.6.1: State what the design basis earthquake (DBE) is. (3)	Y	Per Section 1, Site Characteristics, existing K Basin site criteria is used. This includes a seismic event of 0.2 g ZPA (0.12g ZPA for basin superstructure).	C
62	Page 3-31: Section 3.4.3: • What is the impact of the FRS on any of the B-DBA's considered in the K Basin SAR? • What is the consequence of criticality involving the FRS in the basins? (3)	Y	• No impact has been identified of any on K basin B-DBAs based on reviews of K basin DBEs during development of the SAD and based on the development of a draft Limited Activities Document for FRS, which included a matrix identifying the impacts of FRS on the existing DBE. • Consequence of criticality involving FRS in the Basin under approximately 8 foot of water (sheilding) is minimal from a physical perspective.	C
	Table 3A-2: Comments below may refer to table entries that have been sequentially numbered, from the 1st entry (canister retrieval) to the last (53).			
63	Table 3A-2: General Comment: Many of the ESFs are vague and lack specificity. It would be beneficial to provide more description of the ESFs. e.g. items 21, 30, 38. 40, 44, and 50.	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
64	Table 3A-2: Include the secondary cleaning operation's hazards in the Table. (3)	Y	As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
65	Table 3A-2, Items #4 and 12: Cameras are shown as ESFs. But, there is no further so mention, even as defense-in-depth. Should be a defense-in-depth. (3)	Y	The cameras will be used to monitor the amount of fuel on the table and as such should be considered general service defense in depth items. They will be added to the list in the upgraded FSAR.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
66	Table 3A-2, Item 28: Did not see the ESF in WHC-S-0461. (3)	Y	WHC-S-0461 defines the requirements for design of the FRS system. WHC-S-0461 requires that hazops be performed. Table 3A-2 reflects the results of the hazops. Subsequent to the hazops, design analysis demonstrated that these ESF were not necessary. See pages 3C-9 thru 12. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
67	Table 3A-2, Item 29: Did not see the ESF in WHC-S-0461. (3)	Y	These features are defined in the manipulator procurement specification specification.	C
68	Table 3A-2, Item 42: It should be stated that the decapping vent is routed to another building exhaust vent (as indicated in Section 2.5.1.2). Also, could find no further mention of special Kr sampling in Chapter 7 or 11. (3)	Y	To be addressed as part of the development of the hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
69	Table 3A-2, Item 53: What ESF "isolation" device is referred to here? What interlocks are there? (3)	Y	To be addressed as part of the development of the hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-3: Comment below refers to table entries that have been sequentially numbered.			
* 70	Table 3A-3, Item 15: Engineered safety features should include GFI protection for extra lighting in the basin because the basin underwater lights are 120 volt. (1)	Y	GFIs will be incorporated as required by code. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-4: Comments below refer to table entries that have been sequentially numbered.			
71	Table 3A-4, Item 1: "the Remarks" specifies that an action plan is needed for this scenario. Explain the meaning and status of this action plan. (3)	Y	No action plan is needed. This will be corrected as part of the development of the upgraded FSAR. A hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
72	Table 3A-4, Item 4: Need for control on scrap loading needs to be mentioned in chapter 6 specifically. Not sure what the remark is saying. (3)	Y	The CSER addresses this concern and no controls are necessary. As part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
73	Table 3A-4, Item 5: HNF-2229 states there is no issue, so why not simply so state here? (3)	Y	Will be corrected as part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
74	Table 3A-4, Item 23: Reference to item 19 vs 18 should be used under "Accident". (3)	Y	Will be corrected as part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
75	Table 3A-4, Item 26: Verify that safety assessment confirmed decapping station is within envelop of equipment drops evaluated for construction and operations as reflected in the remarks. (3)	Y	This is covered by HNF-2229. This will be corrected as part of the development of the upgraded FSAR, a hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
76	Table 3A-4, Item 28: Don't see the connection to Question 19. It should probably be 20. (3)	Y	Yes, it should be item 20. This will be corrected as part of the development of the upgraded FSAR. A hazards baseline will be prepared to cover all K Basin activities and update the existing hazards information.	CA
	Table 3A-5: Comments below refer to table entries that have been sequentially numbered.			
77	Item 4: Could find no mention of combustion-safe fan spec in WHC-S-0461. Verify if this is covered in fan spec. (3)	Y	The facility modification specification for this equipment requires a spark proof fan motor.	C
	Chapter 4, "Safety Structures, Systems, and Components":			
78	Page 4-1: Section 4.3: The criteria for safety class of SSCs is not in compliance with DOE Order 6430.1A as it is limited to radiological exposure and criticality but does not include other hazardous material exposure or adverse affects to the environment. Revise the classification of SSCs to be consistent with DOE Order 6430.1A and DOE-STD-3009-94. (3)	Y	The criteria for safety classification and safety significant classification is defined by the governing procedure (HNF-PRO-704) which has been considered to be in compliance with DOE requirements based on approval of SARs. Concerns regarding the compliance of HNF-PRO-704 to DOE requirements need to be addressed to the responsible individuals in FDH. There are no hazardous materials associated with the FRS equipment or operation that would require any safety class or safety significant equipment.	OA
79	Page 4-2: Section 4.3.1.1: A more complete statement of safety functions should be made by adding the words "to prevent criticality" at the end of the first sentence. (2)	Y	The upgraded K Basin SAR will include recommended addition.	CA
* 80	Page 4-3: Table 4-1: All functional requirements specified by DOE Order 6430.1A, Section 1300-3, shall be listed or referenced in this table and/or in another section of this document to clearly identify compliance with these requirements. Compliance must be confirmed to DOE prior to equipment installation. (3)	Y	The safety functions and performance functions listed are all those applicable for the safety class components. A specific review of functional requirements in Section 1300-3 of 6430.1A were provided by cc:Mail during the later part of July.(Copy attached) structural components.	O/ SER
81	The Safety Class Equipment List given in Table 4-1 lists mechanical components only. As such, no TSRs have been proposed for these components. At a minimum, periodic inspections for cracks / other indication of potential mechanical failure / loss of safety function capability should be considered and specified.	Y	No TSRs or inservice inspections are necessary because of the benign environment for carbon steel and low stress from operating loads in the safety class structures.	C
* 82	Section 4.0: General Comment: Has the same DBE (design basis earthquake) been used for all equipment acceptance evaluations for both in-pool and out-of-pool locations? If not, provide justification. (3)	Y	The FRS in-basin safety class equipment was analyzed K Basin seismic event (0.2g ZPA). The seismic analysis of the super structure to account for the added loads from the manipulator support structure was analyzed consistent with the existing KBasin FSAR levels applied to the superstructure (0.12g ZPA). The FRS manipulator support structure tether system attachments were analyzed based on 0.2g ZPA, with acceleration amplifications appropriate for support structure location within the Basin.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 83	Page 4-9: Table 4-2: Provide the basis to justify why the manipulator rail stops and interlocks with the flexible transfer crane are not at least safety significant. (2)	Y	Administrative controls for criticality prevention will ensure no fuel canisters are stored in the MCO basket movement path, so a criticality caused by a failure of the interlock and un-upgraded portion of the rails becomes a double contingency event. In addition weight/height for drops of MCO baskets are within K Basin SAR Table 3-10 limits. Therefore the consequences of the accidents associated with failure of the interlocks are acceptable and they need not be safety class.	C
84	Page 4A-3: Table 4A-1: This table shall be revised as required to be in compliance with DOE Order 6430.1A and DOE-STD-3009-94. Any affected SSC classification shall be identified and documented. (3)	Y	The criteria for safety classification and safety significant classification is defined by the governing procedure (HNF-PRO-704) which has been considered to be in compliance with DOE requirements based on approval of SARs. Concerns regarding the compliance of HNF-PRO-704 to DOE requirements need to be addressed to the responsible individuals in FDH.	OA
	Chapter 5, "Derivation of TSR's":			
	Chapter 6, "Prevention of Inadvertent Criticality":			
85	General Comment: The contractor should re-examine the potential benefits of refining the criticality evaluation using more realistic assumptions than those used in HNF-SD-SNF-CSER-010. "Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject". The possibility of reducing operational restrictions imposed by criticality limits or eliminating the need for safety class controls on some equipment could increase operational flexibility, reduce cost, and shorten the time needed to accomplish fuel retrieval operations.	Y	The standard NRC and DOE criticality evaluation requirements and guidance have been followed. Several independent reviews by criticality experts concluded the analysis is appropriately conservative.	C
* 86	p. 6-1. No reference is given to the Nuclear Criticality Safety requirements given in section 3.4.2 of HNF-S-0461. No reference is provided as to how each of those requirements has been met. The Design Authority for FRS acknowledged this as a legitimate comment, but said that in fact a thorough systems engineering analysis has been performed to assure these and other design requirements have been satisfied. Please provide a reference which documents that analysis.	Y	HNF-S-0461 is nor referenced by the CSER or Chapter 6, however it is referenced by the SAD. The basic requirement of HNF-S-0461 is to comply with the WHC Criticality Safety Manual. The WHC manual was replaced by the HNF-PROs. The criticality analysis and design requirements reflect to the requirements of the WHC Criticality manual and the HNF-PROs. The systematic reviews mentioned by the Design Authority are discussed in the CSER and the SAD. The SAD references are appropriate.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
87	**Section 6.0: General Comment:** There is a need to strengthen this section to more clearly demonstrate compliance with applicable requirements for prevention of inadvertent criticality Examples are: • Provide reference of specific analysis in the CSER covering the last 3 process table limits (ramp, south loading area, and basket loading area). • Clarify how the 150 Kg scrap limit is to be verified. • Clarify how we are going to prevent mixing/confusing/violating the 2 separate limits between the south loading area and the table ramp. • Describe what is keeping the 34 FE's from rolling down the ramp into the loading area. • Clarify "process table MCO basket loading area" limit. Do we mean 3 baskets in the basket stand on the south end of the table, or 3 baskets period?	Y	o The specific analysis for all the limits is covered in the CSER which is referenced. o How the 150 kg limit is verified is an operational implementation detail. Basically, it is expected that the PCM will likely be inspected and cleaned out following each use, but the strict limit is defined as 150 kg. o Since only fuel assemblies and piece of assemblies will be handled in this area - the limits were based on what would fit in a single layer. This limit was originally specified as a single layer, but Operations preferred a specific number of elements. Therefore, as long as the element are not sitting on top of each other, the limit is met. o There is a lip which stops the assemblies from rolling onto the loading area, but even if all the assemblies were to roll into the loading area, this is well within analyzed fuel loading conditions and presents no problem from a criticality perspective. o The limit is that a fully loaded MCO basket may be in each of the 3 loading areas designed to hold a MCO basket. This includes one at the north end and two at the south end of the table. The other areas at the south end of the table are for test weights. This will be clarified in the upgraded FSAR.	CA
88	<u>Page 6-5:</u> top of page: Not all of the limits identified in Appendix 6A are included in Section 6.1.4 e.g. limit 14 is missing. (3)	Y	Limit 14 was unintentionally deleted from the list in Chapter 6, which was cut and pasted from Appendix 6. This will be corrected as appropriate in the FSAR (the presentation form may be different in the FSAR, but all limits will be included).	CA
89	**Section 6A:** The term K limit should include a clear statement of when K (eff.) of 0.95 as required by DB-003 is applied.	Y	The NRC equivalency is not applicable to FRS. The reference to FRS in DB-003 is fuel removal not fuel retrieval. Which limit applies where will be clear when all the sub-projects are included in the FSAR	CA
	Chapter 7, "Radiation Protection"			
90	**7.0 Radiation Protection:** The ALARA assessment, although referenced in this section, provides information which should be summarized as appropriate and included in the K Basin SAR in the Radiation Protection and/or Facility Description Chapters in accordance with 5480.23. General questions raised during the SAD review that should be answered in the ALARA assessment include: the effect of FRS equipment maintenance, decon, space requirements, containment tents, and remote maintenance facility requirements.	Y	The Fuel Retrieval System ALARA Assessment, SNF-FRS-RPT-12, does include discussions on equipment maintenance, decontamination, etc or refers to supporting studies that discuss these considerations in sections 10.0 and 13.0. Section 7.0 of the FRS SAD does provide a summary of the findings in the ALARA Assessment. More detail would not be appropriate in a safety analysis document.	C

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
91	7.0 Krypton should not be a significant problem since the fission yield is low and the gamma yield is insignificant. Justifications for the canister decapping exhaust system are not provided and are requested.	Y	Accumulation of canister gases, including hydrogen and krypton was identified as a potential ALARA concern, as such, the exhaust system was designed and installed to minimize gas buildup in area below grating where decapping will occur.	C
92	The Specification for Design of the SNF Project Fuel Retrieval Subproject, WHC-S-0461 is twice as conservative as 10CFR835 with regard to neutron quality factor. However, this conservatism does not have any significant does consequences for the SNF Project due to the low neutron doses expected to personnel. It is not expected to affect the system cost. The requirement of 10CFR835.2 Quality Factor (l) is: "The quality factors to be used for determining does equivalent in rem are shown below: ... Neutrons, > 10 keV --- 10..." The statement in WHC-S-0461, Section 3.4.3 is: "A neutron quality factor of 20 ... should be used for design purposes." Therefore, WHC-S-0461 is twice as conservative as 10CFR835, but this conservatism should not have any significant effect on the SNF Project.	N	Agree that 10CFR835 specifies a quality factor of 10 for neutrons of unknown eneregy and agree that project costs not increased.	C
	Chapter 10, "Initial Testing, ... and Maintenance":			
93	5480.23, Att. 1, 3.a.(1).(a).6 states that SARs must: - Include a critical evaluation of the proposed design, operation, and test program to assess conformance with safety design objectives and verify the projections of the residual risks. - In addition, inservice inspection and maintenance for FRS needs to be specified. Chapter 10 in the current SAD focuses on the scope of installation testing, and lists examples of system functional testing, but not testing of the safety class / safety significant safety functions. The final modification to the K Basins SAR incorporating this safety analysis information must address this testing.	Y	All of the safety class equipment is passive structural equipment. There are no safety related tests, maintenance or inservice inspection requirements.	OA

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
94	Specific additional measures to enhance the reliability of the hoists and handling equipment (with intent to prevent drops) were not specified, as requested by DOE Ltr 98-SFD-026. Specifically: • control on maintenance so that corrective preventative maintenance is completed as req'd to maintain the equipment per vendor (and safety) specs; • testing of the handling equipment on prescribed intervals. • formal training & qualification of operations staff on the handling equipment (maybe incl in Chapter 12). Specify the measures requested in 98-SFD-026 in the final SAR. In addition, significant recommendations such as recommendation 3 in HNF-SD-CN-009, page D-14, need to be included in the final SAR. (3)	Y	Programmatic controls to be applied to K Basin lift control program are beyond the scope of this SAD. DESH-9852032A R1 identifies the FSAR committments that will be included in the K Basin FSAR regarding this area. The FRS design considered the request from DOE concerning hoists and load handling equipment design. The DESH response to this request is documented in FDH-9761261, Safety Classification of Cranes and Handling Equipment. The FRS load handling equipment was determined to be general service. Recommendation 3 is beyond the scope of the SAR, but should be included in the Design Bases Document for the Fuel Handling System (ie - the recommendation is to evaluate the effects of fatigue for some higher stressed components IF longer term usage of these devices contemplated). This has been referred to the Design Authority.	O/ SER
	Chapter 11, "Operational Safety":			
95	The operational Safety section of the K Basin SAR must include a description of the program to assure systematic identification and incorporation of the various operational commitments of the FRS SAD. A table listing all the various special operational commitments in the SAD is suggested.	Y	As addressed in response to comment 90 this is detail that is beyond the scope of the SAD or SAR. FRS activities will be governed by the K Basin Operational Safety program.	OA
	Chapter 16, "Provisions for D&D":			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
* 96	General Comment: Section 16 does not fully comply with the guidance and expectations contained in DOE Order 5480.23, attachment 1 for the contents of this section. It is critical that this compliance be demonstrated now, prior to equipment installation. This would also include considerations for disposal of hydraulic fluids and other hazardous materials, as applicable to the FRS. (3)	Y	The FRS design addresses the issues of maintenance (see response to #4) and D&D. Specifically in the area of D&D, the FRS has included special features to facilitate eventual decommissioning of in basin equipment: * Long length items are limited, to the extent practical, to 8' lengths or can be easily cut to 8' lengths. * Surface finishes and/coatings have been specified to facilitate decontamination. * All enclosed areas have low point drain holes to avoid hold up of liquids. * Modular design has been employed to facilitate eventual disposal. * Remote handling features have been included in the design to allow disassembly in place.	C
	REFERENCES			
97	<u>General:</u> Draft supporting documents should not be referenced in safety documents per RLIP 5480.83. Please indicate when the draft supporting documents listed in Table ES-4 and ES-5 will be finalized, and if any delays may affect the conclusions summarizes in the SAD.	Y	The analysis for FRS in the upgraded K Basin SAR will be based on approved support documentation.	CA
	Following comments on cited reference documents are provided:			
	HNF-SD-SNF-CN-009:			
98	<u>Page G-8 and G-28:</u> States that calculation results have not been incorporated into the final design. Confirm that calculation results have been incorporated into the final design. (3)	Y	The status of the design and the calculational results will be addressed during the FSAR update to confirm final results are incorporated.	CA
	HNF-2229:			
* 99	<u>Page P-1:</u> Appendix 'P': Cover sheet states that weight calculations require as built weight verification. No evidence is indicated that this has been performed. Since this is critical to drop analysis results, this verification must be performed prior to equipment installation. Provide how this will be assured or evidence that it has been performed. (3)	Y	Weights of components covered by Appendix P will be verified prior to rigging over the basin.	C
	HNF-SD-SNF-CSER-010:			

12. Item	13. Comment(s)/Discrepancy(s) (Provide technical justification for the comment and detailed recommendation of the action required to correct/ resolve the discrepancy/problem indicated.)	14. Hold Point	15. Disposition (Provide justification if NOT accepted.)	16. Status
100	Page 7: Limit 8: Justify that the mass values used in the analysis bound the maximum possible mass that could be contained in a canister such that the use of "one canister" is an acceptable limit for the PCM. (3)	Y	The analysis supporting Limit 8 addressed all the bounding combinations of mass allowed in canisters based on the mass limits from the existing FSAR. See Table 4.3 of the CSER.	OA
101	Page 22: Table 2.6: General Comment: The design features listed here do not read the same (ver batim, as they should) as Table 4.1 or 6.3 or Section 3.4.2.5.5 in the SAD. eg, Primary Clean Machine states "SC bottom and supports" is not the same as (from 3.4.2.5.5) "PCM lower half". The entire lower half of the PCM would seem (to me) a much larger section of the machine than just its bottom. Also, the supports must be SC and this may/may not be the same as the lower half. It should be crystal clear to everyone precisely and exactly what must be SC.	N	Agree. this will be fixed in the FSAR.	CA

DON'T SAY IT --- *Write It!*

DATE: August 26, 1998

TO: Robert M. Hiegel

FROM: Robert G. Morgan — RElls for Robert Morgan

Telephone: 373-9451

cc: R.L. Besser R3-26
G. Baston R3-82
R.G. Holt S7-41
S.H. Peck X3-75

SUBJECT: Responses to Independent Review Panel (IRP) comments on Fuel Retrieval Subproject (FRS) Safety Analysis Document (SAD), HNF-2032.

Attached, please find the responses to the comments provided by the IRP in their memo concerning the FRS SAD, dated July 14, 1998. If you have any questions, please contact Steve H. Peck at 372-3641.

A-3000-723 (01/95) GEF014

INDEPENDENT REVIEW PANEL (IRP) COMMENTS ON FUEL RETRIEVAL SUBPROJECT (FRS) SAFETY ANALYSIS DOCUMENT (SAD), HNF-2032, Rev. 0

1. This SAD does not cover the role and use of the FRS in the process of installing loaded baskets into the Multi-Canister Overpacks (MCOs). The IRP desires an explanation of where and how that installation process and its safety evaluation will be addressed. The IRP has two specific comments or questions that arise from the lack of coverage of that installation process in the present FRS SAD.

Response: *Loading of MCO baskets and load out of the Cask/MCO is covered by the Cask Loading System (CLS) SAD.*

a) In Section 2.5.1.7, on page 2-10, the description of the grapples for both the empty and the loaded MCO baskets describe attachments which enter the central tube of the MCO basket and use a center rod to press latching balls outward into grooves on the inner diameter of the basket's central tube. It is not clear how this equipment can be used to load the basket into the MCO, since the basket's central tube must engage the central tube of the MCO. Please clarify how the MCO will be loaded and the use of FRS tools and equipment in that process.

Response: *The FRS MCO stiffback grapple is used to initially move the MCO baskets from the FRS MCO basket queue to the MCO Loading System shuttle cart, which is located in the transfer channel of the loadout pit. Loading of the MCO baskets from the cart into the MCO is accomplished with a MCO loading machine, which has a similar grapple attachment.*

The MCO central tube is attached to the MCO lid and is placed in the MCO with the MCO lid after the CMO baskets have been loaded, so there is no interference problem with the grapple.

The CLS SAD will provide more details of the loading process.

b) In Section 6.0, a requirement of maintaining k_{eff} less than or equal to 0.98 is stated as the basis for preventing inadvertent criticality. The IRP understands that the 0.98 value applies for FRS and K Basin operations. However, additional NRC Requirement 27 of HNF-SD-SNF-DB-003, Rev. 3, states: "Incorporate a criticality safety value of 0.95 for k_{eff}. (This requirement applies at the point where the spent fuel, in an MCO basket, is placed in an MCO.)" The IRP wishes to review the document in which the criticality analysis for spent fuel placement in MCO baskets is provided to satisfy additional NRC Requirement 27. Further, that document should be referenced and discussed in the FRS SAD in the context of satisfying the NRC equivalency requirement. Is that document the *Criticality Safety Evaluation Report for the K Basin Fuel Retrieval Subproject,* HNF-SD-SNF-CSER-010, FDNW, 1998, or the *Criticality Safety Evaluation Report for Spent Nuclear Fuel Processing and Storage Facilities,* HNF-SD-SNF-CSER-005, Rev. 3, Schwinkendorf, 1997?

Response: *Application of NRC equivalent k_{eff} is covered by the CSER for the CLS system, HNF-2151. The NRC equivalency requirements apply when the spent fuel is placed in the*

MCO; this is covered in the CLS SAD. The 0.95 K_{eff} will be properly addressed in the revision of the K Basin FSAR.

2. The acceptance criteria for the completion of cleaning and inspection of the spent nuclear fuel are not provided or discussed in this SAD. The acceptance criteria for the cleanliness of SNF placed in the MCOs, including the amount of aluminum hydroxide film on some K West elements, provide the basis for the parameters selected for the safety case for cold vacuum drying and interim storage of the MCOs. Therefore, the IRP wishes to review the acceptance criteria and its associated safety analyses. The IRP has two specific comments and questions from which this overall comment derives.

Response: *The current fuel cleanliness requirements are discussed in Chapter 5 of the FRS SAD. Since there are no FRS equipment or operation accidents associated with fuel cleanliness, any fuel cleanliness, any fuel cleanliness requirements resulting from down stream facility safety requirements will be implemented as operational controls. The present safety analysis has not defined any critical cleanliness requirements that would result in the implementation of specified controls.*

See response for 2.a and 2.b for more details.

a) In Sections 2.5.2.3, on page 2-14, and 2.5.2.5, on page 2-15, no acceptance criteria for the completion of cleaning with the Primary Clean Machine (PCM), for the need to conduct inspections at the fuel element disassembler station, or for the satisfactory completion of such inspections are given. Table 5-1, on page 5-1, summarizes the fuel inspection criteria for fuel retrieval operations and refers to two documents for requirements. Those documents are: (1) *Spent Nuclear Fuel Project Product Specification,* HNF-SD-SNF-OCD-001, Rev. 2, Pajunen and Sederburg, FDH, 1998; and (2) *Fuel Retrieval System Process Validation Plan,* HNF-SD-SNF-PAP-003, Rev. 0, Shen, DESH, 1997. The IRP wishes to review those two documents and any others that contain the FRS cleaning and inspection acceptance criteria.

Response: *The acceptance criteria for fuel cleanliness are defined in HNF-SD-SNF-OCD-001, Rev. 2 as stated in Chapter 5. The FRS validation plan based on the current requirements is defined in HNF-SD-SNF-PAP-003, Rev. 0.*

HNF-SD-SNF-OCD-001 is to be revised by 10/30/98.

b) In Section 2.5.2.3, on page 2-13, the primary cleaning system appears to reflect the assumption that there will not be separate cleaning to remove the aluminum hydroxide film expected on some K West fuel elements. The only option, as stated on page 2-15, is to clean in the secondary station "using long-handled tools." The SNF Project intentions and planning regarding the FRS and aluminum hydroxide deposits should be confirmed, and the documents that contain the necessary information should be provided to the IRP. The IRP understands that such information may be included in the latest revisions of HNF-1523 and -1527, which are already being sent, per the presentations on July 8. The IRP wishes to review the revisions to HNF-1523 and -1527 that are expected based on final testing to determine the amount of aluminum hydroxide on K West fuel. We also wish to review the latest revisions of FM/97-113 and CN-017, which define the scrap and fuel surface area that will be the bases for safety analyses.

Response: *HNF-1523 and HNF-1527, which provide the basis for aluminum hydroxide, have been provided to the IRP. These documents are to be revised by 9/30/98. These documents do not define any requirements for cleaning alumimum hydroxide from the fuel and as such no additional requirements have been placed on the FRS equipment. Closure of the alumimum hydroxide issue is expected to be captured in the revisions to HNF-1523 and HNF-1527.*

3. In Section 3.0 and Appendix 3A, the hazard evaluation documented appears to be thorough and comprehensive, worthy of compliment. The IRP has the following comments.

a) In Section 3.4.2.1, on page 3-17, the scrap basket over-lift and fire is confusing. It is presented and analyzed as a design-basis accident rather than a beyond-design-basis accident, even though "it is physically impossible." The safety rationale should be clarified.

Response: *This accident is physically impossible when the MCO stiffback grapple is used. The stiffback grapple is lifted from the top of the grapple, so provided the grapple is of sufficient length (and the design isn't changed such that the MCO basket could be lifted higher due to a hoist failure) this accident is physically impossible. A different lifting mechanism design could result in overlift of the basket due to hoist failure. The contractor kept is as a design basis accident since the consequences of that event were unacceptable and it was necessary to have a safety class engineered design feature to preclude the event. This event will be clarified in the FSAR.*

b) There is unfounded precision reflected in the calculated dose consequences given in Table 3-10, on page 3-23, with results given to three significant figures. This simple plume model is applied to releases of respirable particles from a fire within the building to receptors outside the building, even at some distance. At most one might say that this is an attempt at showing that the bounding dose at 100 meters is roughly the same as the Guideline Value.

Response: *Your comment is correct, however, since the results are conservative and the guidelines are conservative, the conclusion is still appropriate, i.e., no safety class or safety significant equipment is required to mitigate this event. The defense in depth telescoping stiffback provides adequate protection.*

4. On page 2-14, in the fourth paragraph, what debris of "nonreactor-origin" is being separated here, apparently in a low-level waste stream? How is the cleaning assurance called for in the last sentence to be provided?

Response: *During the course of storage of the fuel, items have been dropped into the open canisters. This type of material and the empty canisters are the type of materials that will be handled as debris.*

The detailed methods that will be employed to check for tramp SNF in the debris have not been developed yet.

5. In Section 2.5.2.6, on page 2-16, it appears that the submerged weight of the loaded basket is being measured with the installed load cell. There is not an exact figure for the volume of the loaded material, so an exact weight is not obtained. What is the purpose of this weight measurement?

Response: *There are two reasons to weigh the fuel – to establish the amount of fuel in the MCO basket for accountability purposes and to assure the criticality mass limits are not exceeded. Exact weights are not required.*

6. The IRP wishes to review the report, *K Basin Fuel Ignition Issues,* HNF-1894, DESH, 1997, which deals with fuel ignition experience in France, as discussed in Section 3 4.2.3.1, on page 3-23.

Response: *In response to the issue contained in HNF-1894, another analysis has been performed to address fuel flashes. This document, HNF-2786, "Assessment of the Potential for Rapid Ignition of Submerged N Reactor Fuel," is in the review and approval process.*

7. In Section 4.0, safety-class systems, structures, and components (SSCs) are identified. Since the NRC's important-to-safety criteria are not applied to the FRS, per item 29 of the Additional NRC Requirements document, HNF-SD-SNF-DB-003, Rev. 3, the IRP will not comment on the SSCs selected in the FRS SAD.