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Nuclear Fuel
Columbia Fuel Site
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Your ref:
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Cc: Marc Rosser, Gerry Couture, Elle Binns

Date: February 21, 2012

Subject: Assessment of Public Radiological Dose from Liquid and Gaseous Effluents for Calendar Year 2011

Effluents released from plant operations are monitored to determine the quantities of radio nuclides discharged into the environment. The accumulated activities for the period starting 1-1-2011 and ending 12-31-2011 were summarized and input into dose models developed by the NRC/EPA to estimate commitment rates from the following pathways:

- Air Effluents by Direct Inhalation – Estimated by running EPA's COMPLY Code at level 2 complexity. The organ dose was estimated by calculating the X/Q factor used in the COMPLY analysis of stack number 6 using the measured release quantity and dose conversion factors from Federal Guidance Report No 11, "Limiting Values of Radionuclide Intake and Air concentration Factors for Inhalation, Submersion, and Ingestion"(FGR 11) for inhalation.
- Liquid Effluents by Ingestion of Potable Water – Estimated from formulas and recommended values in Regulatory Guide 1.109, Doses from Liquid Effluent Pathways (RG1.109). Dose conversion factors were taken from FGR 11.
- Liquid Effluents by Ingestion of Fish – Estimated from formulas and recommended values in RG 1.109. Dose conversion factors where taken from FGR 11.
- Liquid Effluents by Irradiation from Shoreline Deposits – Estimated from formulas and recommended values in RG 1.109. Dose conversion factors where taken from Federal Guidance report No 12, "External Exposure to Radionuclides in Air, Water, and Soil"

The radiological impacts were assessed by calculating the maximum total body dose and selected organ doses at the nearest site boundary.

- The inhalation dose is determined at the nearest site boundary at a distance of 595 meters.
- The ingestion dose from liquid and external dose from sediment is determined at the point at which the liquid effluent leaves the diffuser in the Congaree River.

The release rates (source term) for gaseous effluent used in all of the calculations are taken from measured values obtained from daily air samples, one per stack for 47 stacks, measured for gross alpha. The release rates (source term) for liquid effluent, used in all of the calculations, is taken from monthly composite liquid effluent samples which are sent to an off-site lab for isotopic analysis. There is potential for technetium in our feed material and the liquid effluent is also tested for this isotope. Air samples were also tested for Tc-99 and no detectable quantities were found.

The total activities measured and /or estimated for calendar year 2011 were:

401.6 μCi of Uranium released as gaseous effluent
6.9 mCi of Uranium released in liquid effluent
14.1 mCi of Technetium released in liquid effluent

For airborne effluents released into the environment, the pathways considered for the individual dose calculations included direct inhalation and an estimate of the dose to the maximally exposed organ (lung and bone). For liquid effluent releases, the pathways included potable water, aquatic food (fish) and shoreline deposition. The models and various assumptions used in the liquid effluent environmental pathways are taken from Regulatory guide 1.109 and the details of both the gaseous and liquid dose calculations are documented in the attached spreadsheets listed below:

Attachment 1:	Dose From Gaseous Effluents
Attachment 2:	Lung/Bone Organ Dose for Gaseous Effluent
Attachment 3:	Dose from Liquid Effluent Pathways Potable Water Total
Attachment 4:	Dose from Liquid Effluent Pathways Potable Water Bone
Attachment 5:	Dose from Liquid Effluent Pathways Aquatic Foods Total
Attachment 6:	Dose from Liquid Effluent Pathways Aquatic Foods Bone
Attachment 7:	Dose from Liquid Effluent Pathways Sediment
Attachment 8:	2011 Liquid Effluent Totals
Attachment 9:	Uranium Specific Activity

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The results summarized in the table below indicate that the critical pathway is due to inhalation resulting in a maximum whole body dose of 0.160 mRem/yr and a lung dose of 1.45 mRem/yr. These doses are well below both the 25 mrem annual dose limit as well as the 10 mrem ALARA limit.

Results			
Pathways	Total Body (mRem/yr)	Organ Dose (mRem/yr)	Organ Dose (mRem/yr)
		Bone	Lung
Air Effluents			
Direct inhalation*	0.16	5.50-03	1.45
Liquid Effluents			
Potable Water	1.67E-04	2.44E-03	
Aquatic Food(Fish)	1.03E-05	1.40E-04	
Shoreline Deposit	5.47E-09		
Total (mRem/Yr)	0.16	8.04E-03	1.45

* 80 % residence time

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Technical Review by Anna Pearson
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Attachment 1

Dose from Gaseous
Effluent-Total Body
Calendar Year 2011

02-21-2012

						Quantity							
	GASEOUS EFFLUENT DISCHARGES -		Calendar year 2011		Released								
	GASEOUS EFFLUENTS	Stack Height	1st half	2nd half	Total uCi					Ci/s			
	STACK IDENTIFICATION	Meter	uCi Uranium /6months	uCi URANIUM/ 6months		uCi/d	uCi/h	uCi/s	U234	U235	U238		
1	FURNACE EX LINE 1	13	3.99	4.78	8.77	2.40E-02	1.00E-03	2.78E-07	2.36E-13	8.34E-15	3.34E-14		
2	FURNACE EX LINE 2	13	3.75	4.72	8.47	2.32E-02	9.67E-04	2.69E-07	2.28E-13	8.06E-15	3.22E-14		
3	FURNACE EX LINE 3	13	4.18	4.8	8.98	2.46E-02	1.03E-03	2.85E-07	2.42E-13	8.54E-15	3.42E-14		
4	FURNACE EX LINE 4	13	3.93	4.49	8.42	2.31E-02	9.61E-04	2.67E-07	2.27E-13	8.01E-15	3.20E-14		
5	FURNACE EX LINE 5	13	4.64	6.68	11.32	3.10E-02	1.29E-03	3.59E-07	3.05E-13	1.08E-14	4.31E-14		
6	NEW DECON RM	13	2.78	28.5	31.28	8.57E-02	3.57E-03	9.92E-07	8.43E-13	2.98E-14	1.19E-13		
7	MET LAB EX	10	2.2	3.18	5.38	1.47E-02	6.14E-04	1.71E-07	1.45E-13	5.12E-15	2.05E-14		
8	INCINER EX	13	13.29	4.96	18.25	5.00E-02	2.08E-03	5.79E-07	4.92E-13	1.74E-14	6.94E-14		
9	SUPPL INC EX	13	1.88	3.67	5.55	1.52E-02	6.34E-04	1.76E-07	1.50E-13	5.28E-15	2.11E-14		
10	CONVERS 1-A EX	16	7.77	8.11	15.88	4.35E-02	1.81E-03	5.04E-07	**4.28E-13**	**1.51E-14**	**6.04E-14**		
11	CONVERSION 1-B	16	0	0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
12	S-1030-A	16	13.19	15.04	28.23	7.73E-02	3.22E-03	8.95E-07	**7.61E-13**	**2.69E-14**	**1.07E-13**		
13	S-1030-B	16	1.73	3.2	4.93	1.35E-02	5.63E-04	1.56E-07	1.33E-13	4.69E-15	1.88E-14		
14	MAINT ENCL 4B	13	0	0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
15	CONV ENCL EX 4C	13	6.66	9.94	16.60	4.55E-02	1.89E-03	5.26E-07	**4.47E-13**	**1.58E-14**	**6.32E-14**		
16	CONV ENCL EX 4D	13	0	0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
17	CONV EMERG EX 4E	13	0.99	1.61	2.60	7.12E-03	2.97E-04	8.24E-08	7.01E-14	2.47E-15	9.89E-15		
18	CHEM LAB FILTERED EX	17	7.68	8.73	16.41	4.50E-02	1.87E-03	5.20E-07	**4.42E-13**	**1.56E-14**	**6.24E-14**		
19	DECON ROOM EX	13	2.2	3.23	5.43	1.49E-02	6.20E-04	1.72E-07	**1.46E-13**	**5.17E-15**	**2.07E-14**		
20	CAL COMBGAS LN 1	12	0.53	1.52	2.05	5.62E-03	2.34E-04	6.50E-08	5.53E-14	1.95E-15	7.80E-15		
21	CAL COMBGAS LN 2	12	0.29	0.57	0.86	2.36E-03	9.82E-05	2.73E-08	2.32E-14	8.18E-16	3.27E-15		
22	CAL COMBGAS LN 3	12	0.37	0.57	0.94	2.58E-03	1.07E-04	2.98E-08	2.53E-14	8.94E-16	3.58E-15		
23	CAL COMBGAS LN 4	12	0.32	0.46	0.78	2.14E-03	8.90E-05	2.47E-08	2.10E-14	7.42E-16	2.97E-15		
24	CAL COMBGAS LN 5	12	1.14	1.28	2.42	6.63E-03	2.76E-04	7.67E-08	6.52E-14	2.30E-15	9.21E-15		
25	CHEM LAB # 2	16	1.83	4.81	6.64	1.82E-02	7.58E-04	2.11E-07	1.79E-13	6.32E-15	2.53E-14		
26	CHEM LAB #3	12	0.42	0.45	0.87	2.38E-03	9.93E-05	2.76E-08	2.34E-14	8.28E-16	3.31E-15		
27	HP LAB EX	15	0.81	0.96	1.77	4.85E-03	2.02E-04	5.61E-08	4.77E-14	1.68E-15	6.74E-15		
28	DEV LAB 1 EX	13	3.41	5.15	8.56	2.35E-02	9.77E-04	2.71E-07	2.31E-13	8.14E-15	3.26E-14		
29	DEV LAB 2 EX	12	4.15	8.26	12.41	3.40E-02	1.42E-03	3.94E-07	3.34E-13	1.18E-14	4.72E-14		
30	PELLET COMBINED	13	6.15	7.19	13.34	3.65E-02	1.52E-03	4.23E-07	**3.60E-13**	**1.27E-14**	**5.08E-14**		
31	SOLV X N	13	3.86	4.52	8.38	2.30E-02	9.57E-04	2.66E-07	2.26E-13	7.97E-15	3.19E-14		
32	SOLV X S	13	2.19	3.22	5.41	1.48E-02	6.18E-04	1.72E-07	1.46E-13	5.15E-15	2.06E-14		
34	MAP COMBINED	15	0	0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
35	ABF HOOD TORIT EX	12	2.31	3.01	5.32	1.46E-02	6.07E-04	1.69E-07	1.43E-13	5.06E-15	2.02E-14		
36	IFBA EX	10	5.89	6.02	11.91	3.26E-02	1.36E-03	3.78E-07	**3.21E-13**	**1.13E-14**	**4.53E-14**		
37	MAINT WELD EX	11	3.51	4.18	7.69	2.11E-02	8.78E-04	2.44E-07	2.07E-13	7.32E-15	2.93E-14		
38	AC-3	15	4.83	5.36	10.19	2.79E-02	1.16E-03	3.23E-07	2.75E-13	9.69E-15	3.88E-14		
39	PELLET LINE 6	12	3.87	3.8	7.67	2.10E-02	8.76E-04	2.43E-07	2.07E-13	7.30E-15	2.92E-14		
40	AC-5	17	4.73	5.53	10.26	2.81E-02	1.17E-03	3.25E-07	2.77E-13	9.76E-15	3.90E-14		
41	AC-8	11	4.93	5.5	10.43	2.86E-02	1.19E-03	3.31E-07	2.81E-13	9.92E-15	3.97E-14		
42	AMMONIA FUME SC 1008-A	17	3.21	4.27	7.48	2.05E-02	8.54E-04	2.37E-07	2.02E-13	7.12E-15	2.85E-14		
43	AMMONIA FUME SC 1008-B	17	0	0	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		
44	AC-4	15	6.67	5.25	11.92	3.27E-02	1.36E-03	3.78E-07	3.21E-13	1.13E-14	4.54E-14		
45	HOT OIL RM EX	12	7.8	13.22	21.02	5.76E-02	2.40E-03	6.67E-07	**5.67E-13**	**2.00E-14**	**8.00E-14**		
46	ERBIA FURNACE EX	18	10.16	10.33	20.49	5.61E-02	2.34E-03	6.50E-07	**5.52E-13**	**1.95E-14**	**7.80E-14**		
47	ERBIA SCRUBBER EX	18	5.39	5.53	10.92	2.99E-02	1.25E-03	3.46E-07	2.94E-13	1.04E-14	4.16E-14		
48	ERBIA CHANGE ROOM	18	2.54	2.83	5.37	1.47E-02	6.13E-04	1.70E-07	1.45E-13	5.11E-15	2.04E-14		
					401.60				1.08E-11	3.82E-13	**1.53E-12**		
											Sum of Offsite Dose		
									0.20	**mRem/yr**			
									0.16	80% residence time			
								Result is substantially less than 10 mRem/yr					

Lung/Bone Organ
Dose
For Gaseous Effluent
Calendar Year 2011

	2011			Released	EPA				
	GASEOUS EFFLUENTS	1st half	2nd half	Total uCi	Comply Run Results				
	STACK IDENTIFICATION	uCi Uranium /6months	uCi URANIUM/ 6months		Dose, Mrem/yr				
6	New Decon Rm	2.78	28.5	31.28	1.70E-02				
	use highest release for year to calculate X/Q used by COMPLY								
	Dose from comply	0.01700	mrem/yr			13 meters			
	release quantity	31.28	uCi/yr						
	Inhalation from RG1.109	3.13E-05	Ci/yr			Ci/s			
						U-234	U-235	U-238	
	App E table E-5	8000.00	m3/yr			8.43E-13	2.98E-14	1.19E-13	
	Effective Dose conversion								
	EPA FGR 11 p150-151								
	U-234	3.58E-05	Sv/Bq	85%					
	U-235	3.32E-05	Sv/Bq	3%					
	U-238	3.20E-05	Sv/Bq	12%					
	weighted dose conversion	3.53E-05	Sv/Bq						
	conversion factor	3700.00	mrem/pCi= factor* Sv/Bq						
	weighted dose conversion	0.1305	mrem/pCi						
				equations					
	Dose (mrem/yr) = R(a)*3.17e4*Q*(X/Q)*effective Dose conversion			see RG1.109-25					
	Dose (mrem/yr)/(R(a)*3.17e4*Q*effective Dose conversion)=(X/Q)								
		1.64E-05	X/Q						
	Estimate Lung Dose using X/Q and total released for 2011				Estimate Bone Dose using X/Q and total released for 2011				
	App E table E-5								
	Lung Organ Dose conversion								
	EPA FGR 11 p150-151								
	U-234	2.98E-04	Sv/Bq	85%	1.13E-06	Sv/Bq			
	U-235	2.76E-04	Sv/Bq	3%	1.05E-06	Sv/Bq			
	U-238	2.66E-04	Sv/Bq	12%	1.01E-06	Sv/Bq			
	weighted dose conversion	2.93E-04	Sv/Bq		1.11E-06	Sv/Bq			
	conversion factor	3700.00	mrem/pCi= factor* Sv/Bq		3700.00	m/pCi= factor* Sv/Bq			
	weighted dose conversion	1.0846	mrem/pCi		4.11E-03	mrem/pCi			
	release quantity	401.60	uCi/yr		401.60	uCi/yr			
		4.02E-04	Ci/yr		4.02E-04	Ci/yr			
	Lung *	**1.45**	**mrem/yr**	**Bone ***	**5.50E-03**	**mrem/yr**			
		assume 80% residence							

Doses from Liquid Effluent Pathway																					
Potable Water		Whole Body-Ingestion																			
730	liters	Usage by adult	U	10CFR20	7.3 x 10^5 (ml) which is the annual water intake of "Reference Man."																
31293	mixing - dilution	Dilution at difuser	M																		
				Congaree Flow		9388	cubic feet/sec	see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1985													
0.3	cubic ft/sec	Average discharge	F	Effluent Flow		3.00E-01	cubic feet/sec														
									effective	bone	effective	bone									
2.83E-04	U-234	mRem/pCi	D	EPA Limiting Values of Radioanuclide Intake.....					Sv/Bq	Sv/Bq	mRem/pCi	mRem/pCi									
2.66E-04	U-235	mRem/pCi	D	FRG no 11	1988			U-234	7.66E-08	1.13E-06	2.83E-04	4.18E-03		for comaprison only							
2.69E-04	U-236	mRem/pCi	D	Exposure-to-dose conversion factors for ingestion				U-235	7.19E-08	1.05E-06	2.66E-04	3.88E-03									
2.55E-04	U-238	mRem/pCi	D					U-236	7.26E-08	1.07E-06	2.69E-04	3.96E-03		Part 20 table 2		soluble forms					
1.46E-06	Tc-99	mRem/pCi	D					U-238	6.88E-08	1.01E-06	2.55E-04	3.74E-03		Dose Conversion							
								Tc-99	3.95E-10	6.04E-11	1.46E-06	2.23E-07			uCi/ml	milliters	uCi	pCi	mRem	mRem/pC
12	hrs	transit time	t-p	reg guide 1.109	table E-15									U-234	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04	
														U-235	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04	
3.23557E-10	U-234	decay const	λ	Nuclide		T(1/2) yr	T(1/2) hr	λ						U-236	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04	
1.12404E-13	U-235	decay const	λ	URANIUM234		2.45E+05	2.14E+09	3.24E-10						U-238	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04	
3.38075E-12	U-236	decay const	λ	URANIUM235		7.04E+08	6.17E+12	1.12E-13						Tc-99	6.00E-05	7.30E+05	4.38E+01	4.38E+07	50	1.14E-06	
1.77058E-14	U-238	decay const	λ	URANIUM236		2.34E+07	2.05E+11	3.38E-12													
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14						ICRP 69	Comparison						
				TC-99		2.13E+05	1.87E+09	3.71E-10													
0.9999999961	U-234	exp(-λt-p)													Sv/Bq	Rem/Bq	mRem/pCi				
1.0000000000	U-235	exp(-λt-p)																			
1.0000000000	U-236	exp(-λt-p)												adult	5.00E-08	0.005	1.85E-04				
1.0000000000	U-238	exp(-λt-p)												infant	3.70E-07	0.037	1.37E-03				
0.9999999955	Tc-99	exp(-λt-p)												bone-adult	7.90E-07	0.079	2.92E-03				
Annual Release rate																					
0.0069230	total uranium(Ci)	Q		summation of liquid effluent alpha activity for 2011		see Total Liq tab															
				% of activity based on current nominal uranium isotopic				see u activity tab													
5.8914E-03	U-234 release fraction	Ci	URANIUM234	85.100%																	
2.2154E-04	U-235 release fraction	Ci	URANIUM235	3.200%																	
6.9230E-06	U-236 release fraction	Ci	URANIUM236	0.100%																	
8.0306E-04	U-238 release fraction	Ci	URANIUM238	11.600%																	
1.4089E-02	Tc-99 release fraction	Ci	TC-99																		
check U sum	0.00692																				
1.67E-06	U-234	release fraction *dose factor*exp(-λ*tp)																			
5.89E-08	U-235	release fraction *dose factor*exp(-λ*tp)																			
1.86E-09	U-236	release fraction *dose factor*exp(-λ*tp)																			
2.04E-07	U-238	release fraction *dose factor*exp(-λ*tp)																			
2.06E-08	Tc-99	release fraction *dose factor*exp(-λ*tp)																			
1.96E-06	all nuclides	sum of nuclides																			
85.53473	usage	1100*(usage*dilution)/flow																			
1.67E-04	mRem/yr	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.																			

Doses from Liquid Effluent Pathway

Potable Water — **Bone Surface-Ingestion**

730	liters	Usage by adult	U	10CFR20	7.3 x 10^3 (ml) which is the annual water intake of "Reference Man."																
31293	mixing - dilution	Dilution at difuser	M																		
				Congaree Flow		9388	cubic feet/sec		see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1985												
0.3	cubic ft/sec	Average discharge	F	Effluent Flow		3.00E-01	cubic feet/sec														
									effective	bone	effective	bone									
4.18E-03	U-234	mRem/pCi	D-bone	EPA Limiting Values of Radioanuclide Intake.....					Sv/Bq	Sv/Bq	mRem/pCi	mRem/pCi		Part 20 table 2		soluble forms					
3.88E-03	U-235	mRem/pCi	D-bone	FRG no 11	1988			U-234	7.66E-08	1.13E-06	2.83E-04	4.18E-03		Dose Conversion							
3.96E-03	U-236	mRem/pCi	D-bone	Exposure-to-dose conversion factors for ingestion				U-235	7.19E-08	1.05E-06	2.66E-04	3.88E-03			uCi/ml	milliters	uCi	pCi	mRem	mRem/pCi
3.74E-03	U-238	mRem/pCi	D-bone					U-236	7.26E-08	1.07E-06	2.69E-04	3.96E-03		U-234	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
2.23E-07	Tc-99	mRem/pCi	D-bone					U-238	6.88E-08	1.01E-06	2.55E-04	3.74E-03		U-235	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
								Tc-99	3.95E-10	6.04E-11	1.46E-06	2.23E-07		U-236	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
12	hrs	transit time	t-p	reg guide	table E-15									U-238	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
														Tc-99	6.00E-05	7.30E+05	4.38E+01	4.38E+07	50	1.14E-06
3.23557E-10	U-234	decay const	λ	Nuclide		T(1/2) yr	T(1/2) hr	λ													
1.12404E-13	U-235	decay const	λ	URANIUM234		2.45E+05	2.14E+09	3.24E-10						ICRP 69	Comparison						
3.38075E-12	U-236	decay const	λ	URANIUM235		7.04E+08	6.17E+12	1.12E-13													
1.77058E-14	U-238	decay const	λ	URANIUM236		2.34E+07	2.05E+11	3.38E-12							Sv/Bq	Rem/Bq	mRem/pCi				
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14													
				TC-99		2.13E+05	1.87E+09	3.71E-10						adult	5.00E-08	0.005	1.85E-04				
0.9999999961	U-234	exp(-λt-p)												infant	3.70E-07	0.037	1.37E-03				
1.0000000000	U-235	exp(-λt-p)												bone-adult	7.90E-07	0.079	2.92E-03				
1.0000000000	U-236	exp(-λt-p)																			
1.0000000000	U-238	exp(-λt-p)																			
0.9999999955	Tc-99	exp(-λt-p)																			
Annual Release rate																					
0.0069230	total uranium(Ci)	Q		summation of liquid effluent alpha activity			see Total Liq tab														
				% of activity based on current nominal uranium isotop			see u activity tab														
5.8914E-03	U-234 release fraction	Ci	URANIUM234	85.100%																	
2.2154E-04	U-235 release fraction	Ci	URANIUM235	3.200%																	
6.9230E-06	U-236 release fraction	Ci	URANIUM236	0.100%																	
8.0306E-04	U-238 release fraction	Ci	URANIUM238	11.600%																	
1.4089E-02	Tc-99 release fraction	Ci	TC-99																		
check U sum	0.00692																				
2.46E-05	U-234	release fraction *dose factor*exp(-λ*tp)																			
8.61E-07	U-235	release fraction *dose factor*exp(-λ*tp)																			
2.74E-08	U-236	release fraction *dose factor*exp(-λ*tp)																			
3.00E-06	U-238	release fraction *dose factor*exp(-λ*tp)																			
3.15E-09	Tc-99	release fraction *dose factor*exp(-λ*tp)																			
2.85E-05	all nuclides	sum of nuclides																			
85.53473	usage	1100*(usage*dilution)/flow																			
2.44E-03	mRem/yr	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.																			

Doses from Liquid Effluent Pathway																				
Aquatic Foods		**Whole Body**																		
21	Kg	Usage by adult	U	see regulatory guide 1.109 page 1.109-40 table E-5, Recommended Values for U(ap)																
31293	mixing - dilution	Dilution at difuser	M	Congaree Flow		9388	cubic feet/sec		see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1985											
0.3	cubic ft/sec	Average discharge	F	Effluent Flow		3.00E-01	cubic feet/sec													
									effective	bone	effective	bone								
2.83E-04	U-234	mRem/pCi	D	EPA Limiting Values of Radioanuclide Intake.....					Sv/Bq	Sv/Bq	mRem/pCi	mRem/pCi								
2.66E-04	U-235	mRem/pCi	D	FRG no 11 1988				U-234	7.66E-08	1.13E-06	2.83E-04	4.18E-03		for comaprison only						
2.69E-04	U-236	mRem/pCi	D	Exposure-to-dose conversion factors for ingestion				U-235	7.19E-08	1.05E-06	2.66E-04	3.88E-03								
2.55E-04	U-238	mRem/pCi	D					U-236	7.26E-08	1.07E-06	2.69E-04	3.96E-03		Part 20 table 2		soluble forms				
1.46E-06	Tc-99	mRem/pCi	D					U-238	6.88E-08	1.01E-06	2.55E-04	3.74E-03		Dose Conversion						
								Tc-99	3.95E-10	6.04E-11	1.46E-06	2.23E-07			uCi/ml	milliliters	uCi	pCi	mRem	mRem/pC
24	hrs	transit time	t-p	reg guide	table E-15									U-234	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
														U-235	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
3.23557E-10	U-234	decay const	λ	Nuclide		T(1/2) yr	T(1/2) hr	λ						U-236	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
1.12404E-13	U-235	decay const	λ	URANIUM234		2.45E+05	2.14E+09	3.24E-10						U-238	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
3.38075E-12	U-236	decay const	λ	URANIUM235		7.04E+08	6.17E+12	1.12E-13						To-99	6.00E-05	7.30E+05	4.38E+01	4.38E+07	50	1.14E-06
1.77058E-14	U-238	decay const	λ	URANIUM236		2.34E+07	2.05E+11	3.38E-12												
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14						ICRP 69	Comparison					
				TC-99		2.13E+05	1.87E+09	3.71E-10												
0.99999999223	U-234	exp(-λt-p)													Sv/Bq	Rem/Bq	mRem/pCi			
1.00000000000	U-235	exp(-λt-p)																		
0.99999999992	U-236	exp(-λt-p)												adult	5.00E-08	0.005	1.85E-04			
1.00000000000	U-238	exp(-λt-p)												infant	3.70E-07	0.037	1.37E-03			
0.99999999109	Tc-99	exp(-λt-p)												bone-adult	7.90E-07	0.079	2.92E-03			
Annual Release rate																				
0.0069230	total uranium(Ci)	Q		summation of liquid effluent alpha activity for 2011		see Total Liq tab														
				% of activity based on current nominal uranium isotopic				see u activity tab												
5.8914E-03	U-234 release fraction	Ci	URANIUM234	85.100%																
2.2154E-04	U-235 release fraction	Ci	URANIUM235	3.200%																
6.9230E-06	U-236 release fraction	Ci	URANIUM236	0.100%																
8.0306E-04	U-238 release fraction	Ci	URANIUM238	11.600%																
1.4089E-02	Tc-99 release fraction	Ci	TC-99																	
check U sum	0.00692																			
							bioaccumulation factor		BNWL-2075											
3.34E-06	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		UC-11											
1.18E-07	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Methodology for Calculation of Radiation Doses											
3.72E-09	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		in the Environs from Nuclear Fuel											
4.09E-07	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Cycle Facilities											
3.09E-07	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					15													
4.18E-06	all nuclides	sum of nuclides																		
2.46059	usage	1100*(usage*dilution)/flow																		
1.03E-05	mRem/yr	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.																		

Doses from Liquid Effluent Pathway																						
Aquatic Foods	**Bone**																					
21	Kg	Usage by adult	U	see regulatory guide 1.109 page 1.109-40 table E-5, Recommended Values for U(ap)																		
31293	mixing - dilution	Dilution at difuser	M	Congaree Flow			9388	cubic feet/sec		see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1985												
0.3	cubic ft/sec	Average discharge	F	Effluent Flow			3.00E-01	cubic feet/sec														
										effective	bone	effective	bone		for comaprison only							
4.18E-03	U-234	mRem/pCi	D	EPA Limiting Values of Radioanuclide Intake.....						Sv/Bq	Sv/Bq	mRem/pCi	mRem/pCi									
3.88E-03	U-235	mRem/pCi	D	FRG no 11	1988				U-234	7.66E-08	1.13E-06	2.83E-04	4.18E-03		Part 20 table 2		soluble forms					
3.96E-03	U-236	mRem/pCi	D	Exposure-to-dose conversion factors for ingestion					U-235	7.19E-08	1.05E-06	2.66E-04	3.88E-03		Dose Conversion							
3.74E-03	U-238	mRem/pCi	D						U-236	7.26E-08	1.07E-06	2.69E-04	3.96E-03			uCi/ml	milliters	uCi	pCi	mRem	mRem/pC
2.23E-07	Tc-99	mRem/pCi	D						U-238	6.88E-08	1.01E-06	2.55E-04	3.74E-03		U-234	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
									Tc-99	3.95E-10	6.04E-11	1.46E-06	2.23E-07		U-235	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
24	hrs	transit time	t-p	reg guide 1.109	table E-15										U-236	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
															U-238	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50	2.28E-04
3.23557E-10	U-234	decay const	λ	Nuclide		T(1/2) yr	T(1/2) hr	λ							Tc-99	6.00E-05	7.30E+05	4.38E+01	4.38E+07	50	1.14E-06
1.12404E-13	U-235	decay const	λ	URANIUM234		2.45E+05	2.14E+09	3.24E-10													
3.38075E-12	U-236	decay const	λ	URANIUM235		7.04E+08	6.17E+12	1.12E-13							ICRP 69	Comparison					
1.77058E-14	U-238	decay const	λ	URANIUM236		2.34E+07	2.05E+11	3.38E-12									Sv/Bq	Rem/Bq	mRem/pCi		
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14													
				TC-99		2.13E+05	1.87E+09	3.71E-10													
0.99999999223	U-234	exp(-λt-p)													adult	5.00E-08	0.005	1.85E-04			
1.00000000000	U-235	exp(-λt-p)													infant	3.70E-07	0.037	1.37E-03			
0.99999999992	U-236	exp(-λt-p)													bone-adult	7.90E-07	0.079	2.92E-03			
1.00000000000	U-238	exp(-λt-p)																			
0.99999999109	Tc-99	exp(-λt-p)																			
Annual Release rate																					
0.0069230	total uranium(C	Q		summation of liquid effluent alpha activity for 2011		see Total Liq tab															
				% of activity based on current nominal uranium isotopic					see u activity tab												
5.8914E-03	U-234 release fra	Ci		URANIUM234	85.100%																
2.2154E-04	U-235 release fra	Ci		URANIUM235	3.200%																
6.9230E-06	U-236 release fra	Ci		URANIUM236	0.100%																
8.0306E-04	U-238 release fra	Ci		URANIUM238	11.600%																
1.4089E-02	Tc-99 release fra	Ci		TC-99																	
check U sum	0.00692																				
								bioaccumulation factor		BNWL-2075											
4.93E-05	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			UC-11											
1.72E-06	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			Methodology for Calculation of Radiation Doses											
5.48E-08	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			in the Environs from Nuclear Fuel											
6.00E-06	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			Cycle Facilities											
4.72E-08	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					15														
5.71E-05	all nuclides	sum of nuclides																			
2.46059	usage	1100*(usage*dilution)/flow																			
1.40E-04	mRem/yr	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.																			

Doses from Liquid Effluent Pathway															
Shore Line Deposits		**Whole Body**													
12	hr	Usage by adult	U	see regulatory guide 1.109 page 1.109-40 table E-5, Recommended Values for U(ap)											
31293	mixing - dilution	Dilution at difuser	M												
				Congaree Flow		9388	cubic feet/sec			see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1					
0.3	cubic ft/sec	Average discharge	F	Effluent Flow		3.00E-01	cubic feet/sec								
					Sv/s:Bq/m^2	mrem/hr:pCi/m^2									
9.86E-12	U-234	mRem*m^2/pCi*hr	D	U-234	7.40E-19	9.86E-12	EPA FRG 12			Dose Coeff for exposure to contaminated ground surface					
1.97E-09	U-235	mRem*m^2/pCi*hr	D	U-235	1.48E-16	1.97E-09									
8.66E-12	U-236	mRem*m^2/pCi*hr	D	U-236	6.50E-19	8.66E-12									
7.34E-12	U-238	mRem*m^2/pCi*hr	D	U-238	5.51E-19	7.34E-12									
1.04E-12	Tc-99	mRem*m^2/pCi*hr	D	Tc-99	7.80E-20	1.04E-12									
12	hrs	transit time	t-p	see regulatory guide 1.109 page 1.109-69 table E-15, Recommended Values ...									t-i		
131040	hrs	xposure time of sedime	t-b	page 1.109-68			Nuclide		T(1/2) yr	T(1/2) hr	λ	T(1/2) day			
3.23557E-10	U-234	decay const	λ				URANIUM234		2.45E+05	2.14E+09	3.24E-10	8.90E+07			
1.12404E-13	U-235	decay const	λ				URANIUM235		7.04E+08	6.17E+12	1.12E-13	2.56E+11			
3.38075E-12	U-236	decay const	λ				URANIUM236		2.34E+07	2.05E+11	3.38E-12	8.52E+09			
1.77058E-14	U-238	decay const	λ				URANIUM238		4.47E+09	3.91E+13	1.77E-14	1.63E+12			
3.71407E-10	Tc-99	decay const	λ				TC-99		2.13E+05	1.87E+09	3.71E-10	7.75E+07			
0.0000423980	U-234	exp(-λt-p)*[1-exp(-λt-b)]													
0.0000000147	U-235	exp(-λt-p)*[1-exp(-λt-b)]													
0.0000004430	U-236	exp(-λt-p)*[1-exp(-λt-b)]													
0.0000000023	U-238	exp(-λt-p)*[1-exp(-λt-b)]													
0.0000486679	Tc-99	exp(-λt-p)*[1-exp(-λt-b)]													
Annual Release rate															
0.0069230	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2011			**see Total Liq tab**									
				% of activity based on current nominal uranium isotopic				**see u activity tab**							
5.8914E-03	U-234 release fraction	Ci	URANIUM234	85.100%											
2.2154E-04	U-235 release fraction	Ci	URANIUM235	3.200%											
6.9230E-06	U-236 release fraction	Ci	URANIUM236	0.100%											
8.0306E-04	U-238 release fraction	Ci	URANIUM238	11.600%											
1.4089E-02	Tc-99 release fraction	Ci	TC-99												
check U sum	0.00692														
2.19E-10	U-234	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
1.65E-09	U-235	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
2.26E-13	U-236	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
2.22E-11	U-238	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
5.52E-11	Tc-99	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
1.94E-09	all nuclides	sum of nuclides													
2.812101	usage	11000*(usage*dilution*shore width factor)/flow		see regulatory guide 1.109 page 1.109-40 table A-2,Shore width...											
5.47E-09	**mRem/yr**	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.													

Attachment 8

2011 Liquid Effluent
Totals

02-21-2012

FIRST HALF LIQUID DISCHARGES

Radionuclide	Volume(ml)	uCi/ml		Error	LLD,uCi/ml		Quantity Released, uCi	Ci
U234	6.211E+10	4.12459E-08	+/-	3.55E-09	6E-10		2561.9	2.5619E-03
U235		1.45574E-09	+/-	8.06E-10	6E-10		90.4	9.0421E-05
U238		5.82294E-09	+/-	1.36E-09	6E-10		361.7	3.6168E-04
Tc-99		1.17197E-07	+/-	1.28E-07	6E-10	**subtotal Tc99**	**7279.6**	**7.2796E-03**
						subtotal U	**3014.0**	**3.0140E-03**

SECOND HALF LIQUID DISCHARGES

Radionuclide	Volume(ml)	uCi/ml		Error	LLD,uCi/ml		Quantity Released, uCi	Ci
U234	7.065E+10	4.70312E-08	+/-	3.32E-09	6E-10		3322.6	3.3226E-03
U235		1.65992E-09	+/-	7.91E-10	6E-10		117.3	1.1727E-04
U238		6.63969E-09	+/-	1.33E-09	6E-10		469.1	4.6907E-04
Tc-99		9.63888E-08	+/-	5.44E-09	6E-10	**subtotal Tc99**	**6809.5**	**6.8095E-03**
						Subtotal U	**3908.9**	**3.9089E-03**

Total	Volume(ml)						Quantity Released, uCi	Ci
U234	1.328E+11	4.43244E-08					5884.5	5.8845E-03
U235		1.56439E-09					207.7	2.0769E-04
U238		6.25757E-09					830.8	8.3076E-04
Tc-99		1.06124E-07					14089.1	1.4089E-02
						total U	6.923E+03	6.9230E-03
						total TC99	1.409E+04	1.4089E-02

U234	0.851		5.8914E-03
U235	0.032		2.2154E-04
U236	0.001		6.9230E-06
U238	0.116		8.0306E-04
Tc-99	1		1.4089E-02

2011 **First HALF LIQUID EFFLUENT RADIOACTIVITY DISCHARGES - NRC**

Month	Average kgal/day	kgal/month	Isotopic uCi/ml E-06 U234 piC/l	U234	U235 piC/l	U235	U238 piC/l	U238	SUM ISO (Tc-99 piC/l	Tc-99	Sum U & Tc	Total uCi/month U234	U-235	U-238	Tc-99	
JAN	86.285	2588.540	50.800	0.051	1.860	0.002	7.420	0.007	0.06008	191	0.191	0.251	514.312	18.831	75.122	1933.732	
FEB	110.745	2436.387	36.400	0.036	2.120	0.002	4.320	0.004	0.04284	104	0.104	0.147	427.218	24.882	50.703	1220.623	
MAR	101.406	3143.570	22.500	0.023	0.634	0.001	3.770	0.004	0.026904	132	0.132	0.159	267.716	7.544	44.857	1570.598	
APR	104.329	2816.890	24.700	0.025	1.060	0.001	4.540	0.005	0.0303	118	0.118	0.148	292.610	12.557	53.783	1397.894	
MAY	92.517	2497.960	32.900	0.033	1.420	0.001	4.870	0.005	0.03919	64.2	0.0642	0.103	357.145	15.415	52.866	696.922	
JUNE	97.571	2927.140	62.000	0.062	2.230	0.002	7.840	0.008	0.07207	41.5	0.0415	0.114	686.910	24.707	86.861	459.786	
													2545.910	103.935	364.192		3014.038 uCi U
		16410.487	KGAL/6 MONTHS									4.173%	2561.932	90.421	361.685	7279.555	10293.593 uCi U & Tc
		1.641E+07	gal/6months														
		6.211E+07	LITERS/6 MONTHS														
		6.211E+10	ML/6 MONTHS														

	Isoptopic Error U234 piC/l	U234	xE-06 uCi/ml U235 piC/l	U235	U238 piC/l	U238	Tc-99 piC/l	Tc-99
JAN	4.090	0.00409	0.885	0.000885	1.57	0.00157	127	0.127
FEB	3.080	0.00308	0.844	0.000844	1.09	0.00109	121	0.121
MAR	2.780	0.00278	0.531	0.000531	1.15	0.00115	116	0.116
APR	2.470	0.00247	0.58	0.00058	1.06	0.00106	118	0.118
MAY	3.140	0.00314	0.732	0.000732	1.21	0.00121	96.2	0.0962
JUNE	3.850	0.00385	0.813	0.000813	1.37	0.00137	116	0.116

	U234	U-235	U-238	Tc-99
JAN	41.408	8.960	15.895	1285.780
FEB	40.022	10.967	14.164	1572.306
MAR	32.011	6.114	13.242	1335.700
APR	30.236	7.100	12.976	1444.490
MAY	34.789	8.110	13.406	1065.818
JUNE	41.794	8.826	14.872	1259.236
TOTAL	220.260	50.077	84.554	7963.329 8318.221

FIRST HALF LIQUID DISCHARGES

Radionuclide	uCi/ml		Error	LLD,uCi/ml	Quantity Released, uCi	Ci	
U234	4.12E-08	+/-	3.55E-09	6.00E-10	2561.9	0.002562	
U235	1.46E-09	+/-	8.06E-10	6.00E-10	90.4	9.04E-05	
U238	5.82E-09	+/-	1.36E-09	6.00E-10	361.7	0.000362	0.003014
Tc-99	1.172E-07	+/-	1.262E-07	6.00E-10	7279.555	0.00728	1.213259 mCi/month
				sum	10293.6		

*** Fill in blue cells**

*** Yellow cells contain reporting data**

2011 **Second HALF LIQUID EFFLUENT RADIOACTIVITY DISCHARGES - NRC**

Month	Average kgal/day	kgal/month	Isotopic U234 piC/l	uCi/ml E-06 U234	U235 piC/l	uCi/ml E-06 U235	U238 piC/l	uCi/ml E-06 U238	SUM ISO I	Tc-99 piC/	uCi/ml E-06 Tc-99	Sum U & Tc	Total uCi/month U234	U-235	U-238	Tc-99	
JULY	84.584	2283.770	53.100	0.053	2.420	0.002	8.120	0.008	0.06364	101	0.101	0.165	527.00	24.018	80.588	1002.391	
AUG	115.271	3458.130	70.600	0.071	2.570	0.003	12.900	0.013	0.08607	165	0.165	0.251	954.89	34.760	174.477	2015.709	
SEPT	104.907	3147.220	60.400	0.060	2.530	0.003	9.560	0.010	0.07249	111	0.111	0.183	719.50	30.138	113.881	1366.328	
OCT	110.438	3423.560	25.000	0.025	1.870	0.002	4.470	0.004	0.03134	136	0.136	0.167	323.96	24.232	57.923	1705.472	
NOV	100.662	3019.870	28.900	0.029	1.320	0.001	3.350	0.003	0.03357	32.2	0.0322	0.066	330.33	15.088	38.291	380.320	
DEC	107.495	3332.350	30.800	0.031	1.230	0.001	4.430	0.004	0.03646	27.8	0.0278	0.064	388.48	15.514	55.875	339.328	
													3244.150	143.749	521.035		3908.934 uCi U
		18664.900	KGAL/6 MONTHS										@4.173 % 3322.594	117.268	469.072	6809.549	10718.483 uCi U & Tc
		1.866E+07	gal/6months														
		7.065E+07	LITERS/6 MONTHS														
		7.065E+10	ML/6 MONTHS														

	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
	36.62201	70.06117	42.16915	29.54479	27.77531	28.12682	234.3
	8.763478	14.87786	9.577401	8.954146	6.789521	6.924496	55.9
	14.39076	29.89096	16.79619	12.47879	9.544192	10.96063	94.1
							384.2
							768.495

Isoptopic Error xE-06 uCi/ml

	U234 piC/l	U234	U235 piC/l	U235	U238 piC/l	U238	Tc-99 piC/	Tc-99
JULY	3.69	0.00369	0.883	0.000883	1.45	0.00145	98.3	0.0983
AUG	5.18	0.00518	1.1	0.0011	2.21	0.00221	126	0.126
SEPT	3.54	0.00354	0.804	0.000804	1.41	0.00141	95.4	0.0954
OCT	2.28	0.00228	0.691	0.000691	0.963	0.000963	132	0.132
NOV	2.43	0.00243	0.594	0.000594	0.835	0.000835	96.3	0.0963
DEC	2.23	0.00223	0.549	0.000549	0.869	0.000869	134	0.134

SECOND HALF LIQUID DISCHARGES

Radionuclide	uCi/ml		Error	LLD,uCi/ml		Quantity Released, uCi
U234	4.70E-08	+/-	3.32E-09	6.00E-10		3322.6
U235	1.66E-09	+/-	7.91E-10	6.00E-10		117.3
U238	6.64E-09	+/-	1.33E-09	6.00E-10		469.1
Tc-99	9.639E-08	+/-	5.439E-09	6.00E-10		6809.549
					sum	10718.5

*** Fill in blue cells**

*** Yellow cells contain reporting data**

Based on 2011 nominals - 235 established by safeguards personnel, 234 and 236 by average pellet chemistry in 2010-2011 and 238 by diff

Nuclid	Concent. U-235 Bas	Wt% U Basis	uCi/g Nuclide	uCi/g	Bq/g	Nuclide % Activity	
U-232	0.00	**0.00E+00**	21300000	0.000	0.00E+00	0.000	
U-233	0.00	**0.00E+00**	9480	0.000	0.00E+00	0.000	
U-234	9,106	**0.0380**	6234	2.369	8.77E+04	0.851	0.85
U-235		**4.173**	2.14	0.089	3.31E+03	0.032	0.03
U-236	1,438	**0.00600**	64.7	0.004	1.44E+02	0.001	0.00
U-238		**95.783**	0.34	0.322	1.19E+04	0.116	0.12
Totals		100.000		2.784	103014.360	1.000	