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FUEL RETRIEVAL SYSTEM PROCESS FLOW DIAGRAMS MASS BALANCE CALCULATIONS FOR K WEST BASIN

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Abstract: this calculation justifies the numbers used for the material balance on the process flow diagrams for the KW Basin Fuel Retrieval Subproject.

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Fuel Retrieval System PFD Mass Balance Calculations K West Basin

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Fuel Retrieval System PFD Mass Balance Calculations K West Basin

1.0 PURPOSE AND OBJECTIVE

The purpose of these calculations is to develop the material balances that are documented in the FRS Process Flow Diagrams for future reference. The attached mass calculations were prepared in support of revising the fuel retrieval system process flow diagrams for the 105K West Basin. The calculations refer to diagram H-1-81164.

2.0 SUMMARY OF FINAL RESULTS AND CONCLUSIONS

See appendix A for final results.

3.0 ASSUMPTIONS

See assumptions page in appendix A.

4.0 SOFTWARE APPLICATIONS

None used.

5.0 COMPUTER MODEL

Excel spreadsheet used to display material balance and verify hand calculations.

6.0 INPUT DATA

See appendix A.

7.0 CALCULATIONS

7.1 Average Masses of MK IV and MK IA Fuel Assemblies

MK IV and MK IA fuels were manufactured in a variety of lengths (and masses). This calculation is an estimate of the average mass per fuel assembly according to the combined distribution of fuel in both the KE and KW Basins.

Per Table 3.1 of Reference 4:

Table 1: Distribution of MK IV Fuel Assemblies in K Basins

MK IV Length	E	S	A	C
Outer clad (kg)	1.09	1.04	0.99	0.79
Inner clad (kg)	0.55	0.52	0.50	0.40
Outer U (kg)	16.0	15.0	14.1	10.5
Inner U (kg)	7.48	7.03	6.62	4.94
Total kg per assembly	25.12	23.59	22.21	16.63
% of MK IV assemblies in K Basins	78%	10%	7%	5%

Average mass of a MK IV assembly is:

$$0.78 (25.12 \text{ kg}) + 0.1 (23.59 \text{ kg}) + 0.07 (22.21 \text{ kg}) + 0.05 (16.63 \text{ kg}) = 24.34 \text{ kg/assembly}$$

Table 2: Distribution of MK IA Fuel Assemblies in K Basins

MK IA Length	E	M	T	F
Outer clad (kg)	1.07	0.88	0.83	0.66
Inner clad (kg)	0.66	0.54	0.51	0.40
Outer U (kg)	13.8	11.1	10.4	7.85
Inner U (kg)	6.84	5.49	5.12	3.90
Total kg per assembly	22.37	18.01	16.86	12.81
% of MK IA assemblies in K Basins	0.03%	87%	10%	3%

Average mass of a MK IA assembly is:

$$0.0003 (22.37 \text{ kg}) + 0.87 (18.01 \text{ kg}) + 0.1 (16.86 \text{ kg}) + 0.03 (12.81 \text{ kg}) = 17.75 \text{ kg/assembly}$$

Results of these calculations are used in H-1-81164 notes.

7.2 KW wt% water in canister sludge plus wash sludge

Per Table 2-2 of Reference 4a:

Table 3: KW Sludge Water Content

Sludge Type	Volume of Sludge (m ³)	As-settled Sludge Density (g/cm ³)	As-settled Sludge Solid Content (g dry solids/cm ³ as-settled sludge)
¹ Canister Sludge	1.01	2.68	2.053
² Fuel Wash Internal Sludge	0.518	3.00	2.310
² Fuel Wash - Coating	0.405	1.50	0.970
² Fuel Wash - Fuel Pieces	0.149	11.02	10.612

¹ Corrosion products within the canister

² Sludge dislodged during processing due to the brittleness of irradiated uranium metal and the fractured state of the uranium within the breached fuel that is made up of three components: coating material, internal sludge, and fuel pieces.

$$\text{Then, the wet weight of the sludge is } (2.68 \text{ MT/m}^3 \times 1.01 \text{ m}^3) + (3.00 \text{ MT/m}^3 \times 0.518 \text{ m}^3) + (1.50 \text{ MT/m}^3 \times 0.405 \text{ m}^3) + (11.02 \text{ MT/m}^3 \times 0.149 \text{ m}^3) = 6.5 \text{ MT}$$

$$\text{Then, the dry weight of sludge is } (2.053 \text{ MT/m}^3 \times 1.01 \text{ m}^3) + (2.310 \text{ MT/m}^3 \times 0.518 \text{ m}^3) + (0.970 \text{ MT/m}^3 \times 0.405 \text{ m}^3) + (10.612 \text{ MT/m}^3 \times 0.149 \text{ m}^3) = 5.244 \text{ MT}$$

The amount of water is the difference between the wet and dry weights.

$$\text{Water is } 6.5 \text{ MT} - 5.244 \text{ MT} = 1.266 \text{ MT}$$

$$\text{The water is } 1.266 \text{ MT} / 6.5 \text{ MT} = 20 \text{ wt\% of the wet sludge.}$$

This calculation forms the basis for the interstitial sludge water shown in Assumption 1 of H-1-81164.

7.3 Estimated Volume of Gas per Canister in KW

This estimate is the maximum gas volume in the canister and gas trap, which occurs in a Mark II canister. The estimate does not include any additional volume of gas in the canister barrel generated by the consumption of water in the uranium oxidation reaction. The volumes are based on the volume of inert gas initially charged to the canister at standard temperature and pressure.

The total volume of gas per barrel (max) in a Mark II canister is 1.46 liters per Reference 11.

The total volume of gas per gas trap in a Mark II canister is about 40 cubic inches (0.66 liters) per Drawing H-1-46215, Rev. 4, Sheet 4.

The total gas is the sum for the barrel and gas trap, and is 2.12 liters/barrel, which is 4.24 liters per canister.

7.4 Discussion of KW Stream Calculations in H-1-81164

FW-1 Retrieved Canister to Staging

Entries for this stream are the numbers of canisters and fuel elements per the drawing notes. The fuel isotopic activities and sludge data are calculated by the spreadsheet using the data in the H-1-81164 Assumption 1 table. The SPR fuel is not included in the spreadsheet calculations, except for showing the MCO baskets that will be used to load the SPR fuel into a single MCO.

FW-2 Loose/Spilled Fuel Retrieved from Basin

No fuel is estimated to be spilled by FRS.

FW-3 Loose/Spilled Fuel Retrieved from Basin

No fuel is estimated to be spilled by FRS.

FW-4 Loose/Spilled Fuel Retrieved from Basin

No fuel is estimated to be spilled by FRS.

FW-5 Staged Canister to Decapping

This stream is the same as FW-1.

FW-6 Canister Gas to Offgas Treatment

All canister gas is assumed to go to offgas treatment in this PFD, although some gas will be released directly to the basin. The volume of the gas is expanded in this stream to atmospheric pressure.

FW-7 Canister Lids to Debris Bin

There are two lids per canister in FW-5.

FW-8 Empty Debris Bin

Assume 20 lids per debris bin. With a total of 3841 canisters, 2 lids per canister, a total of $(3841 \times 2 = 7682 \text{ lids})$ divided by 20 lids per debris bin gives 385 debris bins.

FW-9 Filled Debris Bin to Debris Staging

The canister lids will go to debris staging. This stream is the sum of FW-8 and FW-7.

FW-10 Decapped Canister to Primary Cleaning

Same as FW-5 without the canister lids or the canister gas.

FW-11 Empty Wash Basket to Primary Cleaning

Assume baskets will be emptied once out of every 10 canisters processed. Total canisters $3841 + 20 \text{ stuck fuel} = 3861$ canisters processed. 10% of canisters processed is 386 baskets needed. The frequency which the baskets will be emptied will depend on the rate at which they fill with debris therefore 10% is used for material balance purposes and this number may change depending on necessity during processing.

FW-12 Empty Strainer Basket to Primary Cleaning

One basket emptied per every twenty canisters processed. Total canisters $3841 + 20 \text{ stuck fuel} = 3861$ canisters processed. 5% of canisters processed is 193 baskets used. Strainer baskets will be reused. The frequency which the baskets will be emptied will depend on the rate at which they fill, therefore 5% is used for material balance purposes and this number may change depending on necessity during processing.

FW-14 Basin Water to Decapping and Primary Cleaning

Stream is FW-15 less the sum of FW-77 and FW-78.

FW-15 Water/Sludge from Primary Cleaning and Decapping

All sludge from FW-1 plus 150 gpm over the 2 year processing period.

FW-16 Fuel Bits in PCM Strainer Basket to Sorting

Assume this stream is 0.1% of fuel. Strainer basket hold approximately 78 kg of fuel bits per ref. 7.

FW-17 Canister Removed from Tipping Station

Sum of initial canisters in FW-1 plus 20 canister containing 2 barrels each that are recycled back. Assume only half of the barrels contain stuck fuel (one per canister). There are seven fuel assemblies in each barrel and two elements per assembly. $2 \text{ elements} \times 7 \text{ assemblies} \times 1 \text{ barrel} \times 20 \text{ canisters} = 280 \text{ elements of stuck fuel}$.

FW-18 Empty Canister to Debris Staging

Canisters without stuck fuel. FW-1 canisters less 20 stuck fuel canisters.

FW-19 Canister to Stuck Fuel Station

20 canisters with 10 barrels of stuck fuel.

FW-21 Empty Canister to Stuck Fuel Station

20 canisters.

FW-24 Empty Canisters After Stuck Fuel Removal

20 canisters.

FW-25 Empty Canisters to Debris Staging from Stuck Fuel

20 canisters.

FW-26 Removed Stuck Fuel to Canister

Fuel from FW-19.

FW-28 Canister with Formerly Stuck Fuel to Primary Cleaning

Sum of streams FW-21 and FW-26.

FW-29 Fuel in Canister to Processing Table

All fuel except bits in PCM Strainer.

FW-30 Emptied Wash Basket

Same as FW-11. Note that wash baskets are reused.

FW-31 Fuel to Sorting

This stream is the same as FW-29 minus wash basket and canister.

FW-33 Basin Water to Secondary Cleaning and Suction Wand

150 gpm continuous over the 2 year process period.

FW-35 Water/Sludge from Secondary Cleaning /Suction Wand

Same as FW-33. There is no sludge anticipated.

FW-37 Debris from Sort Area to Debris Bin

Debris from sort area not calculated but the potential flow path is observed for processing. Any observed mass will be small compared to canister debris.

FW-39 Empty Debris Bin to Fuel Sorting Area

Debris from sort area not calculated but the potential flow path is observed for processing. Any observed mass will be small compared to canister debris.

FW-41 Filled Debris Bin to Debris Staging

Debris from sort area not calculated but the potential flow path is observed for processing. Any observed mass will be small compared to canister debris.

FW-43 Fuel Bits and Scrap to Scrap Basket

This stream is, by assumption, 4% of all fuel. It includes the bits from the PCM strainer basket and scrap from the sort area.

FW-45 Fuel Directly to MCO Basket Loading and Staging

Fuel that bypasses disassembly and inspection. $FW-1 - [FW-43 + FW-47]$.

FW-47 Fuel to Disassembly

For process validation. This stream is the sum of one out of every ten canisters per ref. 12, section 4.2.

FW-49 Disassembled Fuel to Inspection

Same as FW-47.

FW-51 Dirty Fuel to Staging for Secondary Cleaning

Not normally used.

FW-52 Empty Strainer Basket

Same as FW-12.

FW-59 Secondary Cleaned Fuel to Staging

Same as FW-51.

FW-61 Clean Fuel to Staging from Disassembly/Inspection

Same as FW-49.

FW-63 Fuel to MCO Fuel Basket

85% of all fuel. See assumption 18 of drawing H-1-81164.

FW-65 Filled MCO Basket to Verification

Assume 6 baskets for SPR Fuel. MK IV fuel loaded to capacity of 54 assemblies per fuel basket, and MK IA fuel loaded to capacity of 48 assemblies per basket per ref. 5.

FW-67 Filled MCO Fuel Basket to Queue

Same as FW-65.

FW-69 Damaged Fuel to Scrap Basket

This stream is 11% of all fuel. By assumption 19, scrap is 15% of all fuel. By assumption 26, 4% is already separated in FW-43. $15\% - 4\% = 11\%$.

FW-71 Scrap Basket to Fuel Bits Loading

11% of all fuel, but the number of baskets is sufficient to hold 15% of all fuel at scrap basket loading limits.

FW-73 Filled Scrap Basket to Verification

15% of all fuel. Number of baskets same as FW-71.

FW-75 Filled Scrap Basket to MCO Basket Queue

Same as FW-73.

FW-76 Fuel Cleaning Water to Equipment Wash Station

Intermittent flow of 5 gpm. Assume 20 min/canister for equipment wash.

FW-77 Fuel Cleaning Water to Primary Cleaning

Intermittent flow of 50 gpm assume for 20 minutes per canister.

FW-78 Fuel Cleaning Water to Decapping Station

Intermittent flow of 25 gpm for decapping assume 10 min/canister.

IC-016 Basin Water

Sum of FW-14 and FW-33.

IC-017 Water/Sludge to IWTS from PCM/Decapping

Same as FW-15.

IC-022 Debris to Debris Removal

Sum of FW-25, FW-18, and FW-41.

IC-029 Oversize Fuel Bits from Sludge Removal

None anticipated.

IC-080 Debris Bin to Debris Removal

Same as FW-9.

IC-089 Empty MCO Fuel Basket

Baskets from FW-67.

IC-091 Fuel Cleaning Water to Primary Cleaning

This stream is the sum of FW-77, FW-78, and FW-76.

IC-127 Empty Scrap Basket

Number of scrap baskets from FW-75.

IC-197 Loaded Basket to MCO Loading

Sum of FW-75 and FW-67.

IC-198 Contaminated Water from Secondary Cleaning/Suction Wand to IWTS

Same as stream FW-35.

8.0 RESULTS

Results of the calculations are tabulated in Drawing H-1-81164.

9.0 CONCLUSIONS

Drawing H-1-81164 reflects the current processing strategy and configuration of the Fuel Retrieval Subproject.

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Appendix A

MS Excel Spreadsheet Calculations
And Formulas Used to Develop
Drawing H-1-81164

Stream Number	FW-1	FW-2	FW-3	FW-4	FW-5	FW-6	FW-7	FW-8	FW-9	FW-10	FW-11	FW-12	FW-14	FW-15
Description	Retrieved Canister in Staging	Loose/Spilled Fuel Retrieved from Basin	Empty Canister for Loose Fuel	Loaded Canister with Loose Fuel	Staged Canister to Decapping	Canister Gas to Offgas Treatment	Canister Lids to Debris Bin	Empty Debris Bin	Filled Debris Bin to Debris Staging	Decapped Canister to Primary Cleaning	Empty Wash Basket to Primary Cleaning	Empty Strainer Basket to Primary Cleaning	Basin Water to Decapping and Primary Cleaning	Water/Sludge from Primary Cleaning and Decapping
Phase	S	S	S	S	S	G	S	S	S	S	S		L	SL
Canisters	3841				3841					3841				
Fuel Elements	105942				105942					105942				
Canister Lids	7682				7682									
MK IA MCO Baskets														
MK IA Scrap Baskets														
MK IV MCO Baskets														
MK IV Scrap Baskets														
SPR MCO Baskets														
Wash Baskets														
PCM Strainer Baskets														
Fuel (kg)	1035000				1035000					1035000	386	193		
Sr-90 (Ci)	5170000				5170000					5170000				
CS-137 (Ci)	6640000				6640000					6640000				
U (Ci)	804				804					804				
Pu (Ci)	3470000				3470000					3470000				
Am-241 (Ci)	169000				169000					169000				
Sludge (kg)	6510				6510					6510				6510
Interstitial Water (kg)	1270				1270					1270				1270
Sr-90 (Ci)	33000				33000					33000				33000
CS-137 (Ci)	34600				34600					26613				34600
U (Ci)	5.55				5.55					5.55				5.55
Pu (Ci)	15000				15000					15000				15000
Am-241 (Ci)	1240				1240					1240				1240
water (gallons)														
Gas (l) (STP)	16300				16300								152878750	157680000
Kr-85 (Ci)	31				31									
H-3 (Ci)	3.3				3.3									

Does not include SPR fuel. Sludge data includes Cs from canister water.

Fuel is not estimated to be spilled at FRS.

Fuel is not estimated to be spilled at FRS.

Fuel is not estimated to be spilled at FRS.

Same as FW-1 See assum 25.

Assume approximately 385 bins for lid removal.

Assume 98% of canister liquor (Cs-137) is removed. See note 27.

Assume baskets emptied 1 out of every ten canisters processed. See assumption 31.

Assume baskets emptied 1 out of every twenty canisters processed. See assumption 31.

Passive airflow is FW-150 gpm 15 less the sum of FW-77 See assum. 8a and FW-78 & 8b.

All sludge plus

See assumption 31.

Stream Number	FW-16	FW-17	FW-18	FW-19	FW-21	FW-24	FW-25	FW-26	FW-28	FW-29	FW-30	FW-31	FW-33	FW-35
Description	Fuel Bits in PCM Strainer Removed from Basket to Sorting	Canister Removed from Tipping Station	Empty Canister to Debris Staging	Canister to Stuck Fuel Station	Empty Canister to Stuck Fuel Station	Empty Canisters after Stuck Fuel Removal	Empty Canisters to Debris Staging from Stuck Fuel	Removed Stuck Fuel to Canister	Canister with Formerly Stuck Fuel to Primary Cleaning	Fuel in Canister to Processing Table	Emptied Wash Basket	Fuel to Sorting	Basin Water to Secondary Cleaning & Suction Wand	Water/Sludge from Secondary Cleaning/Suction Wand
Phase	S	S	S	S	S	S	S	S	S	S	S	S	L	S/L
Canisters		3861	3841	20	20	20	20	280		3841		105836		
Fuel Elements	106	280								105836				
Canister Lids														
MK IA MCO Baskets														
MK IA Scrap Baskets														
MK IV MCO Baskets														
MK IV Scrap Baskets														
SPR MCO Baskets														
Wash Baskets														
PCM Strainer Baskets	14										386			
Fuel (kg)	1035	2691	2691	2691	2691	2691	2691	2691	2691	1034000		1034000		
Sr-90 (Ci)	5170	13442		13442				13442	13442	5165000		5165000		
CS-137 (Ci)	6640	17264		17264				17264	17264	6633000		6633000		
U (Ci)	1	2		2				2	2	803		803		
Pu (Ci)	3470	9022		9022				9022	9022	3467000		3467000		
Am-241 (Ci)	169	439		439				439	439	168800		168800		
Sludge (kg)														
Interstitial Water (kg)														
Sr-90 (Ci)														
CS-137 (Ci)														
U (Ci)														
Pu (Ci)														
Am-241 (Ci)														
water (gallons)														
Gas (l) (STP)													157680000	157680000
Kr-85 (Ci)														
H-3 (Ci)														

0.1% of fuel. 20 canisters 20 empty See assumption 6

See assumption. with 20 barrels canisters are
10. 78 of stuck fuel, recycled to
kg/strainer. See assumption. 6 collect stuck
See assumption. fuel
22

Fuel from
FW-19

FW-21 + FW-26 All fuel except Same as FW- Same as FW- See assumption 9. Same as FW-33. No
bits in PCM 29. Note that 29 less wash 150 gpm sludge anticipated.
strainer. See wash baskets baskets continuous
assumption. 10 are reused

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Appendix A

Stream Number	FW-37	FW-39	FW-41	FW-43	FW-45	FW-47	FW-49	FW-51	FW-52	FW-59	FW-61	FW-63	FW-65
Description	Debris from Sort Area to Debrin Bin	Empty Debris Bin to Fuel Sorting Area	Filled Debris Bin to Debris Staging	Fuel Bits and Scrap to Scrap Basket	Fuel Directly to MCO Basket Loading and Staging	Fuel to Disassembly	Disassembled Fuel to Inspection	Dirty Fuel for Secondary Cleaning	Empty Strainer Basket	Secondary Cleaned Fuel to Staging	Clean fuel to Staging from Disassembly/Inspection	Fuel to MCO Fuel Basket	Filled MCO Basket to Verification
Phase	S	S	S	S	S	S	S	S	S	S	S	S	S
Canisters													
Fuel Elements													
Canister Lids													
MK IA MCO Baskets													
MK IA Scrap Baskets													
MK IV MCO Baskets													
MK IV Scrap Baskets													
SPR MCO Baskets													
Wash Baskets													
PCM Strainer Baskets													
Fuel (kg)													
Sr-90 (Ci)													
CS-137 (Ci)													
U (Ci)													
Pu (Ci)													
Am-241 (Ci)													
Sludge (kg)													
Interstitial Water (kg)													
Sr-90 (Ci)													
CS-137 (Ci)													
U (Ci)													
Pu (Ci)													
Am-241 (Ci)													
water (gallons)													
Gas (l) (STP)													
Kr-85 (Ci)													
H-3 (Ci)													

Not calculated, see assump 28.

See assump 28.

See assump 28.

See assump 26.

Fuel that bypasses disassembly and inspection. See assump. 20

10% of FW-31 minus FW-43.

Same as FW-47

Not normally used.

Same as FW-12. Note that baskets 51 are reused.

Same as FW-59

Clean fuel to Staging from Disassembly/Inspection

Fuel to MCO Fuel Basket

Filled MCO Basket to Verification

85% of all fuel. See assump. 18

See assump. 3, 14, 15, 16, & 18. SPR fuel mass not included.

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Appendix A

Stream Number	FW-67	FW-69	FW-71	FW-73	FW-75	FW-76	FW-77	FW-78
Description	Filled MCO Fuel Basket to Queue	Damaged Fuel to Scrap Basket	Scrap Basket to Fuel Bits Loading	Filled Scrap Basket to Verification	Filled Scrap Basket to MCO Basket Queue	Fuel Cleaning Water to Equipment Wash Station	Fuel Cleaning Water to Primary Cleaning Station	Fuel Cleaning Water to Decapping Station
Phase	S	S	S	S	S	L	L	L
Canisters								
Fuel Elements	90051	11654	11654	15891	15891			
Canister Lids	685							
MK IA MCO Baskets			187	187	187			
MK IA Scrap Baskets	226							
MK IV MCO Baskets			57	57	57			
SPR MCO Baskets	6							
Wash Baskets								
PCM Strainer Baskets								
Fuel (kg)	879800	113850	113850	155250	155250			
Sr-90 (Ci)	4395000	568700	568700	775500	775500			
CS-137 (Ci)	5644000	730400	730400	996000	996000			
U (Ci)	683	88	88	121	121			
Pu (Ci)	2950000	381700	381700	520500	520500			
Am-241 (Ci)	143700	18590	18590	25350	25350			
Sludge (kg)								
Interstitial Water (kg)								
Sr-90 (Ci)								
CS-137 (Ci)								
U (Ci)								
Pu (Ci)								
Am-241 (Ci)								
water (gallons)						384100	3841000	960250
Gas (l) (STP)								
Kr-85 (Ci)								
H-3 (Ci)								

Same as FW-65.
11% of all fuel. See assum 19 and 26.
No. of baskets includes room for fuel bits. See assum. 29, 30.
15% of all fuel. Number of baskets same as FW-71.
Same as FW-73
Intermittent flow of about 5 gpm. See assum. 7
Intermittent flow of 25 gpm for decapping 10 min per canister. See assum. 7

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Appendix A

Stream Number	IC-016	IC-017	IC-022	IC-029	IC-080	IC-089	IC-091	IC-127	IC-197	IC-198
Description	Basin Water	Water/Sludge to IWTS from PCM/Decapign	Debris to Debris Removal	Oversize Fuel Bits from Sludge Removal	Debris Bin to Debris Removal	Empty MCO Fuel Basket	Fuel Cleaning Water to Primary Cleaning	Empty Scrap Basket	Loaded Basket to MCO Loading	Contaminated Water from Secondary Cleaning/Suction Wand to IWTS
Phase	L	S/L	S	S	S	S	L	S	S	S/L
Canisters			3861							
Fuel Elements										
Canister Life					7682				105942	
MK IA MCO Baskets						685			685	
MK IA Scrap Baskets								187	187	
MK IV MCO Baskets						226			226	
MK IV Scrap Baskets								57	57	
SPR MCO Baskets						6			6	
Wash Baskets										
Strainer Baskets										
Fuel (kg)										
Sr-90 (Ci)										
CS-137 (Ci)										
U (Ci)										
Pu (Ci)										
Am-241 (Ci)										
Sludge (kg)		6510								
Intersil Water (kg)										
Sr-90 (Ci)		1270								
CS-137 (Ci)		33000								
U (Ci)		34600								
Pu (Ci)		5.55								
Am-241 (Ci)		15000								
water (gallons)	310558750	157680000					5185350			157680000
Gas (l ³)										
Kr-85 (Ci)										
H-3 (Ci)										

Sum of FW-14 and FW-33 Same as FW-15 Sum of FW-25, FW-18, FW-41 None anticipated Same as FW-9 From FW-67 FW-77 + FW-78 + FW-76 From FW-75 All fuel Same as FW-35

MASS BALANCE ASSUMPTIONS:

- 1) Radionuclide inventories as follows:

Isotope	Total Activity	Average Activity per Assembly	Total Sludge in Canisters	Ave Sludge per Canister
Si-90 (Ci)	5.17E+06	9.76E+01	3.30E+04	8.59E+00
Cs-137 (Ci)	6.64E+06	1.25E+02	3.46E+04	9.01E+00
U-234 (Ci)	4.08E+02		2.85E+00	
U-235 (Ci)	1.60E+01		1.11E-01	
U-236 (Ci)	6.11E+01		4.14E-01	
U-238 (Ci)	3.16E+02		2.17E+00	
Total U (Ci)	8.04E+02	1.52E-02	5.55E+00	1.44E-03
Pu-238 (Ci)	5.10E+04		3.27E+02	
Pu-239 (Ci)	1.01E+05		1.24E+03	
Pu-240 (Ci)	5.53E+04		*	
Pu-241 (Ci)	3.26E+06		1.34E+04	
Total Pu (Ci)	3.47E+06	6.55E+01	1.50E+04	3.90E+00
Am-241 (Ci)	1.69E+05	3.19E+00	1.24E+03	3.23E-01
Sludge (kg)			6.51E+03	1.69E+00
Interstitial Water (kg)			1.27E+03	3.31E-01
No. of Assemblies	52971			
No. of Canisters	3841			

Notes:

- The fuel radionuclide inventories are taken from Table 4-12 (N Reactor Fuel) of HNF-SD-SNF-TI-015, Rev 6, decayed to 5/31/98.
 - The sludge radionuclide inventories are nominal values from Table 8 of HNF-SD-SNF-TI-053, Rev 0, 1/98, for sum of canister and fuel wash.
 - The canister sludge total mass inventory is taken from Table 2-2 of HNF-SD-SNF-TI-009, Vol 2, Rev 2, 7/98, and converted to wet basis using As-settled sludge density and volume of sludge for canister and fuel wash.
 - Canister count is taken from Section 3.1.1 of HNF-SD-SNF-TI-009, Vol 1, Rev 3, 10/99. No. of assemblies is [(Mark IA + Mark IV elements)/2] per footnote 3. SPR fuel is not included, mass is negligible.
 - The mass for the interstitial water is 20% of the wet sludge mass, based on HNF-SD-SNF-TI-009, Vol 2, Rev 2, 7/98, Table 2-2 data of canister and fuel wash sludge using as-settled solid content, as-settled sludge density, and volume of sludge.
- Canister inventory: 3841 (from Section 3.1.1 of HNF-SD-SNF-TI-009, Vol 1, Rev 2, 10/99)
 - Fuel element inventory (from Table 1 of HNF-SD-SNF-CN-012, Rev 0): 77,282 pieces Mark IA; 28,660 pieces Mark IV; 833 Pieces SPR Fuel.***
 - Not used
 - Canister gas composition: Tritium-620 microcuries/canister, Kr-85 -1.90 microcuries/cc average at storage depth; hydrogen 76.77 vol% average. Basis HNF-SD-SNF-TI-049, Rev 0, Table 4, and Section 4.5.
 - Canisters with stuck fuel: 20 canisters with stuck fuel at expected per SNF-4331, Rev 0; 6/99, page 22. Assume half of the fuel in these canisters is stuck.
 - Fuel Cleaning Water: Capacity for intermittent flow of 80 gpm; 50 gpm is nominal for PCM flush, 5 gpm is for equip. wash stations, and 25 gpm for decapping station. Basis IC-091, Rev 2, 11/6/97. Assume 20 min per canister for equipment wash and PCM, and 10 min per canister for decapping.

- 8a) Primary Clean Machine discharge: 80 gpm continuous with provision for shut off. Basis: IC-017, Rev 3, 5/97.
 - 8b) Decapping station discharge: 70 gpm continuous with provision for shut off. Basis: IC-017, Rev 3, 5/97.
 - 9) Process Table Downdraft: continuous 150 gpm includes secondary cleaning area and suction wand. Basis IC-198, Rev 3, 3/98.
 - 10) Percentage of fuel as fuel bits collected in PCM strainer basket: assume 0.1% of fuel in PCM.
 - 11) Not used
 - 12) Percentage of N Fuel that is Mark IA: 73% of place count per assumption 3.
 - 13) Percentage of N Fuel that is Mark IV: 27% of place count per assumption 3.
 - 14) SPR fuel in basin: 833 pieces in KW will be combined with the 138 pieces from KE and loaded by special procedure in a single MCO. Masses and isotopes of SPR fuel are not included in this PFD, except to show the single MCO. Basis: HNF-SD-SNF-CN-012, Rev 0, 6/97, Page 3.
 - 15) Mark IA fuel assemblies: 48/MCO Basket. HNF-SD-SNF-CN-012, Rev 0, 6/97, Table 1.
 - 16) Mark IV fuel assemblies: 54/MCO Basket. HNF-SD-SNF-CN-012, Rev 0, 6/97, Table 1.
 - 17) Not used
 - 18) Percentage of fuel to MCO Baskets: 85% (Ref. HNF-SD-SNF-CN-012, Rev 0, 6/97, Table 1, for nominal case)
 - 19) Percentage of fuel to Scrap Baskets: 15% (Ref. HNF-SD-SNF-CN-012, Rev 0, 6/97, Table 1, for nominal case)
 - 20) 1 in every ten canisters will be validated. (Ref. SNF-4331, Rev 0, 6/99, page 78.)
 - 21) Not used
 - 22) PCM Strainer basket capacity is 78 kg per HNF-SD-SNF-CSER-010, Rev 1, 9/99. Page 39.
 - 23) Not used
 - 24) Process time is 2.0 years with 340 operating days/yr per SNF-4331, Rev 0, 7/99, page 15.
 - 25) All canister gas is assumed released to the KW canister exhaust. In practice, some gas will be released to the basin when canisters are lifted from storage and when MK-1 canister gas traps are transferred to debris.
 - 26) Fuel scrap and bits loaded at the North Scrap Basket Station is assumed to be 4% of all fuel.
 - 27) Assume 98% of liquor removed from canister during decapping. Liquor contains approximately 8150 Ci of ¹³⁷Cs per HNF-SD-ANAL-014, Rev 0, page 1. Small amounts of potassium, nitrite and nitrate were also found in the liquid stream, approximately 60g potassium, 4g nitrite and 51g nitrate per WHC-SD-SNF-ANAL-008, Rev. 0, Table 2. Specific activity of ¹³⁷Cs is 8.699E+01 Ci/g per HNF-SD-SNF-TI-009, vol 1. Rev 2, Appendix C.
 - 28) Debris from sort area not calculated but the potential flow path is observed for processing. Any observed mass will be small compared to canister debris.
 - 29) There are a total of 187 Mark IA scrap baskets per Table 2, HNF-SD-SNF-CN-012, Rev. 0.
 - 30) There are a total of 57 Mark IV scrap baskets per Table 2, HNF-SD-SNF-CN-012, Rev. 0.
 - 31) Wash baskets and strainer baskets are reused. Assume wash baskets emptied one out of every ten canisters processed and strainer baskets one out of every twenty. These numbers depend on the rate at which baskets fill with debris. 10% and 5% are used for material balance purposes but may be changed during processing.
- * Included with Pu-239.
- *** the assembly count was not taken from HNF-SD-SNF-TI-009, Section 3.1.1 because that count included assemblies, elements, or pieces.

REVIEW CHECKLIST

SNF-5580
RWO.

Document Reviewed:

SNF-5580, Fuel Retrieval System Process Flow Diagram Mass Balance Calculations for K West Basin

Scope of Review:

Examined calculations and verified resources for input data and assumptions.

Yes No NA

- ☒ ☐ ☐ * Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
- ☐ ☐ ☒ Problem completely defined.
- ☐ ☐ ☒ Accident scenarios developed in a clear and logical manner.
- ☒ ☐ ☐ Necessary assumptions explicitly stated and supported.
- ☐ ☐ ☒ Computer codes and data files documented.
- ☒ ☐ ☐ Data used in calculations explicitly stated in document.
- ☒ ☐ ☐ Data checked for consistency with original source information as applicable.
- ☒ ☐ ☐ Mathematical derivation checked including dimensional consistency of results.
- ☐ ☐ ☒ Models appropriate and used within range of validity or use outside range of established validity justified.
- ☒ ☐ ☐ Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
- ☐ ☐ ☒ Software input correct and consistent with document reviewed.
- ☐ ☐ ☒ Software output consistent with input and with results reported in document reviewed.
- ☒ ☐ ☐ Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
- ☒ ☐ ☐ Safety margins consistent with good engineering practices.
- ☐ ☐ ☒ Conclusions consistent with analytical results and applicable limits.
- ☐ ☐ ☒ Results and conclusions address all points required in the problem statement.
- ☒ ☐ ☐ Format consistent with appropriate NRC Regulatory Guide or other standards.
- ☐ ☒ ☐ * Review calculations, comments, and/or notes are attached.
- ☒ ☐ ☐ Document approved.

Heather Boles Heather Boles
Reviewer (Printed Name and Signature)

12/15/99
Date

*Any calculations, comments, or notes generated as part of this review should be signed, dated and attached to this checklist. Such material should be labeled and recorded in such a manner as to be intelligible to a technically qualified third party.