Attachment A

Attachment A: 40-Year License Renewal Site Visit Meeting Summary
August 18-19, 2015

Introduction

On December 17, 2014, Westinghouse Electric Company LLC (Westinghouse) submitted an application to renew Special Nuclear Materials (SNM) license, SNM-1107, for a period of 40 years. As part of the application, Westinghouse submitted an environmental report. The staff of the U.S. Nuclear Regulatory Commission (NRC) visited the Columbia Fuel Fabrication Facility (CFFF) on August 18-19, 2015. During that time, the NRC staff toured the CFFF site and reviewed documents in support of the environmental report review. A summary of the site visit participants and discussions follows.

Participants

NRC
Christopher Ryder, Licensing Project Manager
Asimios Malliakos, Environmental Technical Reviewer
Kallee Jamerson, Environmental Technical Reviewer

Westinghouse
Nancy Parr, Licensing Manager
Diana Joyner, Environmental Engineer
David Wagoner, Radiation Safety Engineer

Public Health and Safety

1. Section 3.11.2, Public Health and Safety, of the Environmental Report (ER) dated December 17, 2014, states that the annual radiological total effective dose from liquid effluents is only 1.34×10^{-4} mrem and cites (Westinghouse 2014h) as a reference. Discuss the contribution of the dose from Technecium-99 (Tc-99). Identify and discuss other radionuclides. Provide the technical basis for the estimates.

Reply
Representative samples of our liquid discharge are analyzed by a 3rd party laboratory. The sample results are used in conjunction with the equations and assumptions from Regulatory Guide 1.109 to calculate a dose to the public via the following pathways: potable water, aquatic foods, and shoreline deposition. The source term consists of U-234, U-235, U-238, and Tc-99. The primary dose contributor is U-234.

2. Stack emissions from the CFFF are stated to result in a total effective dose of less than 0.18 mrem to a hypothetical exposed individual living at the site boundary (Westinghouse 2014h). Discuss the radionuclides contributing to the dose. Provide the technical basis.

Reply
Each stack is continuously (24/7/365) sampled. The sample media is changed daily and analyzed for gross alpha activity. The sample results are used to calculate the concentration of U-234, U-235, and U238 that is released at the stack. Those concentrations are used as input

into the COMPLY code that was developed by the EPA and NRC to calculate the dose to a member of the public at the site boundary.

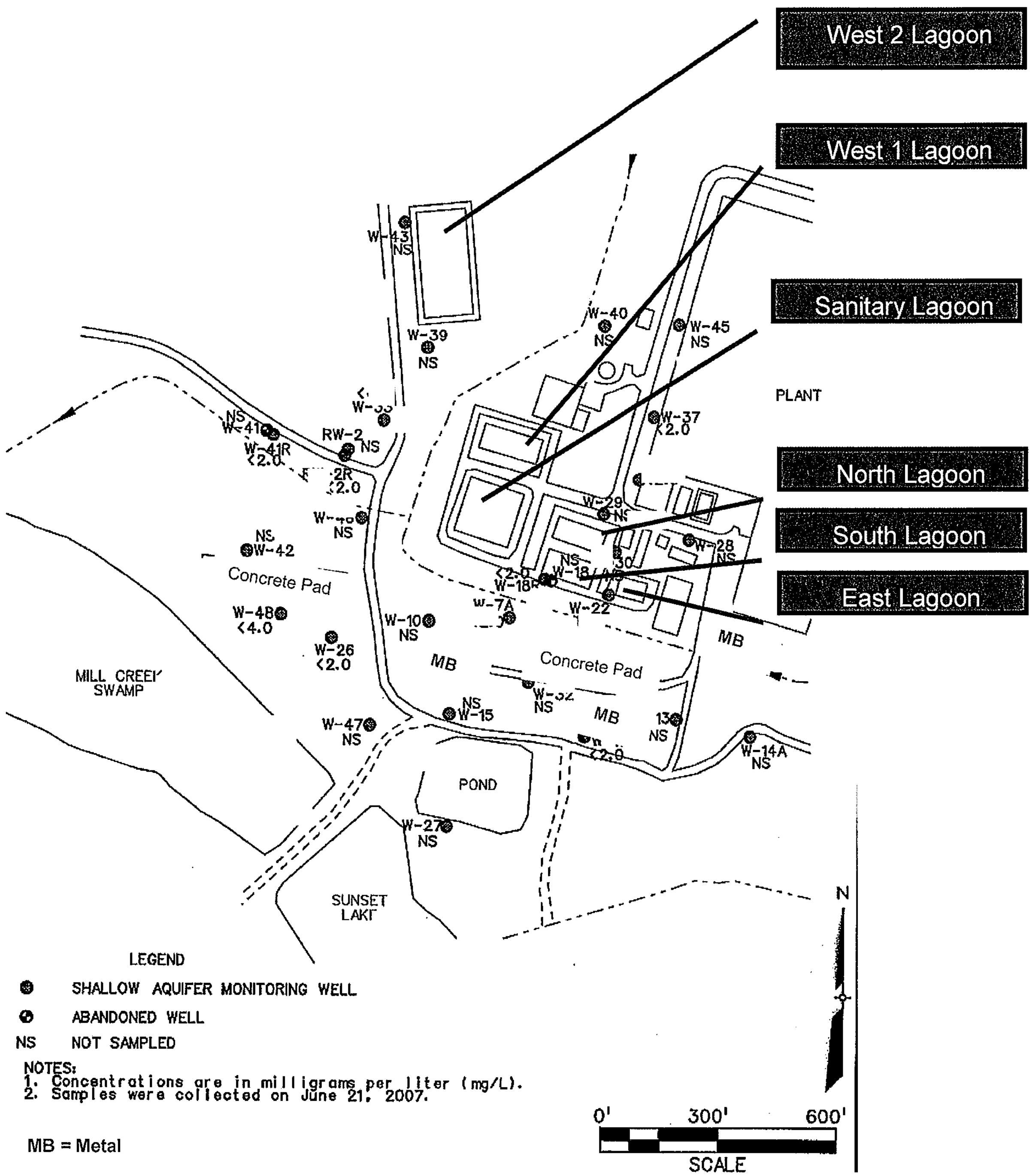
Note: Tc-99 is not included in this calculation because it is left behind in the cylinder during vaporization. Tc-99 is present in liquid effluent from the cylinder re-certification process where the heels (and Tc-99) are removed. Stack samples have been analyzed in the past to verify the absence of Tc-99.

3. **The ER in Section 2.1.4, Waste Confinement and Effluent Control, in page 2-17, states that during ground water sampling in 2010, elevated gross beta concentrations were noted. Liquid effluent sampling was initiated for Tc-99 in 2010 (Westinghouse, 2011b).** The amount of Tc-99 discharged in liquid effluents was 19.16mCi in 2010, 14.09 mCi in 2011, 18.5 mCi in 2012, 9.3 mCi in 2013 and 10.1 mCi in 2014. The average annual discharge in liquid effluents since monitoring of Tc-99 began in 2010 is 14.2 mCi **(Westinghouse 2011b, 2013 and site visit).”**

3.1. Identify the engineered structures locations presented in Figure 6.2-3, “Locations of Monitoring Wells” of the ER.

Reply

Westinghouse drawing 600E00CV01 should assist with this determination. However, below are the identified objects.



West 2 Lagoon
West 1 Lagoon
Sanitary Lagoon
North Lagoon
South Lagoon
East Lagoon
PLANT
W-43
NS
W-39
NS
W-40
NS
W-45
NS
W-37
<2.0
RW-2
NS
W-41R
<2.0
NS
W-41
W-42
NS
Concrete Pad
W-48
<4.0
W-26
<2.0
W-10
NS
W-7A
W-22
W-28
NS
W-29
W-18R
<2.0
MB
Concrete Pad
MB
MB
W-15
NS
W-47
NS
13
NS
W-14A
NS
<2.0
MILL CREEK
SWAMP
POND
W-27
NS
SUNSET
LAKE
N
LEGEND
SHALLOW AQUIFER MONITORING WELL
ABANDONED WELL
NS NOT SAMPLED
NOTES:
1. Concentrations are in milligrams per liter (mg/L).
2. Samples were collected on June 21, 2007.
MB = Metal
0' 300' 600'
SCALE

3.2. Label the engineered structures in Figure 2.1-4.

Reply

Figure 2.1-4 is an aerial photograph of the facility. For security purposes, which were agreed upon by NRC representatives in the meeting on 8/19/15, this figure will not be labeled in the ER.

3.3. Provide a readable legend for Figure 2.1-5 to include groundwater monitoring locations.

Reply

Figure 2.1-5 "CFFF Boundary" is Westinghouse drawing 600E00CV01. Enlarged copies of 600E00CV01 were mailed to the NRC after the 8/19/2015 meeting to satisfy this request.

3.4. As shown in Figure 6.1-1, provide rationale for the location of the four monitoring stations (air, vegetation and soil), and how they provide sufficient coverage of detection of releases.

Reply

The detailed features of the radiological monitoring program were established in 1975 based on the background alpha, beta and uranium concentration levels; discussions with radiation monitoring subject matter experts from both government and private industry; monitoring programs established for similar facilities; and probable exposure pathways for uranium movement through the environment.

3.5. Provide Figure 2.15 discussed in page 2-16 of the ER.

Reply

This reference to Figure "2.15" should actually read "2.1-5". The lagoons mentioned here are depicted in Westinghouse drawing 600E00CV01.

4. Page 2-17 of the ER states "The amount of Tc-99 discharged in liquid effluents was 19.16mCi in 2010, 14.09 mCi in 2011, 18.5 mCi in 2012, 9.3 mCi in 2013 and 10.1 mCi in 2014. The average annual discharge in liquid effluents since monitoring of Tc-99 began in 2010 is 14.2 mCi **(Westinghouse 2011 b, 2013 and site visit)." Describe the analysis used to estimate the activity of the liquid effluent discharges; discuss whether or not this an annual discharge estimate.**

Reply

A representative sample of the discharge stream is collected daily. The daily samples are combined to make a monthly composite. The sample is packaged and sent to General Engineering Labs (GEL) for analysis of Gross Alpha, Gross Beta, Isotopic Uranium, and Tc-99. The results from GEL along with the average daily volume discharged are used to determine the total activity released. Westinghouse procedure ROP-06-001 was reviewed on-site to understand the sampling method.

In addition to the above information, NRC visitors reviewed sample lab reports during the 8/19/2015 visit to Westinghouse.

5. In Section 4.4.2, on page 4-6, Westinghouse states that any contamination that might be detected by periodic monitoring would be confined to the property, with little or

no possibility of groundwater withdrawals to create drawdown for flow off-site. Provide the technical basis for the ER statement.

Reply

This conclusion was drawn by TetraTech engineers after reviewing monitoring results and pertinent geological data for the Westinghouse site as part of their development of the Environmental Report. The conclusions made by TetraTech were later reinforced by AECOM in a "Remedial Investigation Report" prepared for Westinghouse at the request of South Carolina Department of Health and Environmental Control (SCDHEC). The specific section of the report which addresses this topic is Section 5.0, "Contaminant Fate and Transport." Per the AECOM report, the primary routes of migration include the following:

1. subsurface soil to groundwater within the shallow aquifer;
2. groundwater flow within the shallow aquifer toward the manmade pond and Sunset Lake; and
3. surface water flow through the system of ditches that drain the plant area and flow toward upper sunset lake.

Based on surface and groundwater monitoring results, all migration areas are confined to the property including the manmade pond and Sunset Lake.

AECOM 2013. "Remedial Investigation Report prepared for Westinghouse Electric Company." AECOM Project No. 60302740, December 31, 2013. Submitted to SCDHEC on January 3, 2014 via Westinghouse document LTR-RAC-14-2.

Please find attached summary tables (Attachment H) extracted from the AECOM Remedial Investigation Report (AECOM 2013). The summary includes data from 2004-2013. Data sampling frequency prior to 2004 varied by well and parameter. As a result, a request was submitted by Westinghouse to SCDHEC to begin sampling analysis/review for the Remedial Investigation Report starting with 2004 data. SCDHEC approved this request.

6. Data in the ER for discharged Tc-99 are for 2010 to 2012. Provide all monitoring data for the wells used to monitor for Tc-99 from initiation of monitoring and up to the most recent data recorded.

Reply

Monitoring data is conducted "quarterly" in January, April, July, and October. Because of SCDHEC requirements, some samples must be obtained during defined summer and winter months.

	Well 7		Well 13		Well 32	
	Gross α (pCi/l)	Gross β (pCi/l)	Gross α (pCi/l)	Gross β (pCi/l)	Gross α (pCi/l)	Gross β (pCi/l)
Apr-11	3	136	3	86	1	196
Jun-11	6	146	10	121	1	211
Sep-11	8	112	17	91	10	183
Dec-11	9	185	18	132	12	315
Mar-12	10	199	7	138	5	258
Jun-12	6	93	8	68	5	208
Sep-12	5	102	3	110	3	136
Dec-12	6	181	10	142	0	283
Mar-13	5	135	6	99	8	264
Jun-13	2	102	3	130	2	213

Oct-13	5	164	2	140	15	265
Dec-13	8	166	3	147	9	331
Jan-14	4	144	6	155	10	250
Apr-14	5	127	1	120	14	276
Jul-14	8	147	1	98	5	253
Oct-14	6	116	5	85	4	232

The April 2015 monitoring data was printed for NRC representatives during the site visit to review as a representative report. The remaining reports were not printed but were available to review electronically, as each report is approximately 100 pages.

The amount of Tc-99 discharged in liquid effluents was 19.16mCi in 2010, 14.09 mCi in 2011, 18.5 mCi in 2012, 9.3 mCi in 2013 and 10.1 mCi in 2014. The average annual discharge in liquid effluents since monitoring of Tc-99 began in 2010 is 14.2 mCi.

7. Provide the source and location of Tc-99 contamination or the status of the measures used to identify the source of Tc-99 contamination.

Reply
Section 4.4 Water Resource Impacts of the ER states:

"In 2010, however, two identified NRC sampling well sites exceeded the 50 pCi/L Gross Beta investigation limit (Westinghouse, 2011b). Well 7 averaged 193 pCi/l Gross Beta, and Well 32 averaged 234 pCi/l Gross Beta. Four other wells (W10, W15, W18, W22,) which are not on the NRC sampling list, also exceeded the 50 pCi/l Gross Beta limit. This elevated Gross Beta content was identified and confirmed as Technicium-99 (Tc-99). The investigation evaluated potential causes from lagoon leaks, K-40 natural contamination, sampling errors, the cylinder recertification building, and adjacent surface water contamination from the concrete pad. The cylinder recertification building liquid from the hydrostatic test process appeared to have the highest potential of being a major contributor since this liquid (from remnants of activity in the cleaned cylinders) could contain elevated uranium daughter beta, Tc-99 beta, and low alpha concentrations. Monitoring of these wells on a routine basis will continue, and further sampling and investigation of Tc-99 in groundwater was initiated in 2011."

8. Provide the mitigation measures used to eliminate Tc-99 contamination.

Reply
Approximately 15 years ago, the Hydrostatic Water Supply Tank (T-1405) in the cylinder recertification building overflowed because an operator opened the manual fill valve and left the area before turning the valve off. When the tank overflowed on the floor, some water spilled outside the building and onto the grass. As a result, some grass was excavated, and an active engineered interlock was installed on top of the tank to prevent this type of overflow from recurring.

This one event is the suspected source of Tc-99 contamination. Measured concentrations are far less than the EPA's MCL of 900 pCi/L for drinking water. Monitoring will continue, and if Westinghouse needs to perform additional measures based on the sample data results, appropriate federal, state and local government agencies will be involved.

9. Based on the current monitoring data, state an estimate of the amount of Tc-99 that has been released to the environment.

Reply

There is no estimation for the total quantity of Tc-99 that has leached into groundwater as the measured concentrations are far less than the EPA's MCL of 900 pCi/L for drinking water. There is no requirement to monitor for Tc-99 or to mitigate Tc-99 leached to the groundwater.

10. Discuss pathways of Tc-99 to the drinking water sources. Provide the technical basis.

Reply

Monitoring results are attached to the public dose assessments.

Tc-99 is monitored by Westinghouse in the following ways:

- Composite effluent
- Sediment
- Fish
- Vegetation
- Congaree River
- Groundwater wells (all)

The possible paths to drinking water are through effluent discharges to the Congaree River. (Tc-99 discharged to the river is included in the annual public dose calculation). The Congaree River is monitored separately by Westinghouse for pollutants periodically.

The liquid effluent discharged to the Congaree River is sampled. The sample results in conjunction with the guidance/equations in RG 1.109 are used to calculate the dose to the public. One component (or pathway) in the dose to the public calculation is ingestion of river water. The Congaree River may be a source of drinking water for members of the public downstream. CFFF dose calculations demonstrate exposures below the MCLs and NRC limits. There is no indication Tc-99 is getting into off-site wells, and there is no regulatory requirement to monitor off-site wells.

Public dose calculations are attached for the years 2010-2015 (Attachments B – G).

11. Discuss defining the gross beta contamination plume of Tc-99. Include changes in the plume (e.g., expanding, contracting). Discuss the concentration trend at the monitoring wells where the 50 pCi/l gross beta limit was exceeded in 2011.

Reply

Quarterly groundwater samples quantify gross beta and Tc-99. A comparison of 2013 and 2008 data indicates that the plume has expanded around the wastewater lagoons and in the direction of groundwater flow for fluoride, nitrate, gross alpha, and gross beta parameters. This was expected, as the wastewater lagoons were determined to be the source of fluoride, nitrate, gross alpha, and gross beta contamination prior to being relined in 2012. Future sample results are expected to plateau and eventually decline after steady state is reached. Year over year monitoring trends can be examined by reviewing the AECOM Remedial Investigation Report (AECOM 2013) which also includes concentration contours for gross beta.
Specific Tc-99 monitoring is self-imposed by Westinghouse. The Tc-99 concentration levels are well below the drinking water standards and NRC limits, as discussed in Questions 8-10 above.

Now that Westinghouse has collected several years of monitoring data for Tc-99, Westinghouse has voluntary plans to further analyze these results in the upcoming years.

See also the data provided in Question #6.

12. Discuss the estimated cumulative discharged amounts from the residual contaminant plume and the impact of Tc-99 given both for the no action alternative and license renewal. Include UF_6 cylinder washing.

Reply

There is no estimation for the total quantity of Tc-99 that has leached into groundwater, and there is no planned mitigation of Tc-99 from groundwater. Measured concentrations are far less than the EPA's MCL of 900 pCi/L for drinking water.

CFFF has 3 different areas for the cylinder program.

1. **Cylinder Wash**, located in the SOLX Bay. A heel quantity (less than 40lbs, typically 25 lbs of UF6) is removed from a 30 B cylinder. Water is utilized in 5 gallon quantities to dissolve and remove UF6 from cylinders. Wash water is sent to the Conversion Scrap Cage.
2. **Cylinder Recertification**, located in the LLRW building across from Greggs shop. Empty DOT cylinders are inspected and hydrostatically tested with the water source from T-1405. New valves and plugs are installed, and then the cylinders are pneumatically tested in this facility. Other operations include cylinder drying, drawing a vacuum to establish a tare weight, pressurizing with Nitrogen for shipment, and stamping new recertification dates on the manufacture's plate. Water is sent to T-1405, which is pumped to T-1160A, which is processed through Waterglass.
3. **External Cylinder Washing**, located by the UF6 Pad. Prior to shipping a 30B cylinder offsite, every cylinder is processed through the external cleaning facility. It sprays pressurized water on the cylinders, dries them, and provides a staging area for inspection for visible contamination and frisking. The external cleaning facility drains to the Contaminated Sump.

The previous suspected source of Tc-99 contamination, the Hydrostatic Water Supply tank (T-1405) in the recertification building, was addressed by installing an active engineered interlock that closes an automatic valve on the water inlet to the top of the tank in a high high level condition.

Because the source of Tc-99 was identified and an engineered interlock installed, the Tc-99 measured concentrations are not expected to increase. As a result, the impact of the no action alternative and 40-year license renewal would be the same.

UF_6 external cylinder washing is not a source of Tc-99. All tanks associated with these processes are above ground.

Volatile Organic Compounds (VOCs)

13. Provide sampling test results for VOC since 2011. Provide sampling test results for VOC before 2011. If the information is in reference Westinghouse, 2012d, so state.

Reply

VOC testing is conducted by Shealy Environmental. Hard copy reports were available for NRC representatives to review for 2011 sampling-present for the wells monitored for VOCs, including RW-2, MW-41, W-48, and W-26.

Tables summarizing data from 2004-2013 can be found in the AECOM Remedial Investigation Report (citation AECOM 2013). Data sampling frequency prior to 2004 varied by well and parameter. As a result, a request was submitted by Westinghouse to SCDHEC to begin sampling analysis and review for the AECOM Remedial Investigation Report, starting with 2004 data. SCDHEC approved this request. This report was submitted to SCDHEC on January 3, 2014 via Westinghouse document LTR-RAC-14-2.

14. Discuss the status (i.e., operating, not operating) of the air-sparge-soil-vapor-extraction system, as agreed by SC-DHEC as stated in reference Westinghouse 2011b.

Reply

The site utilized Air Sparge / Soil Vapor Extraction (AS/SVE) from 1998 to 2010 as part of a groundwater remediation project. In December 2010, the air sparge soil vapor extraction system was turned off, as agreed to by SCDHEC. The system may remain off, provided that quarterly ground water samples show no rebound in VOC levels. An annual groundwater report is submitted to SCDHEC to confirm that the levels are not rebounding.

Per an AECOM Remedial Investigation Report (AECOM 2013), CVOC concentrations have decreased or remained stable since shutdown of the AS/SVE system. It is evident that the COVC mass is depleting, and mass reduction over time can be expected.

15. Discuss how Westinghouse has evaluated VOCs to determine changes in the soil transport properties, especially for Tc-99.

Reply

VOCs and Tc-99 are two different contaminant plumes with two different sources located at two different places on the site property. The VOC contamination originated when leaking perchloroethylene drums were temporarily stored outside the oil house prior to passage of regulations requiring more prescriptive methods of handling hazardous materials and waste. The Tc-99 originated from the cylinder recertification process. VOCs were remediated with an air sparge system beginning in 1998 and ceasing in 2010 with SCDHEC's approval. Tc-99 does not require remediation. Westinghouse is not under any regulatory requirements to remediate further but does continue to monitor both contaminants in all groundwater wells.

16. On page 4-4 of the ER, Westinghouse states that during investigations to detect groundwater contamination, multiple soil geoprobe penetrations were completed in locations affected by past spills of chlorinated solvents. Soil samples were taken at depths from 0.9 to 3.4 m (3 to 11 ft). One sample was noted to contain Total VOCs equal to 4.5 mg/kg; and nineteen other samples indicated Total VOCs less than 0.3 mg/kg. No management program was necessary specifically to manage the soil. Programs were implemented to manage the groundwater in the shallow surficial aquifer beneath the soil. State the year that the above stated samplings and actions took place.

Reply

The AECOM Remedial Investigation Report (AECOM 2013) states:

"A soil quality investigation was performed as part of the remedial design investigation in 1995 to further delineate the horizontal and vertical extent of VOCs in soil in the vicinity of the Oil House, which was suspected to be the source area of the CVOC plume. The results of the Chlorinated Solvent Assessment (Rust, 1994) had indicated that the source of the chlorinated solvents was most likely the Oil House, which was used to store oils and previously to store drums of solvents prior to 1980. A total of 18 DPT soil borings were completed in the vicinity of the Oil House using a Geoprobe® rig. Soil samples were collected from various depths between 3 and 11 feet bgs and analyzed for VOCs and TPH by an on-site mobile laboratory. Select samples were shipped to an off-site laboratory for analysis for VOCs and TPH. Details regarding the site investigation activities for the Remedial Design Investigation were included in the Conceptual Design Report (Rust, 1995). The soil quality results of the Remedial Design Investigation are discussed in Section 4.2.2."

17. On page 4-4 of the ER, Westinghouse states that the current performance monitoring program demonstrates the stabilization of PCE and TCE plumes with no sign of plume expansion or shrinkage. Provide the technical basis for the statement.

Reply

This section of the ER has been revised and updated based on the Remedial Investigation Report prepared by AECOM (December 2013). The ER section that addresses the plume's reduction in size is captured in the paragraph below, which is based on monitoring data analysis from 2004-2013.

"Operation of the AS/SVE system resulted in decreasing CVOC concentrations in a number of monitoring wells. Wells W-15, W-16, W-26, and W-48, located along the escarpment, indicate a decreasing trend in contaminant concentration. Well W-48 indicated a dramatic change, where TCE, DCE, and vinyl chloride (VC) concentrations no longer exceed MCLs and the PCE concentration decreased significantly between April 1995 and December 2008. This dramatic decrease was likely due to the proximity of well W-48 to the southern AS/SVE area. Wells located in the northern AS/SVE area also indicate decreasing concentration trends. Well W-41R indicated a dramatic change, which is likely due to the proximity of well W-41R to the northern AS/SVE area. The estimated total was reduced approximately 76 percent eleven years after the AS/SVE system was installed in 1997.

Apparent mass reduction in the areas influenced by the AS/SVE system was 97 percent, in the southern AS/SVE area, and 44 percent in the northern AS/SVE area. Air sparging, biodegradation of the CVOCs, and other natural attenuation mechanisms can be attributed for the mass removal in these areas. Use of the AS/SVE system was discontinued in December 2010, as agreed to by SC-DHEC (Westinghouse, 2011b) when performance appeared to have reached a plateau phase with reduced efficiency and decreased ability to reduce contaminant concentrations. The system may remain off, provided that quarterly ground water samples show no rebound in VOC levels. VOC sampling conducted in December 2010, the last month that the AS/SVE system was operational, yielded a maximum PCE concentration of 340 µg/l at W-48 (Westinghouse 2011c). Subsequent testing conducted for the 2014 annual report to SCDHEC revealed a maximum PCE concentration of 170 µg/l at W-48 and 200 µg/l at W-41 (Westinghouse 2014m). July 2015 test results indicated a PCE concentration of 170 µg/l at W-48 and 140 µg/l at W-41. Sampling of VOCs in the groundwater continues quarterly, and the above results confirm that no rebound in VOC concentrations exists."

18. On page 4-4 of the ER, Westinghouse states that the tetrachloroethene (PCE) and

trichloroethene (TCE) levels have gradually increased over time at wells RW-2R and W-33. Provide PCE and TCE levels from 1998 since the air sparging and soil vapor extraction (AS/SVE) system was installed.

Reply

Summary tables extracted from the AECOM Remedial Investigation Report (AECOM 2013) were reviewed on-site by NRC. This data from 2004-2013 is included in Attachment H. Data sampling frequency prior to 2004 varied by well and parameter. As a result, a request was submitted by Westinghouse to SCDHEC to begin sampling analysis/review for the Remedial Investigation Report starting with 2004 data. SCDHEC approved this request.

Please note that well RW-2R is also referred to as WRW-2.

19. On page 4-4 of the ER, Westinghouse states that no requirements were established by SC-DHEC to remove soil at the low documented levels of contamination. Discuss other remediation methods stated by SC-DHEC. Discuss the form of such statements (e.g., recommendation, requirement).

Reply

No remediation methods have been required by SCDHEC. The air sparge system was a voluntary installation by Westinghouse.

Fluoride and Nitrate Leakage

20. Information in the ER for discharged fluoride and nitrate are for or before 2007. Provide monitoring data, from the wells used to monitor for fluoride and nitrate, since 2007 and up to the most recent data recorded.

Reply

The following is the most current data.

Fluoride:

Groundwater monitoring data since 2004 indicates that fluoride concentrations ranged from <0.50 milligrams per liter (mg/L) to 33.70 mg/L. The fluoride MCL (4 mg/L) has been exceeded in groundwater samples from 17 of the 38 wells including W-7, W-10, W-13, W- 15, W-16, W-18, W-19, W-22, W-24, W-27, W-28, W-29, W-30, W-32, W-37, W-38, and W-47 since 2004. The source investigation performed by AECOM in the wastewater lagoon area in 2011 included groundwater sampling from 20 direct push technology (DPT) borings. The samples were analyzed for fluoride and nitrate. A total of 40 DPT groundwater samples were collected from the 20 locations to determine the extent of fluoride and nitrate in the upper and lower portions of the shallow aquifer at the site. As part of the Remedial Investigation (RI) agreement between Westinghouse and SCDHEC, a total of 10 sediment samples coinciding with previous surface water sample locations were analyzed. As part of the RI, AECOM developed isoconcentration maps from select dates from December 2004 through October 2013 and from regular groundwater monitoring events in December 2004, December 2008 and October 2013.

AECOM noted in the Remedial Investigation Report from December 2013 that fluoride generally does not adsorb to soil or react with other compounds. Therefore, fluoride moves with groundwater flow (advection) and is present from the wastewater treatment plant (WWTP) to downgradient wells near the pond and Sunset Lake.

AECOM further elaborated that while chemicals of potential concern (COPCs) have been detected in groundwater near surface water bodies, only fluoride has been detected in Sunset Lake at concentrations exceeding maximum contaminant levels (MCLs). December 2008 fluoride concentrations in surface water ranged from 0.5 mg/l (SW-6) to 12.1 mg/l (SW-1, Upper Sunset Lake and SW-9, Sunset Lake). Other surface water sampling locations SW-7, SW-8, and SW-10 exceeded the MCL of 4 mg/l measuring at 4.7 mg/l, 4.4 mg/l, and 10.3 mg/l, respectively.

Fluoride, however was not detected above the MCL at the spillway, indicating that the fluoride MCL was exceeded only in a localized area near the location of the groundwater plumes. A mitigating circumstance for the Pond is that it is a man-made impoundment with no outflow to the stream system and, therefore is not a natural surface water body.

Nitrate:
Groundwater monitoring data since 2004 indicates that nitrate concentrations ranged from <0.02 mg/L to 2,900 mg/L. The nitrate MCL (10 mg/L) has been exceeded in groundwater samples from 23 of the 38 wells including W-7, W-10, W-13, W-15, W-17, W-18, W-22, W-23, W-26, W-28, W-29, W-30, W-32, W-33, W-38, W-39, W-41, W-43, W-44, W-47, W-48,and RW-2 since 2004. The source investigation performed by AECOM in the wastewater lagoon area in 2011 included groundwater sampling from 20 DPT borings. The samples were analyzed for fluoride and nitrate. A total of 40 DPT groundwater samples were collected from the 20 locations to determine the extent of fluoride and nitrate in the upper and lower portions of the shallow aquifer at the site. As part of the Remedial Investigation R I agreement between Westinghouse and SCDHEC, a total of 10 sediment samples coinciding with previous surface water sample locations were analyzed. As part of the RI, AECOM developed isoconcentration maps from select dates from December 2004 through October 2013 and from regular groundwater monitoring events in December 2004, December 2008 and October 2013.

AECOM noted in the Remedial Investigation Report from December 2013 that fluoride and nitrate are soluble in water. Nitrate moves with groundwater flow but can be depleted through the natural processes of nitrate reduction and denitrification. Denitrification occurs when nitrate is converted to nitrogen and nitrate concentrations measured in groundwater decrease. Nitrate reduction is the process of converting nitrate to nitrite to ammonia. Denitrification can also occur as groundwater discharges to surface water due to the presence of organic carbon.

The 2013 Remedial Investigation Report by AECOM concluded that the concentrations of nitrate exceeding the MCL are located from the vicinity of the WWTP to the area of the escarpment just north of Sunset Lake. Areas of elevated nitrate include the WWTP, the vicinity of the northern and southern equipment pads, and West Lagoon 2. Nitrate has generally increased in the area of the WWTP since 2008. As a result of the data collected during the borings, Westinghouse elected to reline the site lagoons in January and February of 2012.

Source: AECOM 2013. "Remedial Investigation Report prepared for Westinghouse Electric Company." AECOM Project No. 60302740, December 31, 2013. Submitted to SCDHEC on January 3, 2014 via Westinghouse document LTR-RAC-14-2.

<u>Fluoride and Nitrate Leakage</u>

21. On page 4-5 of the ER, Westinghouse states that groundwater borings in May 2011

indicated the North and South Lagoons to be source of nitrate contamination. State the source of fluoride contamination.

Reply

Fluoride is also introduced to the Uranium Recovery and Recycling Services (URRS) lagoons from the treatment of wastewater that leaves the conversion area.

22. Based on the current monitoring data, state the estimated cumulative amount of fluoride and nitrate released.

Reply

The following is the most current data.

Fluoride:

Groundwater monitoring data since 2004 indicates that fluoride concentrations ranged from <0.50 milligrams per liter (mg/L) to 33.70 mg/L. The fluoride MCL (4 mg/L) has been exceeded in groundwater samples from 17 of the 38 wells including W-7, W-10, W-13, W- 15, W-16, W-18, W-19, W-22, W-24, W-27, W-28, W-29, W-30, W-32, W-37, W-38, and W-47 since 2004. The source investigation performed by AECOM in the wastewater lagoon area in 2011 included groundwater sampling from 20 direct push technology (DPT) borings. The samples were analyzed for fluoride and nitrate. A total of 40 DPT groundwater samples were collected from the 20 locations to determine the extent of fluoride and nitrate in the upper and lower portions of the shallow aquifer at the site. As part of the Remedial Investigation agreement between Westinghouse and SCDHEC, a total of 10 sediment samples coinciding with previous surface water sample locations were analyzed. As part of the RI, AECOM developed isoconcentration maps from select dates from December 2004 through October 2013 and from regular groundwater monitoring events in December 2004, December 2008 and October 2013.

AECOM noted in the Remedial Investigation Report from December 2013 that fluoride generally does not adsorb to soil or react with other compounds. Therefore, fluoride moves with groundwater flow (advection) and is present from the wastewater treatment plant (WWTP) to downgradient wells near the pond and Sunset Lake.

AECOM further elaborated that while chemicals of potential concern (COPCs) have been detected in groundwater near surface water bodies, only fluoride has been detected in Sunset Lake at concentrations exceeding maximum contaminant levels (MCLs). December 2008 fluoride concentrations in surface water ranged from 0.5 mg/l (SW-6) to 12.1 mg/l (SW-1, Upper Sunset Lake and SW-9, Sunset Lake). Other surface water sampling locations SW-7, SW-8, and SW-10 exceeded the MCL of 4 mg/l measuring at 4.7 mg/l, 4.4 mg/l, and 10.3 mg/l, respectively.

Fluoride, however was not detected above the MCL at the spillway, indicating that the fluoride MCL was exceeded only in a localized area near the location of the groundwater plumes. A mitigating circumstance for the Pond is that it is a man-made impoundment with no outflow to the stream system and, therefore is not a natural surface water body.

Nitrate:

Groundwater monitoring data since 2004 indicates that nitrate concentrations ranged from <0.02 mg/L to 2,900 mg/L. The nitrate MCL (10 mg/L) has been exceeded in groundwater s amples from 23 of the 38 wells including W-7, W-10, W-13, W-15, W-17, W-18, W-22, W-23,

W-26, W-28, W-29, W-30, W-32, W-33, W-38, W-39, W-41, W-43, W-44, W-47, W-48,and RW-2 since 2004. The source investigation performed by AECOM in the wastewater lagoon area in 2011 included groundwater sampling from 20 DPT borings. The samples were analyzed for fluoride and nitrate. A total of 40 DPT groundwater samples were collected from the 20 locations to determine the extent of fluoride and nitrate in the upper and lower portions of the shallow aquifer at the site. As part of the Remedial Investigation agreement between Westinghouse and SCDHEC, a total of 10 sediment samples coinciding with previous surface water sample locations were analyzed. As part of the RI, AECOM developed isoconcentration maps from select dates from December 2004 through October 2013 and from regular groundwater monitoring events in December 2004, December 2008 and October 2013.

AECOM noted in the Remedial Investigation Report from December 2013 that fluoride and nitrate are soluble in water. Nitrate moves with groundwater flow but can be depleted through the natural processes of nitrate reduction and denitrification. Denitrification occurs when nitrate is converted to nitrogen and nitrate concentrations measured in groundwater decrease. Nitrate reduction is the process of converting nitrate to nitrite to ammonia. Denitrification can also occur as groundwater discharges to surface water due to the presence of organic carbon.

23. State possible pathways of fluorides and nitrates into drinking water sources. State the technical basis of the statements.

Reply

Fluoride and Nitrate are monitored by Westinghouse in the following ways:

- Composite effluent
- Sediment
- Fish
- Vegetation
- Congaree River
- Groundwater wells (all)

Fluoride generally does not adsorb to soil or react with other compounds. Therefore, fluoride moves with groundwater flow (advection). Fluoride in groundwater at the site is present from the Waste Water Treatment Plant (WWTP) to downgradient wells near the pond and Sunset Lake. However, fluoride was not detected above the MCL at the spillway, indicating that the fluoride MCL was exceeded only in a localized area near the location of the groundwater plumes. A mitigating circumstance for the Pond is that it is a man-made impoundment with no outflow to the stream system and, therefore is not a natural surface water body.

Nitrate, also soluble in water was likely entering shallow groundwater in the vicinity of the Waste Water Treatment Plant (WWTP). Nitrate moves with groundwater flow but can be depleted through the processes of denitrification and nitrate reduction. Denitrification can also occur as groundwater discharges to surface water due to the presence of organic carbon.

The possible paths to drinking water are through effluent discharges to the Congaree River. Discharges by Westinghouse to the Congaree River are covered under the site's NPDES permit. Westinghouse does not have NPDES permitted limits for nitrates and fluorides.

Westinghouse does monitor all groundwater wells for nitrates and fluorides, not just those closest to the known source origin (wastewater treatment lagoons). This approach allows Westinghouse to determine any potential impact to the entire site. The existing residual contamination plumes

are confined to the Westinghouse site at this time, and there is no indication of any impact on adjacent properties. There is no regulatory requirement to monitor off-site wells.

Source: AECOM 2013. "Remedial Investigation Report prepared for Westinghouse Electric Company." AECOM Project No. 60302740, December 31, 2013. Submitted to SCDHEC on January 3, 2014 via Westinghouse document LTR-RAC-14-2.

24. State the estimated cumulative discharged amounts from the residual contaminant plume and the impacts of fluoride and nitrate that will be released for both the no-action and proposed licensing action.

Reply

Fluoride:
Groundwater monitoring data since 2004 indicates that fluoride concentrations ranged from <0.50 milligrams per liter (mg/L) to 33.70 mg/L.

Nitrate:
Groundwater monitoring data since 2004 indicates that nitrate concentrations ranged from <0.02 mg/L to 2,900 mg/L.

The CFFF NPDES permit does not have discharge limits for nitrates or fluorides. Westinghouse is required to sample groundwater wells quarterly and submit a report to South Carolina Department of Health and Environmental Control (SCDHEC) annually. Cumulative discharge amounts are not required for either the NPDES permit or the annual groundwater report. Both fluoride and nitrate entered the groundwater at Westinghouse through the wastewater treatment plant's aging lagoon liners. The lagoons in the treatment plant have since been relined, mitigating any continued contamination. As a result, there should be no difference in fluoride and nitrate releases for the no action alternative and the proposed licensing action. At this time there is no action level with SCDHEC for remediation of the residual contaminants.

25. State the groundwater classification for the CFFF site from the South Carolina's Department of Health and Environmental Control. Discuss written concurrence from SC DHEC that the CFFF surficial aquifer is Class GC (i.e., that it is not a potential source of drinking water and will not migrate to Class GA or Class GB groundwater or have a discharge to surface water that could cause degradation).

From: Walker, Adelaide [mailto:walkeras@dhec.sc.gov]
Sent: Wednesday, August 05, 2015 9:08 AM
To: Logsdon, Cynthia J.
Subject: Re: Westinghouse groundwater classification

Class gb

Addie Walker, Hydrologist State Remediation Section
Bureau of Land and Waste Management SCDHEC
2600 Bull St.
Columbia, SC 29201
walkeras@dhec.sc.gov
(803)898-0722

[redacted]

From: Logsdon, Cynthia J. <logsdocj@westinghouse.com>
Sent: Tuesday, August 4, 2015 2:08:14 PM
To: Walker, Adelaide
Subject: Westinghouse groundwater classification

Hi Addie,
Can you tell me what our 'groundwater classification' is? Thanks so much.

Cynthia Logsdon
Principal Environmental Engineer
Nuclear Criticality Safety & Environmental Engineering Environment, Health & Safety
Columbia Fuel Fabrication Facility (CFFF) Westinghouse Electric Company, LLC

26. Section 3.12.2 "Liquid Effluents" of the ER states that exposure calculations from the CFFF radiological liquid effluents are presented in Section 3.1 0. The section citation appears to be incorrect. Provide the correct section reference that provides the exposure calculations from the CFFF radiological liquid effluents.

Reply
The correct section is 3.11. Any future revision of the ER will reflect this correction.

27. Table 3.12-2 "Maximum Modeled Concentrations for CFFF Nonradiological Gaseous Pollutants" of the ER present data from the NRC's EA from 2007. Provide an updated table with recent data.

Reply
The data provided in 2007 ER is still valid for current operations, as no changes have occurred in the process that would alter these modeled concentrations.

28. On page 2-17 of the ER, Table 2.1-3 is missing. Provide missing Table 2.1-3.

Reply
The correct table is provided below.

Table 2.1-3 Annual Release of Uranium in CFFF Liquid Effluents at a Nominal 1,500 MTU/yr Capacity

Year	Discharged, (mCi)
2003	54.5
2004	50.0
2005	25.6
2006	10.2
2007	10.5
2008	10.2
2009	10.3
2010	8.12
2011	6.92
2012	3.1

2013	5.2
2014	3.8
Average	**16.5**

This data is an annual summary of information provided to the NRC semiannually with the "Semi-Annual Assessment of Public Dose from Liquid and Gaseous Effluents" letters.

29. Provide the technical basis as to why the ER Table 4.12-1 "Potential CFFF Accidents" from 1985 is still valid. Update the Table based on recent analysis.

Reply

The table is still valid.

The Integrated Safety Analysis (ISA) identifies equipment and operations presenting hazards, and the control features that are relied upon for protection of the environment, and the health and safety of facility employees and the neighboring public. Compliance with the performance requirements of 10CFR70.61 are adequate to control the environmental consequences of accidents to an acceptable level. Although several minor accidents are likely to happen during the life of the plant, (e.g, a small leak in a pipeline or a small spill), most will not result in a significant release of uranium to the environment. In the performance of the Integrated Safety Analysis (ISA), one accident sequence was identified as having potential consequences meeting the 10CFR70.61 environmental release criteria for an intermediate consequence event. This event involves a rupture of a Uranyl Nitrate (UN) Bulk Storage Tank located outside of the main manufacturing building. A rupture of a Bulk Storage Tank could result in a spill of UN to the soil and subsequently to the groundwater. Any overflow could enter the storm drain and be transported to sunset lake. Items Relied on for Safety (IROFS) exist to assure this accident sequence is unlikely to occur. This satisfies the 10CFR70.61 performance requirements for an environmental release.

The unmitigated, worst case UN environmental release is described below.

A full UN tank would contain approximately 7800 gallons of uranyl nitrate at a maximum concentration of 6 g U235/l (procedure limit) at an enrichment of 5.0% U-235 (license limit).

The following table lists typical isotopic components of uranium enriched by gaseous diffusion to 5 weight percent U-235.

Nuclide	Atomic mass [amu]	Abundance		Isotope SA	Contribution to Total SA	% Contrib to Total SA
		Atom %	Weight %	Ci/g	Ci/g	
U-234	234.0409	0.0456	0.0448	6.21E-03	2.785E-06	86.66
U-235	235.0439	5.065	5.0043	2.16E-06	1.081E-07	3.36
U-236	236.0456	0.00243	0.0024	6.47E-05	1.560E-09	0.05
U-238	238.0508	94.8870	94.9485	3.36E-07	3.190E-07	9.93
	Ave A(U) =	**237.8966**	**Total SA [Ci/g, %] =**		3.213E-06	100

A solution containing 6 g U-235/liter would correspond to approximately 125 g Uranium. This amount of Uranium would contain the following activity concentrations [μCi/ml]:

Isotope	[μCi/ml]
U-234	3.5e-1
U-235	1.4e-2
U-236	2e-4
U-238	4e-2

A 7800 gallon tank spill to the environment would contain:

Isotope	Ci
U-234	10.3
U-235	4E-1
U-236	6e-3
U-238	1.18

All other environmental releases would be less than 1.5E-3 mCi/ml which is the 10CFR70.62 limit [5000 X 10CFR 20 limit] for release to environment.

Isotope	[mCi/ml]	5000 X 10CFR 20 limit [mCi/ml]
U-234	1.4e-2	1.5e-3
U-235	5.4e-4	1.5e-3
U-236	8.0e-6	1.5e-3
U-238	1.6e-3	1.5e-3

All others less than 1.5E-3.

Soil Contamination and Interface with the South Carolina Department of Health and Environmental Control (SC-DHEC)

30. Discuss soil contamination from radionuclide and chemical releases. Discuss measures taken to mitigate such contamination. Discuss informing SC-DHEC of any surface and subsurface contamination. Discuss removal and soil excavation.

Reply
Westinghouse contracted AECOM as subject matter experts to evaluate contaminants and their impacts to the environment in a report entitled "Remedial Investigation Report."

Mitigation for VOCs is discussed in question 17. Permit required monitoring reports are submitted to SCDHEC as required, which would identify any surface water and groundwater contamination.

No soil removal or excavation has been required.

Water Usage for all the Activities at the CFFF

31. As stated in the ER Table 2.2-1, Summary of Resource Use and Effluents, discuss the origin of water used by the CFFF. Discuss the percentages of the annual total water per usage from the source(s) and location(s) used. Provide the sources and quantity of the potable water used by personnel.

Reply

Westinghouse has one source of water, which is the City of Columbia. City of Columbia water is used for potable water and process water. No submetering within the facility currently exists to provide a more detailed description of how water is consumed by individual workers and process areas.

Liquid Effluents

32. Clarify if the NPDES permit for Storm Water Discharges Associated with Industrial Activity, Permit Number is actually SCR000000. Confirm that the stated number is the number on the permit. Provide a copy of the NPDES permit.

Reply

SCR000000 is a general NPDES permit issued by the South Carolina Department of Health and Environmental Control (SCDHEC) for all storm water discharges in the state of SC associated with Industrial Activities except for construction. A copy of the general permit can be found on the SCDHEC website. There is no site specific permit for Westinghouse CFFF. All Industrial users in the state of SC operate under the general permit SCR000000.

Water Quality

33. In Section 3.4.3 of the ER, Westinghouse states that the information given in this section below was taken from a study of ground water and surface water quality conducted by SC-DHEC (SC-DHEC, 1998). Provide results of the most recent study to account for all releases of contaminants.

Reply

There are fifteen SCDHEC monitoring stations along this section of the Congaree River. At special study sites S-956, S-957, S-958, S-959, S-960, S-961, S-965, and S-967, the aquatic life use data is limited to copper measurement. Based on that data, all the above sites except S-967 meet the criteria for copper and support the standards. Special study site S-967 does not meet those copper standards. Only fecal coliform was sampled at special study sites CSB-001R, CSB-001L, S- 955, S-994, S-995, and S-996. At CSB-001R and CSB-001L (stationed along the right and left banks of the headwaters of the Congaree River), recreational uses are partially supported due to fecal coliform bacteria excursions; however, significant decreasing trends in fecal coliform bacteria concentration suggest improving conditions for this parameter. All the remaining downstream special study sites fully support recreational uses. At the furthest downstream site (C-074), aquatic life uses are fully supported; however, there is a significant increasing trend in five-day biochemical oxygen demand and a decreasing trend in dissolved oxygen concentration. Recreational uses are partially supported at this site due to fecal coliform bacteria excursions.

Terrace and the Flood Plain of the CFFF

34. Provide an overview of the CFFF location with regard to the flood plain and adjoining

bluff. Include the elevation of the bluff. Discuss the extent to which the CFFF site is surrounded by the bluff. Discuss how the CFFF is protected in the areas where the bluff does not surround the CFFF. Discuss how the bluff affects river flow during flood conditions, and the effect of the bluff on the CFFF flood protection.

Reply

The CFFF Site characteristics and the effects of natural phenomena hazards are described in the Westinghouse Site and Structures Integrated Safety Analysis (ISA) Summary (January 2016 update). This document includes a description of surface water, flooding, precipitation, etc. as well as a discussion on the storm/flood of October 2015. The water levels during the storm/flood did not result in any safety consequences on NRC licensed activities.

The CFFF site lies within the flood basin of the Congaree River. High water on the Congaree River usually occurs in late winter and early spring, but flooding is possible any time of the year. Flooding occurs as the water level in the river rises above the flood stage and creeks and gullies begin to flow backward into the floodplain. Flood stage for the Congaree River at the Carolina Eastman gauging station, located in close proximity to the CFFF is 115.0 ft (above mean sea level [MSL]). The CFFF site elevation ranges from 110 to 120 ft (above MSL) on the southwest portion of the site, around Mill Creek and Sunset Lake, to 136 to 140 ft (above MSL) on the northeast portion of the site, around the main manufacturing building, tank farm, lagoons, and parking lots. The main manufacturing building's floor sits at 142 ft (above MSL).

Recorded Crest Histories for the Congaree River

Date	Water Level (ft above MSL)
10/12/1976	126.95
02/27/1979	126.90
03/16/1975	126.00
04/03/1973	125.40
09/11/2004	124.60
02/06/1998	124.40
01/28/1978	124.20
12/18/1972	124.00
05/25/2003	124.00
03/04/2007	124.00
10/04/2015	123.30

Significant floods that have affected the area of central South Carolina are described below.

Significant Flood Events

Date	Area Affected	Recurrence Interval (yr)	Remarks
August 1908	**Statewide**	**2 to >50**	**Most extensive flood in state; rainfall of 12 in. in 24 hr**
August 1928	**Statewide**	**2 to >50**	**Bridges destroyed, roads and**

			railways impassable
August 1940	**Statewide**	**2 to >100**	**About 34 deaths and $10 million in damage**
September 1945	**Statewide**	**2 to >100**	**One death and $6-7 million in damages**
September 1959	**Eastern, southern and central South Carolina**	**10 to 20**	**Hurricane Gracie; 6 to 8 in. of rainfall; seven deaths and $20 million in damages**
October 1990	**Central South Carolina**	**Unknown**	**Tropical storms Klaus and Marco; five deaths and 80 bridge failures**
October 2015	**Coastal and central South Carolina**	**500-1000**	**Heavy rainfall occurred as a result of an upper atmospheric low-pressure system that funneled tropical moisture from Hurricane Joaquin; 17 fatalities, 410 roads or bridges closed, $300 million in damages.**

Excerpt from the ISA, section 4.2.3:

The worst recorded flood occurred in 1908. The flood crest in the vicinity of the CFFF would have been 126.8 ft (above MSL). In the vicinity of the CFFF site, the estimated 100-year flood elevation is 130 ft (based on U.S. Corp of Engineers' map). The area to southwest lies within the Federal Emergency Management Administration's (FEMA's) flood zone A.(Zone A is defined by FEMA as the flood insurance rate zone that corresponds to the 100- year floodplains, but no base flood elevation has been determined. The site area to the northeast, including the main manufacturing building lies in FEMA Zone X, which is above the 100-year and 500-year flood elevations. A large flood could impact the low-lying, undeveloped areas of the site. Because the floor elevation of the main manufacturing building is at 142 ft, it is highly unlikely that a large flood would cause significant flooding of the building, resulting in uranium releases or a nuclear criticality accident. Should a large rainfall event result in flooding in the area, appropriate time would be available to take appropriate preventive and emergency management measures, including evacuating employees and shutting down manufacturing operations, if necessary.

A historic flooding event occurred in October 2015. Columbia received 8.19 inches of rain in a 12 hour period, and a total of 12.4 inches over 4 days. 11.5 inches corresponds to a 500 year recurrence for the Columbia area. 13.3 inches corresponds to a 1000 year recurrence.
The Congaree River crested at 123.3 feet (above MSL) in the vicinity of the CFFF. CFFF experienced flooding of low lying areas. The main manufacturing building was not impacted by flood waters. CFFF was closed for 3 days because of loss of city water supply and roads to the plant being closed. There were no safety issues because of the flooding. Also, the water level of the Congaree River remained less than 124 ft above MSL.

There are two dams on the rivers feeding the Congaree River, upstream of the CFFF. These dams are (1) the Lake Murray Dam on the Saluda River, confining the 50,000-acre Lake Murray, and (2) the Parr Shoals Dam on the Broad River, confining the 4,400-acre Parr

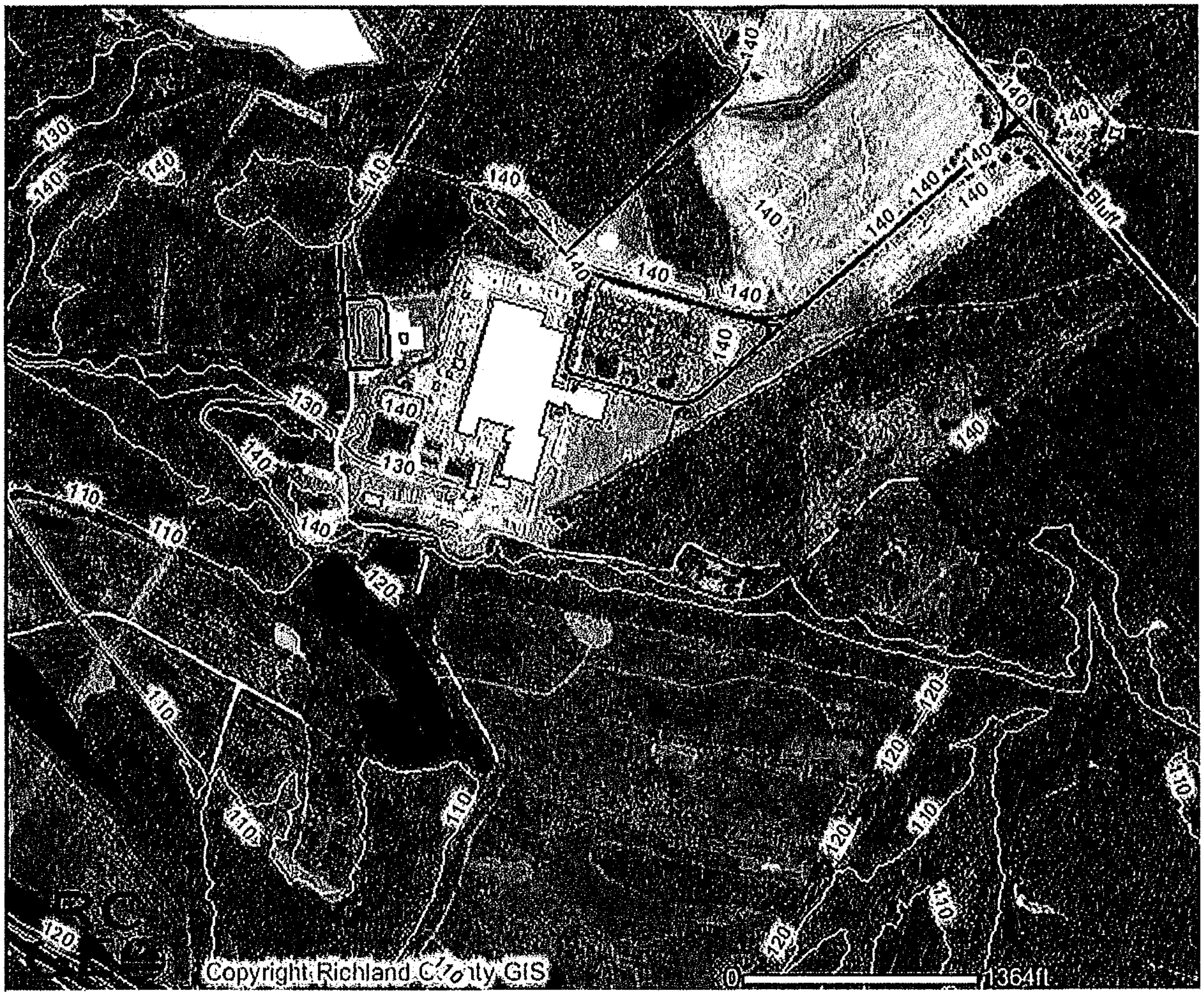
Reservoir. Based on an evaluation by SCE&G, total failure of the Lake Murray Dam could result in a peak flood level of about 154 ft (above MSL) at the CFFF site; overtopping failure of the dam could result in a peak flood level of 169 ft (above MSL). Failure of the Lake Murray Dam would result in substantial flooding of the Columbia area and of the CFFF site. Because of the vulnerability of the Lake Murray Dam (which is an earthen dam) to earthquake-induced failure, SCE&G has built a secondary containment dam. The secondary containment dam is designed to withstand an earthquake the size of the Charleston earthquake of 1886 which measured a maximum Moment Magnitude (M_w) 7.56. Therefore, it is highly unlikely that the Lake Murray Dam system will fail, resulting in flooding of the CFFF.

The SCE&G study revealed that failure of the Parr Shoals Dam would result in a peak flood level of 129 ft (above MSL) at the CFFF site. Failure of the Parr Shoals Dam could impact the low-lying, undeveloped areas of the CFFF site, but would not have any impact on the main manufacturing facilities.

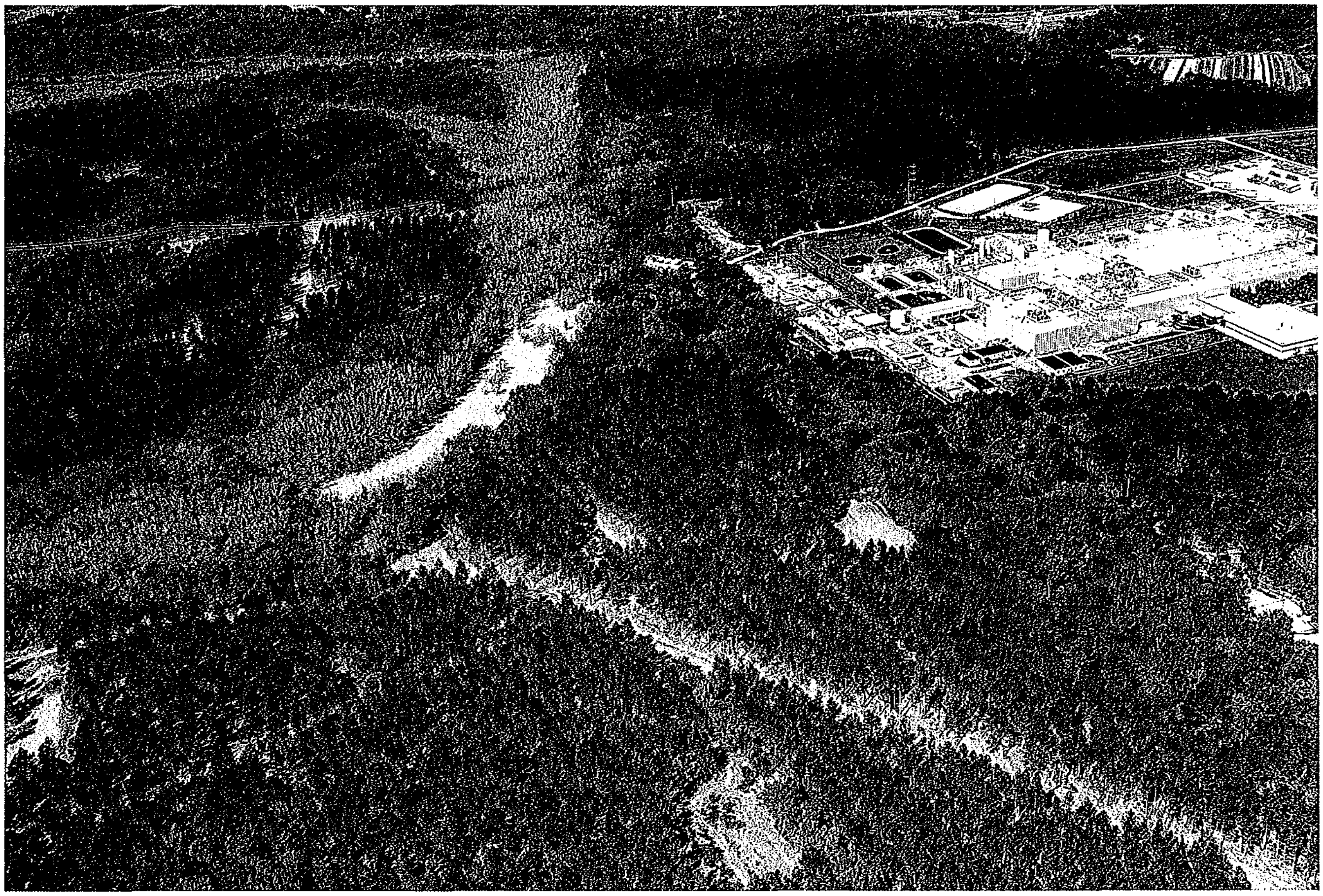
The SCE&G study did not evaluate simultaneous failure of both the Lake Murray Dam and the Parr Shoals Dam. Failure of the Lake Murray Dam by itself or simultaneous failure of both dams would result in complete flooding of the CFFF site, with the floor of the main manufacturing building under at least 12 ft of water. A flood this size would result in release of uranium to the environment, and possibly a nuclear criticality accident. Failure of the Lake Murray Dam requires widespread evacuation in Richland County. As stated above, it is highly unlikely that this could occur.

Two pictures follow to show a contour map of CFFF site elevations and also an aerial image of flooding during the October 2015 storm/flood.

Contour Map of CFFF Site Showing Elevations



Aerial Image of Flooding at Westinghouse CFFF - October 2015



It should be noted that an unusual occurrence did happen during the October 2015 flood regarding two treated wastewater lagoons at the site. Despite diligent, continuous discharging of treated plant wastewater, the heavy rain caused lagoons to reach maximum levels. The heavy rainfall over an extended period of time filled the Sanitary Lagoon beyond its capacity, causing it to overflow into the North Lagoon. The process engineer instructed operations to raise the chlorine rate and to monitor the aerator chlorine along with the residual chlorine. The Sanitary Lagoon passively overflowed into the North Lagoon for approximately 48 hours during the excessive rain event. Ultimately the rain stopped and the level in the Sanitary Lagoon normalized such that it returned to discharge through the rate metering box/ chlorinator. In addition, the West II Lagoon overflowed its liner onto the surrounding banks for approximately 48 hours beginning October 4th and ending October 6th.

The potential environmental impact from the sanitary lagoon overflow is that unknown levels of BOD and fecal coliform could have been released to the surrounding environment. The West II solution overflow could have contributed unknown levels of ammonia, calcium, fluoride and nitrates to the surrounding area. However, on October 5th, a site environmental engineer

confirmed that process samples from the lagoons for ammonia and fluoride passed discharge and effluent limit parameters. Furthermore, since operations were shut down October 4^{th}-6^{th}, the water that overflowed the lagoon banks contained primarily rain water. As of October 6^{th}, both lagoons were within normal containment, and the site resumed normal discharge volumes. As a result of the unintentional bypass events (lagoon overflows), CFFF sent an email notification to SCDHEC on October 5^{th}, 2015. No further action has been identified by SCDHEC for CFFF as a result of this event.

Waste Management

35. Section 3.12 of the Supplemental ER is based on data prior to 2005. Revise Section 3.12 with current information.

Reply

Section 3.12 has been updated with current information as follows:

Section 3.12 Waste Management

This section summarizes air, liquid and solid effluents from CFFF operations (NRC, 2007a).

Section 3.12.1 Airborne Effluents

Airborne effluents are normally treated by HEPA filters, scrubbers, or both prior to release through stacks in accordance with 40 CFR Parts 50 and 61, and 10 CFR Part 20. The CFFF is classified as a minor-source operator, and the SC-DHEC does not require Westinghouse to directly monitor for nonradiological pollutants. Instead, Westinghouse provides modeled emissions rates that the SC Department of Environmental Health and Control uses to determine compliance. Table 3.12-1 contains the modeled emission rates for various CFFF nonradiological gaseous pollutants. Emission rates are calculated based on process throughputs expressed in hours of operation. Typically, the SC-DHEC performs compliance calculations for minor-source operators when permits are renewed or facilities are new or undergo major changes. Table 3.12-2 contains the modeled concentrations for various CFFF nonradiological gaseous pollutants. All pollutant concentrations were below regulatory limits. The only pollutant with concentrations greater than 18 percent of the limit was sulfur dioxide. The sulfur dioxide concentration ranged between 25 and 68 percent of the limit depending on the averaging time used for the calculation. Exposure calculations from the CFFF radiological gaseous emissions are presented in Section 3.11.

Section 3.12.1 Liquid Effluents

Liquid effluents are treated and discharged into the Congaree River in accordance with the NPDES permit and 10 CFR Part 20 requirements. On a typical day, CFFF discharges 492,000 L (130,000 gal) of liquid effluent into the Congaree River. Nonradiological parameters analyzed for NPDES compliance include pH, fluoride, ammonia, dissolved oxygen, biochemical oxygen demand, total suspended solids, phosphorus, fecal coliform, and total residual chlorine (TRC). From 2000 to 2005, the only parameter to exceed NPDES limits was biochemical oxygen demand (Westinghouse, 2004, 2006a). During that time, the daily maximum threshold was exceeded three times, and the monthly average threshold was exceeded four times. The largest of these temporary exceedances occurred on September 19, 2002, when the biochemical oxygen demand was nearly twice the daily maximum threshold (Westinghouse, 2004). From 2005-present, NPDES limits have been exceeded for BOD,

TSS, DO, pH, TRC, and fecal coliform. Over the 10-year period, BOD exceeded the allowable daily maximum 3 times, with the highest being 72.62 lb/d versus a limit of 60 lb/d. The monthly average for BOD has been exceeded once since 2006 at 48.65 lb/d versus an allowable 30 lb/d. BOD was not sampled one week in September of 2013, which also resulted in a permit violation with SCDHEC. TSS exceeded the daily maximum twice and monthly average once with the highest measurement of 93.16 lb/d versus the permit limit of 64 lb/d in April of 2010. Dissolved oxygen has been below the permitted limit once by 0.02 mg/l, which occurred in 2012. Values for pH were not in compliance for 2 events, one in November of 2012 when the maximum of 9.0 was exceeded with 9.24 and then again in January 2014 for 4 days when frozen vacuum breaks caused line siphoning. Another equipment failure caused a violation of TRC in February 2014 where the site discharged effluent measuring 1.38 mg/l TRC versus the allowable 1.0 mg/l. The most recent violations resulted from a sanitary package plant upset where the daily maximum for fecal coliform was exceeded four times in October 2014, with the highest value recorded at 1300 versus the permitted limit of 400. The permit exceedances are acute compliance issues, which are corrected quickly and do not have lasting impact on the environment.

Exposure calculations from the CFFF radiological liquid effluents are presented in Section 3.11. Storm water runoff is regulated by the SC-DHEC under a general NPDES permit for Storm Water Discharges Associated with Industrial Activity (Permit Number SCR000000). As required by this permit, Westinghouse developed a Storm Water Pollution Prevention Plan.

Table 3.12-1 Modeled Emission Rates for CFFF Nonradiological Gaseous Pollutants

Facility Wide Emissions	
Pollutant	**Uncontrolled Emissions (TPY)**
PM	7.86
PM_{10}	6.35
$PM_{2.5}$	3.90
SO_2	86.04
NO_x	27.96
CO	25.53
VOC	8.885
Nitric Acid (HNO_3) [TAP]	0.77

Source: SCDHEC 2012b

This is the most current information that is available, as newer emissions modeling has not been conducted.

Table 3.12-2 Maximum Modeled Concentrations for CFFF Nonradiological Gaseous Pollutants

Pollutant	Averaging Time	Maximum Modeled Concentration ($\mu g/m^3$)	Standard ($\mu g/m^3$)
SO_2	3 hours	724.93	1,300
	24 hours	245.55	365
	Annual	20.082	80
PM_{10}	24 hours	18.04	150
NO_2	Annual	18.06	100

CO	1 hour	202.28	40,000
	8 hours	151.85	10,000
Nitric Acid	--	0.5	125

This is the most current information that is available, as newer emissions modeling has not been conducted.

Source: NRC, 2007a. U.S. Nuclear Regulatory Commission, NRC Environmental Assessment for Renewal of Special Material Nuclear Material License No. SNM-1107 (April 19, 2007).

Section 3.12.3 Solid and Hazardous Waste

The CFFF operations produce low-level radioactive solid waste. As described in Section 1.3.2, the material is either decontaminated for free release or reuse, incinerated onsite, or shipped offsite for disposal. Low-level radioactive waste shipped offsite is usually done so in a sealand container, causing the volume to vary based on the fullness of the sealand container. From 1996 to 2003, the annual amount of low-level radioactive waste shipped offsite varied between 79 m^3 (2,790 ft^3) and 5,132 m^3 (181,235 ft^3) (Westinghouse, 2004). Since 2008, the amount of low-level radioactive waste shipped offsite has decreased, ranging from 356.8 m^3 (12, 600 ft^3) and 733.3 m^3 (25,898 ft3). The cumulative maximum shipped off-site since 2008 is 4,623.3 m^3 (25, 898 ft^3).

Hazardous wastes such as degreasing solvents, lubricating and cutting oils, and spent plating solutions are generated at the CFFF. These wastes are regulated under 40 CFR Part 261, *Identification and Listing of Hazardous Waste*; 40 CFR Part 262, *Standards Applicable to Generators of Hazardous Waste; and South Carolina Hazardous Waste Regulations R61-79.261*. Hazardous Waste Generation Reports are provided quarterly, and the waste is disposed of offsite through permitted contractors. The annual CFFF hazardous waste generation rate is approximately 18,100 kg (39,904 lb) (Westinghouse, 2006a).

Nonhazardous waste is generated from routine office and industrial activities and is disposed of locally at an offsite state-permitted landfill. The annual CFFF generation rate in FY2014 for this type of waste was approximately 148 MT (163 T).

No waste is disposed onsite. Also, no mixed waste (radiological and chemical hazardous waste) is present or generated onsite.

36. In Section 4.13.2 of the Supplemental ER, the text should address the proposed action and not the no-action alternative. Provide a revised Section 4.13.2.

<u>Reply</u>

Under the proposed action, no new manufacturing activities would be constructed. There would be no changes to levels of wastes generated at the CFFF and, therefore, no effects on waste management at the CFFF.

Neither the possession limit increase nor the calcium fluoride limit increase would have an impact on the waste management of CFFF.

<u>Cumulative Impacts</u>

37. Provide the impact to the environment which results from the action when

added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such as, but not limited to, the following:

37.1. Logging roads or unimproved roads used for timber harvesting and access to private properties behind the CFFF site.

Reply

Logging activities have an overall positive impact on the site. Logging is an important part of sustainable forestry and ecosystem management. The increases in transportation on SC-48 is one of the few negative impacts that results from logging activities along with additional carbon emissions. The transportation, however is negligible compared to the 1100 employees already commuting to the site daily. Logging has been practiced on the Westinghouse property for decades and prior to the construction of the nuclear fuel facility.

37.2. Dose estimates to workers and public due to the increase in possession limit for ^{235}U.

Reply

NRC issued SNM-1107, Amendment 18, dated November 2, 2015, which included approval to increase the possession limit for the storage of Uranium Hexafluoride (UF_6). The Safety Evaluation Report (SER) for this amendment discusses that the additional dose to the public would be negligible. Also, there is no significant increase in individual or cumulative occupational exposure because the UF_6 is stored in sealed cylinders, and workers will not spend any more time near the cylinders.

37.3 Expansion of the storage pad

Reply

The project to expand the storage pad was previously reviewed by NRC and documented in the Safety Evaluation Report (SER) for SNM-1107, Amendment 18, dated November 2, 2015. The environmental review in this SER discussed that there were no significant environmental impacts as a result of the project.

37.4 Additional transportation of UF6 cylinders near CFFF due to the increase in possession limits.

Reply

The SER for SNM-1107, Revision 18 determined no significant environmental impacts for the transport of approximately 600 UF_6 cylinders for storage at the CFFF.

The transport of radioactive materials makes up a very small percentage of the total number of hazardous materials transported each year, and radioactive material transportation accidents in the U.S. fuel cycle industry are very rare. If an accident were to occur, the impact to the public or the environment would be minimal due to the robust transport packages, which are designed to withstand worst case accident conditions, and the strict U.S. Department of Transportation regulations. Package designs are approved by the NRC and are manufactured, maintained and modified under a NRC approved quality assurance program.

37.5. Changes in the number of shipments of fuel assemblies.

Reply

There are no anticipated increases in production throughput at the CFFF, which would result in an increase in the number of shipments of fuel assemblies. The CFFF is essentially operating at capacity, and any significant changes in production throughput would require NRC pre-approval to install additional production capacity.

37.6. Delivering of fuel assemblies to any new or different destination places.

Reply

The delivery of fuel assemblies to new or different destinations would have no significant impact on the public or the environment. The CFFF already makes routine shipments globally to the Americas, Europe, and Asia regions.

37.7. Changes in the design of packaging used for shipping fuel assemblies.

Reply

Fuel assembly package design and specifications must be approved by the NRC. These robust transport packages are designed to withstand worst case accident conditions. These packages are also manufactured, maintained and modified under a NRC approved quality assurance program. There is no significant impact to the public or the environment for changes in the design of packaging used for shipping fuel assemblies.

37.8. Changes in the number of fuel assembly packages per shipment.

Reply

The use of a fuel assembly package that holds one versus two assemblies is a positive safety improvement due to additional safety margin provided by the new package. The transportation impacts of shipping 2 less assemblies per vehicle with the use of the newer, more robust package are negligible.

37.9. Receiving shipments of UF_6 cylinders from new or different origins in case there are plans to receive shipments from any new or different origins.

Reply

There are no plans to receive UF_6 cylinders from new or different origins.

37.10. Changes in the type of shipping containers and in the process of loading and unloading.

Reply

There are no significant impacts to the public or the environment for changes to shipping container type. Any such changes would be made in accordance with strict NRC and DOT regulations. Material handling changes in the package loading and unloading process would not have any significant impacts either.

37.11. UF_6 cylinders to various means of transportation.

Reply

UF_6 cylinders have been safely transported by land and by boat for decades. There are no anticipated changes in the transportation method.

38. Discuss the environmental impacts of the proposed natural gas pipeline to go through the CFFF site. Provide a map indicating the path of the natural gas pipeline through the site. Discuss the depth and width of the excavation needed for the gas pipeline. Discuss the depth of the gas pipeline.

Reply

The pipeline location, whether on Westinghouse property or not, is still being determined under Federal Energy Regulatory Commission requirements. Other details such as width and depth of excavation and a map detailing the location do not exist, as this information would be dependent on the final location.

Calcium Fluoride Release Limit

39. The proposed release limit would allow concentrations of 60 pico-curies per gram to replace the current value of the 30 pico-curies per gram limit. Discuss the environmental impacts of the change.

Reply

Calcium fluoride is contained in very low concentrations in treated wastewater. This treated wastewater is pumped to lined lagoons where the solid settles to the bottom of the lagoon. The solid material is removed and dewatered from the bottoms of the lagoons and placed in a large pile where it dries prior to being transported off site for other use or disposal.

A sampling plan is in effect and provides for the monitoring of the material for environmental and radiological concerns as well as for release, e.g., burying or industrial usage. This is performed in compliance with SNM-1107 requirements. The current limit for uranium release is 30 pico-curies per gram.

According to the article "*Uranium Resources in Phosphate Rocks*," M. Ragheb, 1/23/2010, "world phosphate rock deposits have an average content of uranium between 50 – 200 ppm. Marine deposits have averages between 6 – 120 ppm, with organic phosphorite deposits up to 600 ppm." The article further states that there are 15 billion metric tons of phosphate reserves in the world.

Considering the references from the article, naturally occurring uranium concentrations in the environment are much higher than the levels in calcium fluoride generated by the CFFF waste treatment process. A mean uranium concentration of approximately 60 pico-curies per gram converts to about 22 ppm, when using the specific activity (2.590 microcuries per gram U) obtained from isotopic analysis. This concentration is well below naturally occurring material in the environment. Although Tc-99 has been identified in low levels in the wastewater stream, an external analysis shows no Tc 99 is present in the solid calcium fluoride material. Calculations performed using RESRAD to the maximally exposed individual are shown to be less than 10 mrem/yr. Long term exposures continue to be less than 10 mrem/year. The results in Table 1 below are based on the industrial worker scenario in RESRAD considering direct exposure to calcium fluoride. The doses resulting from exposure to 60 pCi/gm of calcium fluoride are less than the 25 mrem/year limit specified in 10CFR20.1402, radiological criteria for unrestricted use. The TEDE does not exceed 25 mrem/ year, and there is no exposure to ground water sources since the product is converted to a stable form. Allowing the unrestricted use of the calcium fluoride for cement production reduces the burden on the environment by preventing disposal to a landfill.

TABLE-1

Dose in mrem/yr

Years	0	1	3	10	30	100	300	1000
60 pCi/gm	1.631	1.627	1.620	1.590	1.532	1.363	1.206	1.853

According to the cement manufacturer, workers are not required to wear a respirator. Employees are in an enclosed cab scooping and dumping loads for approximately 30 minutes per day for a total of 2.5 hours per week. The operator receives no physical exposure to the calcium fluoride.

For this conservative calculation, a 15 hour work week was assumed, and the worker is assumed to have some exposure to the calcium fluoride.

Known Values & Assumptions:
C_{dust} = 60 pci/gm
Mass loading factor (RESRAD) = 200 $\mu g/m^3$
All dust concentrations are equal

Concentration in air = (C_{dust})(mass loading factor)(10^{-6}g/1μg)
Concentration in air = (60 pci/gm)(200 $\mu g/m^3$) = 0.012 pci/gm

Known Values & Assumptions:
DCFs(Decommissioning Health Physics: A Handbook for MARSIMM Users, Second Edition referenced to Table 2.1 of Federal Guidance Report No. 11 (EPA 1988):

U-238 = 0.12 mrem/pci
U-234 = 0.13 mrem/pci
U-235 = 0.12 mrem/pci

Breathing rate (Heavy) =2.5m^3/hour
Worker Exposure to Calcium Fluoride: 15 hours per week

Dose = (0.012 pci/m^3)(breathing rate2.5 m^3/h)(DCF mrem/pci)(15 h/week) (52 weeks)

Annual Dose:

U-238 = 2.808 mrem
U-234 = 3.042 mrem
U-238 = 2.808 mrem
Total Annual Dose = 8.658 mrem < 10 mrem/year
Note: U–236 is not considered due to the low, 0.07%, nuclide percent activity.

Inhalation risks remain below 10 mrem/year. They will actually be even lower with the use of respiratory equipment while working directly with calcium fluoride in the brick or cement manufacturing process. Dose exposures will also be significantly lower due to lower concentrations of calcium fluoride needed in brick or cement products. Shielding provided by the products is a factor for low dose too. Considering the selected pathways in RESRAD 6.5, all doses remain below 10 mrem per year, with no expected environmental risks. In addition, stabilized calcium fluoride material will not support plant growth, so pathways such as plant growth and use, food pathways, and animal plant consumption are not reasonable.

<u>Editorial</u>

40. Resolve the following inconsistency between the ER and the renewal application regarding the acreage of the CFFF site. The ER states that the facility buildings and related support areas occupy about 24 ha (60 acres) of a 469 ha (1158 acre) site. The renewal application states that the total acreage, approximately 68 acres have been developed to accommodate the fuel fabrication buildings, holding ponds, parking and landscaped areas; approximately 1,083 acres of the site remain undeveloped. The total acreage cited in the renewal application is 1151 acres.

<u>Reply</u>
The license renewal application is correct.

41. The following reference is in ADAMS under, as non-publicly available. "Westinghouse, 2014k. Westinghouse Electric Company, "Uranium in Calcium Fluoride Release Limit, CN- SB-12-018" (Matrix Approvals on 11/28/2012, 42 pages)," is in ADAMS as a non-public document (ML12338A043). Provide a redacted version of the reference.

<u>Reply</u>
A redacted version of the reference is no longer necessary as the information was summarized in question 39 above.

Attachment B

Westinghouse

Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Site
P.O. Drawer R
Columbia, South Carolina 29250
USA

Cynthia Logsdon

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Your ref:
Our ref: LTR-EHS-11-78

Cc: Marc Rosser, Gerry Couture, Elle Binns

Date August 25, 2011

Subject: Assessment of Public Radiological Dose from Liquid and Gaseous Effluents for Calendar Year 2010

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 1-1-2010 and ending 12-31-2010 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 10 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.

Our ref: Westinghouse Electric
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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 are 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 2010 were:

411.2 μCi of Uranium released as gaseous effluent
8.1 mCi of Uranium released in liquid effluent
19.2 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:	Uranium Specific Activity
Attachment 9:	History of Liquid Effluents

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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 1.49 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*	0.160	5.65-03	1.49
Liquid Effluents			
Potable Water	1.97E-04	2.86E-03	
Aquatic Food(Fish)	1.22E-05	1.65E-04	
Shoreline Deposit	6.11E-09		
Total (mRem/Yr)	0.160	8.68E-03	1.49

* 80 % residence time

Dan Colwell
Manager, Environment, Health & Safety Operations
RSO

Technical Review by Anna Pearson
Assistant RSO, Principle Engineer
Environment, Health & Safety

	GASEOUS EFFLUENT DISCHARGES - GASEOUS EFFLUENTS STACK IDENTIFICATION	Calendar year 2010 1st half uCi Uranium /6months	2nd half uCi URANIUM/ 6months	Quantity Released Total uCi	uCi/d	uCi/h	uCi/s	Ci/s U234	U235	U238	2010 EPA Comply Run Results Dose, Mrem/yr	2009 EPA Comply Run Results Dose, Mrem/yr	2008 EPA Comply Run Results Dose, Mrem/yr
1	FURNACE EX LINE 1	**3.78**	**5.27**	9.05	2.48E-02	1.03E-03	2.87E-07	2.44E-13	8.61E-15	3.44E-14		4.20E-03	4.70E-03
2	FURNACE EX LINE 2	**3.81**	**5.48**	9.29	2.55E-02	1.06E-03	2.95E-07	2.50E-13	8.84E-15	3.54E-14		4.50E-03	5.00E-03
3	FURNACE EX LINE 3	**3.88**	**5.25**	9.13	2.50E-02	1.04E-03	2.90E-07	2.46E-13	8.69E-15	3.47E-14		4.60E-03	4.90E-03
4	FURNACE EX LINE 4	**3.57**	**4.77**	8.34	2.28E-02	9.52E-04	2.64E-07	2.25E-13	7.93E-15	3.17E-14		4.10E-03	4.50E-03
5	FURNACE EX LINE 5	**3.99**	**7**	10.99	3.01E-02	1.25E-03	3.48E-07	2.96E-13	1.05E-14	4.18E-14		4.80E-03	5.10E-03
6	NEW DECON RM	**2.24**	**3.15**	5.39	1.48E-02	6.15E-04	1.71E-07	1.45E-13	5.13E-15	2.05E-14		5.90E-03	4.30E-03
7	MET LAB EX	**1.58**	**3.63**	5.21	1.43E-02	5.95E-04	1.65E-07	1.40E-13	4.96E-15	1.98E-14		2.70E-03	3.00E-03
8	INCINER EX	**16.5**	**18.15**	34.65	9.49E-02	3.96E-03	1.10E-06	9.34E-13	3.30E-14	1.32E-13		7.50E-03	4.70E-03
9	SUPPL INC EX	**2.24**	**1.86**	4.10	1.12E-02	4.68E-04	1.30E-07	1.11E-13	3.90E-15	1.56E-14		3.60E-03	2.70E-03
10	CONVERS 1-A EX	**32.86**	**13.01**	45.87	1.26E-01	5.24E-03	1.45E-06	**1.24E-12**	**4.36E-14**	**1.75E-13**		**1.40E-02**	**1.50E-02**
11	CONVERSION 1-B	**0**	**0**	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	5.50E-05
12	S-1030-A	**10.62**	**11.2**	21.82	5.98E-02	2.49E-03	6.92E-07	**5.88E-13**	**2.08E-14**	**8.30E-14**		**1.20E-02**	**2.10E-02**
13	S-1030-B	**1.98**	**4.05**	6.03	1.65E-02	6.88E-04	1.91E-07	1.63E-13	5.74E-15	2.29E-14		2.20E-03	1.70E-03
14	MAINT ENCL 4B	**0**	**0**	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	0.00E+00
15	CONV ENCL EX 4C	**7.3**	**11.05**	18.35	5.03E-02	2.09E-03	5.82E-07	**4.95E-13**	**1.75E-14**	**6.98E-14**		**8.80E-03**	**7.90E-03**
16	CONV ENCL EX 4D	**0**	**0**	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	0.00E+00
17	CONV EMERG EX 4E	**1**	**2.1**	3.10	8.49E-03	3.54E-04	9.83E-08	8.36E-14	2.95E-15	1.18E-14		1.20E-03	1.20E-03
18	CHEM LAB FILTERED EX	**7.36**	**10.35**	17.71	4.85E-02	2.02E-03	5.62E-07	**4.77E-13**	**1.68E-14**	**6.74E-14**		**7.90E-03**	**8.80E-03**
19	DECON ROOM EX	**1.86**	**2.34**	4.20	1.15E-02	4.79E-04	1.33E-07	**1.13E-13**	**4.00E-15**	**1.60E-14**		**2.70E-03**	**9.50E-03**
20	CAL COMBGAS LN 1	**0.89**	**0.53**	1.42	3.89E-03	1.62E-04	4.50E-08	3.83E-14	1.35E-15	5.40E-15		1.20E-03	8.80E-04
21	CAL COMBGAS LN 2	**0.57**	**0.53**	1.10	3.01E-03	1.26E-04	3.49E-08	2.96E-14	1.05E-15	4.19E-15		6.40E-04	7.20E-04
22	CAL COMBGAS LN 3	**1.03**	**0.82**	1.85	5.07E-03	2.11E-04	5.87E-08	4.99E-14	1.76E-15	7.04E-15		5.80E-04	4.00E-04
23	CAL COMBGAS LN 4	**0.41**	**0.45**	0.86	2.36E-03	9.82E-05	2.73E-08	2.32E-14	8.18E-16	3.27E-15		4.30E-04	5.30E-04
24	CAL COMBGAS LN 5	**0.35**	**0.56**	0.91	2.49E-03	1.04E-04	2.89E-08	2.45E-14	8.66E-16	3.46E-15		3.80E-04	7.90E-04
25	CHEM LAB # 2	**1.07**	**2.32**	3.39	9.29E-03	3.87E-04	1.07E-07	9.14E-14	3.22E-15	1.29E-14		3.00E-03	3.50E-03
26	CHEM LAB #3	**0.42**	**0.43**	0.85	2.33E-03	9.70E-05	2.70E-08	2.29E-14	8.09E-16	3.23E-15		5.00E-04	4.60E-04
27	HP LAB EX	**0.77**	**0.96**	1.73	4.74E-03	1.97E-04	5.49E-08	4.66E-14	1.65E-15	6.58E-15		8.40E-04	8.90E-04
28	DEV LAB 1 EX	**3.5**	**5.81**	9.31	2.55E-02	1.06E-03	2.95E-07	2.51E-13	8.86E-15	3.54E-14		3.50E-03	4.50E-03
29	DEV LAB 2 EX	**1.37**	**1.86**	3.23	8.85E-03	3.69E-04	1.02E-07	8.71E-14	3.07E-15	1.23E-14		1.50E-03	2.20E-03
30	PELLET COMBINED	**6.62**	**6.36**	12.98	3.56E-02	1.48E-03	4.12E-07	**3.50E-13**	**1.23E-14**	**4.94E-14**		**7.20E-03**	**8.50E-03**
31	SOLV X N	**3.73**	**4.09**	7.82	2.14E-02	8.93E-04	2.48E-07	2.11E-13	7.44E-15	2.98E-14		3.90E-03	6.30E-03
32	SOLV X S	**2.06**	**4.32**	6.38	1.75E-02	7.28E-04	2.02E-07	1.72E-13	6.07E-15	2.43E-14		2.20E-03	2.20E-03
34	MAP COMBINED	**0**	**0**	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	0.00E+00
35	ABF HOOD TORIT EX	**2.12**	**2.05**	4.17	1.14E-02	4.76E-04	1.32E-07	1.12E-13	3.97E-15	1.59E-14		2.70E-03	2.30E-03
36	IFBA EX	**5.91**	**6.09**	12.00	3.29E-02	1.37E-03	3.81E-07	**3.23E-13**	**1.14E-14**	**4.57E-14**		**6.80E-03**	**6.90E-03**
37	MAINT WELD EX	**3.5**	**6.38**	9.88	2.71E-02	1.13E-03	3.13E-07	2.66E-13	9.40E-15	3.76E-14		4.10E-03	5.20E-03
38	AC-3	**4.71**	**4.94**	9.65	2.64E-02	1.10E-03	3.06E-07	2.60E-13	9.18E-15	3.67E-14		5.20E-03	5.30E-03
39	PELLET LINE 6	**3.51**	**3.86**	7.37	2.02E-02	8.41E-04	2.34E-07	1.99E-13	7.01E-15	2.80E-14		4.00E-03	4.20E-03
40	AC-5	**4.75**	**4.82**	9.57	2.62E-02	1.09E-03	3.03E-07	2.58E-13	9.10E-15	3.64E-14		5.10E-03	5.20E-03
41	AC-8	**5.02**	**4.81**	9.83	2.69E-02	1.12E-03	3.12E-07	2.65E-13	9.35E-15	3.74E-14		5.30E-03	5.40E-03
42	AMMONIA FUME SC 1008-A	**5.98**	**3.27**	9.25	2.53E-02	1.06E-03	2.93E-07	2.49E-13	8.80E-15	3.52E-14		7.30E-03	4.00E-03
43	AMMONIA FUME SC 1008-B	**0**	**0**	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00		0.00E+00	1.80E-04
44	AC-4	**4.96**	**6.56**	11.52	3.16E-02	1.32E-03	3.65E-07	3.11E-13	1.10E-14	4.38E-14		5.40E-03	5.60E-03
45	HOT OIL RM EX	**10.48**	**9.66**	20.14	5.52E-02	2.30E-03	6.39E-07	**5.43E-13**	**1.92E-14**	**7.66E-14**		**1.00E-02**	**1.40E-02**
46	ERBIA FURNACE EX	**14.72**	**11.78**	26.50	7.26E-02	3.03E-03	8.40E-07	**7.14E-13**	**2.52E-14**	**1.01E-13**		**1.10E-02**	**1.10E-02**
47	ERBIA SCRUBBER EX	**5.39**	**5.77**	11.16	3.06E-02	1.27E-03	3.54E-07	3.01E-13	1.06E-14	4.25E-14		5.90E-03	6.10E-03
48	ERBIA CHANGE ROOM	**2.55**	**2.56**	5.11	1.40E-02	5.83E-04	1.62E-07	1.38E-13	4.86E-15	1.94E-14		2.70E-03	2.90E-03
				411.21									
								Sum of Offsite Dose mRem/yr			**0.20**	**0.1921**	**0.2142**
								80% residence time			**0.160**	**0.154**	**0.171**
								Result is substantially less than 10 mRem/yr					

Lung/Bone Organ Dose For Gaseous Effluent 2010

2010			**Released**	**EPA**			
GASEOUS EFFLUENTS	**1st half**	**2nd half**	**Total uCi**	**Comply Run Results**			
STACK IDENTIFICATION	**uCi Uranium /6months**	**uCi URANIUM/ 6months**		**Dose, Mrem/yr**		**µCi**	
CONVERS 1-A EX	**32.86**	**13.01**	45.87	**2.50E-02**		3.8990E-05	U-234
use highest release for year to calculate X/Q used by COMPLY						1.3761E-06	U-235
						5.5044E-06	U-238
Dose from comply	0.02500	mrem/yr					
release quantity	45.87	uCi/yr					
Inhalation from RG1.109	4.59E-05	Ci/yr					
App E table E-5	8000.00	m3/yr					
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)							
	1.65E-05	X/Q					
Estimate Lung Dose using X/Q and total released for 2010				Estimate Bone Dose using X/Q and total released for 2010			
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	mrem/pCi= factor* Sv/Bq		
weighted dose conversion	1.0846	mrem/pCi		4.11E-03	mrem/pCi		
release quantity	411.21	uCi/yr		411.21	uCi/yr		
	4.11E-04	Ci/yr		4.11E-04	Ci/yr		
Lung *	**1.49**	**mrem/yr**	**Bone ***	**5.65E-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
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
														U-235	3.00E-07	7.30E+05	2.19E-01	2.19E+05	50
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
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
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
1.77058E-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																			
0.008125	**total uranium(Ci)**	**Q**	summation of liquid effluent alpha activity for 2010			**see 2010 total tab**													
				% of activity based on current nominal uranium isotopic				**see u activity tab**											
0.006906	U-234 release fraction	Ci	URANIUM234	84.70															
0.000244	U-235 release fraction	Ci	URANIUM235	3.40															
0.000000	U-236 release fraction	Ci	URANIUM236	0.10															
0.000975	U-238 release fraction	Ci	URANIUM238	11.70															
0.019165	Tc-99 release fraction	Ci	TC-99																
check U sum	0.0081																		
1.96E-06	U-234	release fraction *dose factor*exp(-λ*tp)																	
6.48E-08	U-235	release fraction *dose factor*exp(-λ*tp)																	
0.00E+00	U-236	release fraction *dose factor*exp(-λ*tp)																	
2.48E-07	U-238	release fraction *dose factor*exp(-λ*tp)																	
2.80E-08	Tc-99	release fraction *dose factor*exp(-λ*tp)																	
2.30E-06	all nuclides	sum of nuclides																	
85.53473	usage	1100*(usage*dilution)/flow																	
1.97E-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 10^5 (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								
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 1	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																				
0.008125	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity			**see 2010 total tab**														
				% of activity based on current nominal uranium isotopic					**see u activity tab**											
0.006906	U-234 release fraction	Ci	URANIUM234	84.70																
0.000244	U-235 release fraction	Ci	URANIUM235	3.40																
0.000000	U-236 release fraction	Ci	URANIUM236	0.10																
0.000975	U-238 release fraction	Ci	URANIUM238	11.70																
0.019165	Tc-99 release fraction	Ci	TC-99																	
0.0081	check U sum																			
2.89E-05	U-234	release fraction *dose factor*exp(-λ*tp)																		
9.47E-07	U-235	release fraction *dose factor*exp(-λ*tp)																		
0.00E+00	U-236	release fraction *dose factor*exp(-λ*tp)																		
3.64E-06	U-238	release fraction *dose factor*exp(-λ*tp)																		
4.28E-09	Tc-99	release fraction *dose factor*exp(-λ*tp)																		
3.35E-05	all nuclides	sum of nuclides																		
85.53473	usage	1100*(usage*dilution)/flow																		
2.86E-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	milliters	uCi	pCi	mRem	mRem/pCi
24	hrs	transit time	t-p	reg guide 1	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												
0.99999999223	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																				
0.008125	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2010			**see 2010 total tab**														
				% of activity based on current nominal uranium isotopic				**see u activity tab**												
0.006906	U-234 release fraction	Ci	URANIUM234	84.70																
0.000244	U-235 release fraction	Ci	URANIUM235	3.40																
0.000000	U-236 release fraction	Ci	URANIUM236	0.10																
0.000975	U-238 release fraction	Ci	URANIUM238	11.70																
0.019165	Tc-99 release fraction	Ci	TC-99																	
check U sum	0.0081																			
							bioaccumulation factor			BNWL-2075										
3.91E-06	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			UC-11										
1.30E-07	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			Methodology for Calculation of Radiation Doses										
0.00E+00	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			in the Environs from Nuclear Fuel										
4.96E-07	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2			Cycle Facilities										
4.20E-07	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					15													
4.96E-06	all nuclides	sum of nuclides																		
2.46059	usage	1100*(usage*dilution)/flow																		
1.22E-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/pCi
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												
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14							Sv/Bq	Rem/Bq	mRem/pCi			
				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																				
0.008125	**total uranium(C**	Q	summation of liquid effluent alpha activity for 2010			**see 2010 total tab**														
				% of activity based on current nominal uranium isotopic				**see u activity tab**												
0.006906	U-234 release fra	Ci	URANIUM234	84.70																
0.000244	U-235 release fra	Ci	URANIUM235	3.40																
0.000000	U-236 release fra	Ci	URANIUM236	0.10																
0.000975	U-238 release fra	Ci	URANIUM238	11.70																
0.019165	Tc-99 release fra	Ci	TC-99																	
check U sum	0.0081																			
							bioaccumulation factor		BNWL-2075											
5.77E-05	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		UC-11											
1.89E-06	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Methodology for Calculation of Radiation Doses											
0.00E+00	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		in the Environs from Nuclear Fuel											
7.29E-06	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Cycle Facilities											
6.42E-08	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					15													
6.70E-05	all nuclides	sum of nuclides																		
2.46059	usage	1100*(usage*dilution)/flow																		
1.65E-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															
0.008125	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2010			**see 2010 total tab**									
				% of activity based on current nominal uranium isotopic				**see u activity tab**							
0.006906	U-234 release fraction	Ci	URANIUM234	84.70											
0.000244	U-235 release fraction	Ci	URANIUM235	3.40											
0.000000	U-236 release fraction	Ci	URANIUM236	0.10											
0.000975	U-238 release fraction	Ci	URANIUM238	11.70											
0.019165	Tc-99 release fraction	Ci	TC-99												
check U sum	0.0081														
2.57E-10	U-234	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
1.81E-09	U-235	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
0.00E+00	U-236	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
2.70E-11	U-238	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
7.51E-11	Tc-99	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
2.17E-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...										
6.11E-09	**mRem/yr**	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.													

Based on 2010 nominals - 235 established by safeguards personnel, 234 and 236 by average pellet chemistry in 2009-2010 and 238 by diff

Nuclide	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	0.00	
U-233	0.00	**0.00E+00**	9480	0.000	0.00E+00	0.00	
U-234	9,167	**0.0372**	6234	2.319	8.58E+04	0.847	0.85
U-235		**4.329**	2.14	0.093	3.43E+03	0.034	0.03
U-236	700	**0.00538**	64.7	0.003	1.29E+02	0.001	0.00
U-238		**95.628**	0.34	0.321	1.19E+04	0.117	0.12
Totals		100.000		2.737	101258.563	0.999	

LIQUID EFFLUENTS

YEAR	6 month mCi	Annual mCi
93A	14.0	
93B	22.0	36.0
94A	30.0	
94B	24.0	54.0
95A	22.0	
95B	25.0	47.0
96A	21.0	
96B	26.0	47.0
97A	31.0	
97B	22.0	53.0
98A	21.2	
98B	23.0	44.2
99A	27.2	
99B	23.8	51.0
2000A	56.6	
2000B	67.4	124.0
2001A	32.3	
2001B	30.8	63.1
2002A	24.5	
2002B	39.7	64.2
2003A	37.3	
2003B	17.2	54.5
2004A	23.2	
2004B	26.8	50.0
2005A	13.4	
2005B	12.2	25.6
2006A	6.0	
2006B	4.0	10.0
2007A	6.7	
2007B	3.7	10.5
2008A	3.9	
2008B	6.3	10.2
2009A	6.3	
2009B	4.0	10.283
2010A	5.1	
2010B	3.0	8.100

Attachment C

Westinghouse

Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Site
P.O. Drawer R
Columbia, South Carolina 29250
USA

Cynthia Logsdon

Direct tel: 803-647-3665
Direct fax: 803-695-4158
e-mail: colweldl@westinghouse.com

Your ref:
Our ref: LTR-EHS-12-19

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

Our ref: Westinghouse Electric
Company
Nuclear Fuel
Columbia Fuel Site
P.O. Drawer R
Columbia, South Carolina 29250
USA

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

Dan Colwell
Manager, Environment, Health & Safety Operations
RSO

Technical Review by Anna Pearson
Assistant RSO, Principle Engineer
Environment, Health & Safety

Attachment 1

Dose from Gaseous
Effluent-Total Body
Calendar Year 2011

02-21-2012

	GASEOUS EFFLUENT DISCHARGES -		Calendar year 2011		Quantity 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			

O:\Regulatory\EH&S Operations\Environment\Environment 2011\2011 annual stack for whole year.xlsx

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 renewarn ...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/pCi
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 10^5 (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								
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 isoto				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.																		

2011 Dose From Liquid
Effluent Pathways
Aquatic Foods
Whole Body

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	milliters	uCi	pCi	mRem	mRem/pCi
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						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												
0.99999999223	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/pCi
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												
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14							Sv/Bq	Rem/Bq	mRem/pCi			
				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	U234 piC/l	Isotopic uCi/ml E-06 U234	U235 piC/l	U235	U238 piC/l	U238	SUM ISO U	Tc-99 piC/l	uCi/ml E-06 Tc-99	Sum U & Tc
JAN	86.285	2588.540	50.800	0.051	1.860	0.002	7.420	0.007	0.06008	191	0.191	0.251
FEB	110.745	2436.387	36.400	0.036	2.120	0.002	4.320	0.004	0.04284	104	0.104	0.147
MAR	101.406	3143.570	22.500	0.023	0.634	0.001	3.770	0.004	0.026904	132	0.132	0.159
APR	104.329	2816.890	24.700	0.025	1.060	0.001	4.540	0.005	0.0303	118	0.118	0.148
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
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

16410.487 KGAL/6 MONTHS
1.641E+07 gal/6months
6.211E+07 LITERS/6 MONTHS
6.211E+10 ML/6 MONTHS

Total uCi/month

	U234	U-235	U-238	Tc-99	
	514.312	18.831	75.122	1933.732	
	427.218	24.882	50.703	1220.623	
	267.716	7.544	44.857	1570.598	
	292.610	12.557	53.783	1397.894	
	357.145	15.415	52.866	696.922	
	686.910	24.707	86.861	459.786	
	2545.910	103.935	364.192		3014.038 uCi U
4.173%	2561.932	90.421	361.685	7279.555	10293.593 uCi U & Tc
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

Isoptopic Error xE-06 uCi/ml

	U234 piC/l	U234	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

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	+/-	1.282E-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

	Average			Isotopic		uCi/ml E-06					uCi/ml E-06	
Month	kgal/day	kgal/month	U234 piC/l	U234	U235 piC/l	U235	U238 piC/l	U238	SUM ISO U	Tc-99 piC/	Tc-99	Sum U & Tc
JULY	84.584	2283.770	53.100	0.053	2.420	0.002	8.120	0.008	0.06364	101	0.101	0.165
AUG	115.271	3458.130	70.600	0.071	2.570	0.003	12.900	0.013	0.08607	165	0.165	0.251
SEPT	104.907	3147.220	60.400	0.060	2.530	0.003	9.560	0.010	0.07249	111	0.111	0.183
OCT	110.438	3423.560	25.000	0.025	1.870	0.002	4.470	0.004	0.03134	136	0.136	0.167
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
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

18664.900	KGAL/6 MONTHS
1.866E+07	gal/6months
7.065E+07	LITERS/6 MONTHS
7.065E+10	ML/6 MONTHS

	Total uCi/month				
	U234	U-235	U-238	Tc-99	
JULY	527.00	24.018	80.588	1002.391	
AUG	954.89	34.760	174.477	2015.709	
SEPT	719.50	30.138	113.881	1366.328	
OCT	323.96	24.232	57.923	1705.472	
NOV	330.33	15.088	38.291	380.320	
DEC	388.48	15.514	55.875	339.328	
	3244.150	143.749	521.035		3908.934 uCi U
@4.173 %	3322.594	117.268	469.072	6809.549	10718.483 uCi U & Tc

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

Nuclide	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	

Attachment D

Westinghouse

Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Site
5801 Bluff Rd
Hopkins, South Carolina 29061

Cynthia Logsdon

Direct tel: 803-647-1919
Direct fax: 803-695-4158
e-mail: wagoneda@westinghouse.com

Your ref:
Our ref: LTR-EHS-13-10 Rev. 1

Cc: Carl Snyder, Wayne Sepitko, Elle Binns

Date: June 19, 2014

Subject: Assessment of Public Radiological Dose from Liquid and Gaseous Effluents for Calendar Year 2012

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 1-1-2012 and ending 12-31-2012 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 12 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 2012 were:

431.5 μCi of Uranium released as gaseous effluent
3.2 mCi of Uranium released in liquid effluent
20.6 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:	2012 Liquid Effluent Totals
Attachment 9:	Uranium Specific Activity

Our ref: Westinghouse Electric
Company
Nuclear Fuel
Columbia Fuel Site
5801 Bluff Rd
Hopkins, South Carolina 29061
USA

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 1.54 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) Bone	Organ Dose (mRem/yr) Lung
Air Effluents			
Direct inhalation*	0.16	5.86-03	1.54
Liquid Effluents			
Potable Water	7.78E-05	1.11E-03	
Aquatic Food(Fish)	5.44E-06	6.39E-05	
Shoreline Deposit	2.71E-09		
Total (mRem/Yr)	0.16	7.03E-03	1.54

*80 % residence time

David Wagoner
Radiation Safety Engineer
EH&S Operations

Technical Review by Anna Pearson
Manager, RSO
EH&S Operations

	GASEOUS EFFLUENT DISCHARGES -		Calendar year 2012								
	GASEOUS EFFLUENTS	Stack Height	1st half	2nd half	Total Released					Ci/s	
	STACK IDENTIFICATION	(meter)	uCi Uranium /6months	uCi URANIUM/ 6months	(µCi)	uCi/d	uCi/h	uCi/s	U234	U235	U238
1	FURNACE EX LINE 1	13	**3.6**	**3.76**	7.36	2.02E-02	8.40E-04	2.33E-07	1.98E-13	7.00E-15	2.80E-14
2	FURNACE EX LINE 2	13	**3.96**	**3.55**	7.51	2.06E-02	8.57E-04	2.38E-07	2.02E-13	7.14E-15	2.86E-14
3	FURNACE EX LINE 3	13	**3.89**	**3.99**	7.88	2.16E-02	9.00E-04	2.50E-07	2.12E-13	7.50E-15	3.00E-14
4	FURNACE EX LINE 4	13	**3.51**	**3.53**	7.04	1.93E-02	8.04E-04	2.23E-07	1.90E-13	6.70E-15	2.68E-14
5	FURNACE EX LINE 5	13	**3.61**	**3.62**	7.23	1.98E-02	8.25E-04	2.29E-07	1.95E-13	6.88E-15	2.75E-14
6	NEW DECON RM	13	**13.41**	**10.67**	24.08	6.60E-02	2.75E-03	7.64E-07	6.49E-13	2.29E-14	9.16E-14
7	MET LAB EX	10	**1.74**	**3.17**	4.91	1.35E-02	5.61E-04	1.56E-07	1.32E-13	4.67E-15	1.87E-14
8	INCINER EX	13	**4.72**	**9.73**	14.45	3.96E-02	1.65E-03	4.58E-07	3.89E-13	1.37E-14	5.50E-14
9	SUPPL INC EX	13	**2.35**	**5.23**	7.58	2.08E-02	8.65E-04	2.40E-07	2.04E-13	7.21E-15	2.88E-14
10	CONVERS 1-A EX	16	**5.62**	**5.7**	11.32	3.10E-02	1.29E-03	3.59E-07	3.05E-13	1.08E-14	4.31E-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	**46.6**	**14.71**	61.31	1.68E-01	7.00E-03	1.94E-06	1.65E-12	5.83E-14	2.33E-13
13	S-1030-B	16	**1.97**	**3.25**	5.22	1.43E-02	5.96E-04	1.66E-07	1.41E-13	4.97E-15	1.99E-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	**6.73**	**10.53**	17.26	4.73E-02	1.97E-03	5.47E-07	4.65E-13	1.64E-14	6.57E-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	**0.98**	**1.58**	2.56	7.01E-03	2.92E-04	8.12E-08	6.90E-14	2.44E-15	9.74E-15
18	CHEM LAB FILTERED EX	17	**7.41**	**9.12**	16.53	4.53E-02	1.89E-03	5.24E-07	4.46E-13	1.57E-14	6.29E-14
19	DECON ROOM EX	13	**2.13**	**2.06**	4.19	1.15E-02	4.78E-04	1.33E-07	1.13E-13	3.99E-15	1.59E-14
20	CAL COMBGAS LN 1	12	**0.74**	**0.74**	1.48	4.05E-03	1.69E-04	4.69E-08	3.99E-14	1.41E-15	5.63E-15
21	CAL COMBGAS LN 2	12	**0.28**	**0.69**	0.97	2.66E-03	1.11E-04	3.08E-08	2.61E-14	9.23E-16	3.69E-15
22	CAL COMBGAS LN 3	12	**0.34**	**0.57**	0.91	2.49E-03	1.04E-04	2.89E-08	2.45E-14	8.66E-16	3.46E-15
23	CAL COMBGAS LN 4	12	**0.33**	**0.48**	0.81	2.22E-03	9.25E-05	2.57E-08	2.18E-14	7.71E-16	3.08E-15
24	CAL COMBGAS LN 5	12	**0.9**	**0.62**	1.52	4.16E-03	1.74E-04	4.82E-08	4.10E-14	1.45E-15	5.78E-15
25	CHEM LAB # 2	16	**3.28**	**4.59**	7.87	2.16E-02	8.98E-04	2.50E-07	2.12E-13	7.49E-15	2.99E-14
26	CHEM LAB #3	12	**0.42**	**0.42**	0.84	2.30E-03	9.59E-05	2.66E-08	2.26E-14	7.99E-16	3.20E-15
27	HP LAB EX	15	**0.76**	**0.9**	1.66	4.55E-03	1.89E-04	5.26E-08	4.47E-14	1.58E-15	6.32E-15
28	DEV LAB 1 EX	13	**3.36**	**5.51**	8.87	2.43E-02	1.01E-03	2.81E-07	2.39E-13	8.44E-15	3.38E-14
29	DEV LAB 2 EX	12	**5.02**	**8.39**	13.41	3.67E-02	1.53E-03	4.25E-07	3.61E-13	1.28E-14	5.10E-14
30	PELLET COMBINED	13	**6.25**	**6.24**	12.49	3.42E-02	1.43E-03	3.96E-07	3.37E-13	1.19E-14	4.75E-14
31	SOLV X N	13	**4.09**	**4.76**	8.85	2.42E-02	1.01E-03	2.81E-07	2.39E-13	8.42E-15	3.37E-14
32	SOLV X S	13	**2.08**	**2.67**	4.75	1.30E-02	5.42E-04	1.51E-07	1.28E-13	4.52E-15	1.81E-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	**2.4**	**2.08**	4.48	1.23E-02	5.11E-04	1.42E-07	1.21E-13	4.26E-15	1.70E-14
36	IFBA EX	10	**6.06**	**5.99**	12.05	3.30E-02	1.38E-03	3.82E-07	3.25E-13	1.15E-14	4.59E-14
37	MAINT WELD EX	11	**3.81**	**5.53**	9.34	2.56E-02	1.07E-03	2.96E-07	2.52E-13	8.89E-15	3.55E-14
38	AC-3	15	**4.76**	**4.91**	9.67	2.65E-02	1.10E-03	3.07E-07	2.61E-13	9.20E-15	3.68E-14
39	PELLET LINE 6	12	**3.54**	**3.64**	7.18	1.97E-02	8.20E-04	2.28E-07	1.94E-13	6.83E-15	2.73E-14
40	AC-5	17	**4.99**	**6.44**	11.43	3.13E-02	1.30E-03	3.62E-07	3.08E-13	1.09E-14	4.35E-14
41	AC-8	11	**5.22**	**6.02**	11.24	3.08E-02	1.28E-03	3.56E-07	3.03E-13	1.07E-14	4.28E-14
42	AMMONIA FUME SC 1008-A	17	**5.19**	**6.88**	12.07	3.31E-02	1.38E-03	3.83E-07	3.25E-13	1.15E-14	4.59E-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	**5.36**	**5.2**	10.56	2.89E-02	1.21E-03	3.35E-07	2.85E-13	1.00E-14	4.02E-14
45	HOT OIL RM EX	12	**13.03**	**11.41**	24.44	6.70E-02	2.79E-03	7.75E-07	6.59E-13	2.32E-14	9.30E-14
46	ERBIA FURNACE EX	18	**10.22**	**21.54**	31.76	8.70E-02	3.63E-03	1.01E-06	8.56E-13	3.02E-14	1.21E-13
47	ERBIA SCRUBBER EX	18	**5.42**	**5.69**	11.11	3.04E-02	1.27E-03	3.52E-07	2.99E-13	1.06E-14	4.23E-14
48	ERBIA CHANGE ROOM	18	**2.59**	**2.76**	5.35	1.47E-02	6.11E-04	1.70E-07	1.44E-13	5.09E-15	2.04E-14
					431.54				**1.16E-11**	**4.11E-13**	**1.64E-12**
									Sum of Offsite Dose using COMPLY		
									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 2012

	2012				EPA				
	GASEOUS EFFLUENTS	1st half	2nd half		Comply Run Results				
	STACK IDENTIFICATION	uCi Uranium /6months	uCi URANIUM/ 6months		Released Total uCi	61.31			
12	S-1030-A	46.6	14.71		Dose, Mrem/yr	3.30E-02			
	use highest release for year to calculate X/Q used by COMPLY				stack height (meter)	16.00			
					Ci/s	U-234	U-235	U-238	
	Dose from comply	0.03300	mrem/yr			1.65E-12	5.83E-14	2.33E-13	
	release quantity	61.31	uCi/yr						
	Inhalation from RG1.109	6.13E-05	Ci/yr						
	App E table E-5	8000.00	m3/yr						
	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)								
		1.63E-05	X/Q						
	Estimate Lung Dose using X/Q and total released for 2012				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	mrem/pCi= factor* Sv/Bq			
	weighted dose conversion	1.0846	mrem/pCi		4.11E-03	mrem/pCi			
	release quantity	431.54	uCi/yr		431.54	uCi/yr			
		4.32E-04	Ci/yr		4.32E-04	Ci/yr			
	Lung *	**1.54**	**mrem/yr**	Bone *	**5.86E-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/pCi
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																				
3.1463E-03	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2012 **(see Total Liq tab)**																	
			% of activity based on current nominal uranium isotopic **(see U activity tab)**																	
2.6712E-03	U-234 release fraction	Ci	URANIUM234	84.900%	0.849															
1.0383E-04	U-235 release fraction	Ci	URANIUM235	3.300%	0.033															
3.1463E-06	U-236 release fraction	Ci	URANIUM236	0.100%	0.001															
3.6812E-04	U-238 release fraction	Ci	URANIUM238	11.700%	0.117															
2.0589E-02	Tc-99 release fraction	Ci	TC-99																	
check U sum	0.00315																			
7.57E-07	U-234	release fraction *dose factor*exp(-λ*tp)																		
2.76E-08	U-235	release fraction *dose factor*exp(-λ*tp)																		
8.45E-10	U-236	release fraction *dose factor*exp(-λ*tp)																		
9.37E-08	U-238	release fraction *dose factor*exp(-λ*tp)																		
3.01E-08	Tc-99	release fraction *dose factor*exp(-λ*tp)																		
9.09E-07	all nuclides	sum of nuclides																		
85.53473	usage	1100*(usage*dilution)/flow																		
7.78E-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																				
Potable Water		**Bone Surface-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								
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 1	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																				
3.1463E-03	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2012 **(see Total Liq tab)**																	
			% of activity based on current nominal uranium isotopic **(see U activity tab)**																	
2.6712E-03	U-234 release fraction	Ci	URANIUM234	84.900%																
1.0383E-04	U-235 release fraction	Ci	URANIUM235	3.300%																
3.1463E-06	U-236 release fraction	Ci	URANIUM236	0.100%																
3.6812E-04	U-238 release fraction	Ci	URANIUM238	11.700%																
2.0589E-02	Tc-99 release fraction	Ci	TC-99																	
check U sum	0.00315																			
1.12E-05	U-234	release fraction *dose factor*exp(-λ*tp)																		
4.03E-07	U-235	release fraction *dose factor*exp(-λ*tp)																		
1.25E-08	U-236	release fraction *dose factor*exp(-λ*tp)																		
1.38E-06	U-238	release fraction *dose factor*exp(-λ*tp)																		
4.60E-09	Tc-99	release fraction *dose factor*exp(-λ*tp)																		
1.30E-05	all nuclides	sum of nuclides																		
85.53473	usage	1100*(usage*dilution)/flow																		
1.11E-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	
0.3	cubic ft/sec	Average discharge	F	Effluent Flow		3.00E-01	cubic feet/sec	
2.83E-04	U-234	mRem/pCi	D	EPA Limiting Values of Radioanuclide Intake......				
2.66E-04	U-235	mRem/pCi	D	FRG no 11	1988			
2.69E-04	U-236	mRem/pCi	D	Exposure-to-dose conversion factors for ingestion				
2.55E-04	U-238	mRem/pCi	D					
1.46E-06	Tc-99	mRem/pCi	D					
24	hrs	transit time	t-p	reg guide 1	table E-15			
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
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
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)						
1.00000000000	U-235	exp(-λt-p)						
0.99999999992	U-236	exp(-λt-p)						
1.00000000000	U-238	exp(-λt-p)						
0.99999999109	Tc-99	exp(-λt-p)						

see Nureg-1118 Environmental Assessment for renewam ...SNM-1107 May 1985

	effective	bone	effective	bone
	Sv/Bq	Sv/Bq	mRem/pCi	mRem/pCi
U-234	7.66E-08	1.13E-06	2.83E-04	4.18E-03
U-235	7.19E-08	1.05E-06	2.66E-04	3.88E-03
U-236	7.26E-08	1.07E-06	2.69E-04	3.96E-03
U-238	6.88E-08	1.01E-06	2.55E-04	3.74E-03
Tc-99	3.95E-10	6.04E-11	1.46E-06	2.23E-07

for comaprison only

Part 20 table 2		soluble forms				
Dose Conversion						
	uCi/ml	milliters	uCi	pCi	mRem	mRem/pCi
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
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
Tc-99	6.00E-05	7.30E+05	4.38E+01	4.38E+07	50	1.14E-06
ICRP 69	Comparison					
	Sv/Bq	Rem/Bq	mRem/pCi			
adult	5.00E-08	0.005	1.85E-04			
infant	3.70E-07	0.037	1.37E-03			
bone-adult	7.90E-07	0.079	2.92E-03			

Annual Release rate				
3.1463E-03	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2012 **(see Total Liq tab)**	
			% of activity based on current nominal uranium isotopic **(see U activity tab)**	
2.6712E-03	U-234 release fraction	Ci	URANIUM234	84.900%
1.0383E-04	U-235 release fraction	Ci	URANIUM235	3.300%
3.1463E-06	U-236 release fraction	Ci	URANIUM236	0.100%
3.6812E-04	U-238 release fraction	Ci	URANIUM238	11.700%
2.0589E-02	Tc-99 release fraction	Ci	TC-99	
check U sum	0.00315			

			bioaccumulation factor	BNWL-2075
1.51E-06	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)	2	UC-11
5.52E-08	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)	2	Methodology for Calculation of Radiation Doses
1.69E-09	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)	2	in the Environs from Nuclear Fuel
1.87E-07	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)	2	Cycle Facilities
4.51E-07	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)	15	
2.21E-06	all nuclides	sum of nuclides		
2.46059	usage	1100*(usage*dilution)/flow		
5.44E-06	**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/pCi
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												
3.71407E-10	Tc-99	decay const	λ	URANIUM238		4.47E+09	3.91E+13	1.77E-14							Sv/Bq	Rem/Bq	mRem/pCi			
				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																				
3.1463E-03	**total uranium(C**	Q	summation of liquid effluent alpha activity for 2012 **(see Total Liq tab)**																	
			% of activity based on current nominal uranium isotopic **(see U activity tab)**																	
2.6712E-03	U-234 release fra	Ci	URANIUM234	84.900%																
1.0383E-04	U-235 release fra	Ci	URANIUM235	3.300%																
3.1463E-06	U-236 release fra	Ci	URANIUM236	0.100%																
3.6812E-04	U-238 release fra	Ci	URANIUM238	11.700%																
2.0589E-02	Tc-99 release fra	Ci	TC-99																	
check U sum	0.00315																			
							bioaccumulation factor		BNWL-2075											
2.23E-05	U-234	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		UC-11											
8.07E-07	U-235	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Methodology for Calculation of Radiation Doses											
2.49E-08	U-236	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		in the Environs from Nuclear Fuel											
2.75E-06	U-238	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					2		Cycle Facilities											
6.90E-08	Tc-99	release fraction *bioaccumulation factor*dose factor*exp(-λ*tp)					15													
2.60E-05	all nuclides	sum of nuclides																		
2.46059	usage	1100*(usage*dilution)/flow																		
6.39E-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															
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 19						
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															
3.1463E-03	**total uranium(Ci)**	Q	summation of liquid effluent alpha activity for 2012**(see Total Liq tab)**												
			% of activity based on current nominal uranium isotopic**(see U activity tab)**												
2.6712E-03	U-234 release fraction	Ci	URANIUM234	84.900%											
1.0383E-04	U-235 release fraction	Ci	URANIUM235	3.300%											
3.1463E-06	U-236 release fraction	Ci	URANIUM236	0.100%											
3.6812E-04	U-238 release fraction	Ci	URANIUM238	11.700%											
2.0589E-02	Tc-99 release fraction	Ci	TC-99												
check U sum	0.00315														
9.93E-11	U-234	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
7.72E-10	U-235	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
1.03E-13	U-236	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
1.02E-11	U-238	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
8.07E-11	Tc-99	release fraction *dose factor*exp(-λt-p)*1-exp(-λt-b)*t-i													
9.63E-10	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...										
2.71E-09	**mRem/yr**	see regulatory guide 1.109 page 1.109-2 and 1.109-3 for formula and definition of terms.													

	FIRST HALF LIQUID DISCHARGES						Quantity	
Radionuclide	Volume(ml)	uCi/ml		Error	LLD,uCi/ml		Released, uCi	Ci
	7.002E+10							
U234		2.25E-08	+/-	2.60E-09	6.00E-10		1574.4	1.5744E-03
U235		7.94E-10	+/-	6.15E-10	6.00E-10		55.6	5.5566E-05
U238		3.17E-09	+/-	9.68E-10	6.00E-10		222.3	2.2226E-04
Tc-99		1.93E-07	+/-	1.32E-07	6.00E-10	**subtotal Tc99**	13505.7	**1.3506E-02**
						subtotal U	**1852.2**	**1.8522E-03**

	SECOND HALF LIQUID DISCHARGES						Quantity	
Radionuclide	Volume(ml)	uCi/ml		Error	LLD,uCi/ml		Released, uCi	Ci
	6.453E+10							
U234		1.70E-08	+/-	2.48E-09	6.00E-10		1100.0	1.1000E-03
U235		6.02E-10	+/-	6.47E-10	6.00E-10		38.8	3.8822E-05
U238		2.41E-09	+/-	9.96E-10	6.00E-10		155.3	1.5529E-04
Tc-99		1.098E-07	+/-	4.119E-09	6.00E-10	**subtotal Tc99**	**7083.7**	**7.0837E-03**
						Subtotal U	**1294.1**	**1.2941E-03**

Total	Volume(ml)			Quantity	
	1.346E+11			Released, uCi	Ci
U234		1.98762E-08		2674.3	2.6743E-03
U235		7.01513E-10		94.4	9.4389E-05
U238		2.80605E-09		377.6	3.7755E-04
Tc-99		1.53025E-07		20589.5	2.0589E-02
			total U	3.146E+03	3.1463E-03
			total TC99	2.059E+04	2.0589E-02

U234	0.849	2.6712E-03
U235	0.033	1.0383E-04
U236	0.001	3.1463E-06
U238	0.117	3.6812E-04
Tc-99	1	2.0589E-02

Based on 2012 nominals - 235 established by safeguards personnel, 234 and 236 by average pellet chemistry in 2011-2012 and 238 by diff

Nuclide	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	8,888	**0.0373**	6234	2.328	8.61E+04	0.849
U-235		**4.202**	2.14	0.090	3.33E+03	0.033
U-236	1,311	**0.00551**	64.7	0.004	1.32E+02	0.001
U-238		**95.755**	0.34	0.322	1.19E+04	0.117
Totals		100.000		2.744	101513.284	1.000