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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 60 – Radiation Protection Systems – RAI Numbers 12.3-1, 12.4-14 and 12.4-19**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter.

If you have any questions or require additional information regarding the information provided here, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

Reference:

1. MFN 06-342, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 60 Related to the ESBWR Design Certification Application*, September 18, 2006

Enclosures:

1. MFN 06-499 – Response to Portion of NRC Request for Additional Information Letter No. 60 – Radiation Protection Systems – RAI Numbers 12.3-1, 12.4-14, and 12.4-19

cc:	AE Cubbage	USNRC (with enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRF	0062-3321 – RAI 12.3-1
		0061-6321 – RAIs 12.4-14 and 12.4-19

ENCLOSURE 1

MFN 06-499

Response to Portion of NRC Request for Additional Information Letter No. 60 Related to ESBWR Design Certification Application

Radiation Protection

RAI Numbers 12.3-1, 12.4-14 and 12.4-19

NRC RAI No. 12.3-1:

DCD Tier 2, Tables 12.2-5 through 12.2-14(b) provide isotopic source strength for several systems and components that present the major source of radiation exposure. Provide the basis for the values in these tables. Are the bases for these sources consistent with an operating offgas rate of 100,000 μCi/sec after a 30 minute delay? Table 12.2-5 also provides contact dose rates on control rod drive (CRD) mechanisms before and after cleaning. Provide the basis for these values. Discuss whether CRD cleaning is a ESBWR designed feature. Is this cleaning performed before or during CFR handling for maintenance?

GE Response:

1. Basis for isotopic source strength

The general bases for the source term definition are:

- Primary activity concentration as indicated in DCD Tier 2 Tables 11.1-1 to 11.1-7
- Equipment geometry in each system (description included in DCD Tier 2 Chapters 5, 9, 10 and 11)
- Systems operational data (description included in DCD Tier 2 Chapters 5, 9, 10 and 11)

The following specific bases for the different systems and components have been used:

Reactor Water Cleanup Unit (RWCU)

The main bases are the primary activity concentrations in the water, as follows:

- Heat Exchanger tube side:

  Primary activity concentrations in the water.
- Demineralizer:

  Source term in the RWCU demineralizer results from the primary activity concentrations in the water and the retention of radionuclides. The source term reaches its maximum concentration when the demineralizer resins are replaced.
- Heat Exchanger shell side:

  Source term is the demineralizer.

Fuel and Auxiliary Pool Cooling System (FAPCS)

Water for the FAPCS comes from the spent fuel pool. Radionuclide concentrations in the spent fuel pool are 1 % of normal reactor water concentration and are the basis for determining the FAPCS source term. The following are the specific bases used for the FAPCS source term definition:

- Filter:

  Source term in filter results from the spent fuel pool activity concentrations and the retention of radionuclides in the filter and reaches its maximum value when the filter is backwashed.

- Demineralizer:

  Source term in demineralizer results from the spent fuel pool activity concentrations and the retention of radionuclides and reaches its maximum when the resins are replaced.

- Heat Exchanger:

  Source terms are water from the spent fuel pool.

- Tanks:

  The function of this tank is to collect filter backwashing. All activity accumulated in the filter passes to the tank. One batch is accumulated in the tank. As a result, activity in the tank is the same as activity in the filter.

Offgas (OGS)

The following are the specific bases used for Offgas source term definition:

- Steam Jet Air Ejectors and Intercooler Condenser

  The source term in equipment constituting the OGS is based on the activity present in the main condenser and the activity present in the main steam lines that serve the steam ejectors. Activity in the condenser has been obtained based on the source term in the main steam and considering the residence time in the condenser.

- Preheater through Charcoal Tanks

  The bases are the noble gases of 100,000 μCi/s (after 30 minutes decay) and, for the remaining radionuclides, the source term in the 2nd Stage Jet Air Ejector. The delay time in each component is considered using the equipment volume and the minimum flow rate.

The calculated source terms for the noble gases in the 2nd Stage Jet Air Ejector are below the bases of 100,000 μCi/s (see Table 12.2-10a). Conservatively, the input source term to the Offgas Reheater for the noble gases is a base rate of 100,000 μCi/s.

Turbine Building

The following are the specific bases used to define the source terms of the turbine systems:

- Turbine condenser:

  The activity concentration in condensate is used as the base source term, along with the transit time to the turbine condenser.

- Ion exchanger filter:

  The activity concentration in condensate is used as base source term along with the decontamination factor and the transit time in the filter.

Liquid Radwaste Management System (LWMS)

The main bases used to define the LWMS source term are:

- Primary activity concentrations (DCD Tier 2 Tables 11.1-1 to 11.1-7)
- Tank volumes (DCD Tier 2 Table 11.2-2)
- Expected inputs to the different streams (ANSI 55.6 and DCD Tier 2 Table 11.2-4)
- Fraction of the primary coolant activity (PCA) (NUREG 0016)
- Decontamination Factors (DF), which depend on the radionuclides, on the system, and on the filter type (DCD Tier 2 Table 11.2-3)

The following are the specific bases used for LWMS source term definition:

- Collection Tanks:

  The expected average inputs from the different streams to each subsystem are taken as inputs. These inputs are calculated using the PCA (fraction of the primary coolant activity), with the transit time for each stream.

- Sample Tanks:

  The inputs to the sample tanks are the outputs from collection tanks, which also take into account the different decontamination factors of the filters in the mobile systems.

Solid Radwaste Management System (SWMS)

The main bases used to define the SWMS source term are:

- Primary activity concentrations (DCD Tier 2 Tables 11.1-1 to 11.1-7)
- Tank volumes
- Decontamination Factors (DF), which depend on the radionuclides in the system, and the filter type (DCD Tier 2 Table 11.2-3)

The expected average inputs from the different streams to each tank are taken as inputs. It is assumed that the tanks are filled during their storage period and when this period is completed, the tanks are empty until the next load.

2. Isotopic source strength

The following revised DCD tables (attached for information and use) will be provided in DCD Tier 2, Revision 3 as shown on the attached mark ups, including the updated source term for the above described systems and components:

- Tables 12.2-6a through 12.2-6c
- Tables 12.2-7 and 12.2-8
- Tables 12.2-8a and 12.2-8b
- Table 12.2-9
- Tables 12.1-10a and 12.2-10b
- Tables 12.2-11 and 12.2-12
- Tables 12.2-13a through 12.2-13g
- Tables 12.2-14a through 12.2-14e

3. Control Rod Drive (CRD) contact dose rates

The ESBWR DCD Table 12.2-5 CRD contact dose rates are based on the ABWR DCD Table 12.2-18a CRD contact dose rates. The CRD dose rates from the ABWR DCD were multiplied by a factor of 1.5 to conservatively account for the difference in rated thermal power between the ABWR and ESBWR.

The control blade principal isotopes in ESBWR DCD Tier 2, Table 12.2-5 were also taken from the ABWR DCD (Table 12.2-18b). The isotope activity values were not changed from the ABWR DCD values, due to the similarity in power density between ABWR and ESBWR.

A detailed discussion of CRD cleaning process, as an ESBWR-designed feature will be subsequently provided by separate letter in response to RAI 12.3-08.

Table 12.2-6a

RWCU/SDC

Regenerative Heat Exchanger Tube Side Activity

Isotopes	Activity (MBq)
Class 2	
I-131	1.75E+02
I-132	1.64E+03
I-133	1.18E+03
I-134	3.03E+03
I-135	1.70E+03
Class 3	
Rb-89	3.08E+02
Cs-134	1.99E+00
Cs-136	1.33E+00
Cs-137	5.30E+00
Cs-138	6.19E+02
Ba-137m	5.30E+00
Class 4	
N-16	1.09E+04
Class 6	
Na-24	1.44E+02
Cr-51	2.21E+02
Mn-54	2.58E+00
Mn-56	1.69E+03
Fe-59	2.21E+00
Co-58	7.40E+00
Co-60	1.47E+01
Cu-64	2.16E+02
Zn-65	7.40E+01

Isotopes	Activity (MBq)
Sr-89	7.40E+00
Sr-91	2.85E+02
Sr-92	6.77E+02
Y-91	2.95E+00
Y-92	4.13E+02
Y-93	2.86E+02
Zr-95	5.93E-01
Nb-95	5.93E-01
Mo-99	1.47E+02
Tc-99m	1.47E+02
Ru-103	1.47E+00
Rh-103m	1.47E+00
Rh-106	2.21E-01
Ag-110m	7.40E-02
Te-129m	2.95E+00
Te-131m	7.31E+00
Te-132	7.35E-01
Ba-140	2.95E+01
La-140	2.95E+01
Ce-141	2.21E+00
Ce-144	2.21E-01
Pr-144	2.21E-01
W-187	2.18E+01
Np-239	5.88E+02
Total	**2.46E+04**

Table 12.2-6b

RWCU/SDC

Non-Regenerative Heat Exchanger Tube Side Activity

Isotopes	Activity (MBq)
Class 2	
I-131	2.01E+02
I-132	1.89E+03
I-133	1.36E+03
I-134	3.48E+03
I-135	1.96E+03
Class 3	
Rb-89	3.55E+02
Cs-134	2.29E+00
Cs-136	1.53E+00
Cs-137	6.10E+00
Cs-138	7.12E+02
Ba-137m	6.10E+00
Class 4	
N-16	3.27E+03
Class 6	
Na-24	1.66E+02
Cr-51	2.55E+02
Mn-54	2.97E+00
Mn-56	1.95E+03
Fe-59	2.55E+00
Co-58	8.51E+00
Co-60	1.70E+01
Cu-64	2.48E+02
Zn-65	8.51E+01

Isotopes	Activity (MBq)
Sr-89	8.51E+00
Sr-91	3.28E+02
Sr-92	7.79E+02
Y-91	3.40E+00
Y-92	4.75E+02
Y-93	3.29E+02
Zr-95	6.82E-01
Nb-95	6.82E-01
Mo-99	1.69E+02
Tc-99m	1.69E+02
Ru-103	1.70E+00
Rh-103m	1.70E+00
Rh-106	2.55E-01
Ag-110m	8.51E-02
Te-129m	3.40E+00
Te-131m	8.41E+00
Te-132	8.46E-01
Ba-140	3.39E+01
La-140	3.39E+01
Ce-141	2.55E+00
Ce-144	2.55E-01
Pr-144	2.55E-01
W-187	2.51E+01
Np-239	6.77E+02
Total	**1.90E+04**

Table 12.2-6c

RWCU/SDC

Regenerative Heat Exchanger Shell Side

Isotopes	Activity (MBq)
Class 2	
I-131	1.02E+02
I-132	9.51E+02
I-133	6.85E+02
I-134	1.75E+03
I-135	9.87E+02
Class 3	
Rb-89	1.79E+02
Cs-134	5.78E+00
Cs-136	3.85E+00
Cs-137	1.54E+01
Cs-138	1.80E+03
Ba-137m	3.08E+00
Class 4	
N-16	1.17E+01
Class 6	
Na-24	8.37E+01
Cr-51	1.28E+02
Mn-54	1.50E+00
Mn-56	9.82E+02
Fe-59	1.28E+00
Co-58	4.29E+00
Co-60	8.55E+00
Cu-64	1.25E+02
Zn-65	4.29E+01

Isotopes	Activity (MBq)
Sr-89	4.29E+00
Sr-91	1.65E+02
Sr-92	3.93E+02
Y-91	1.71E+00
Y-92	2.39E+02
Y-93	1.66E+02
Zr-95	3.44E-01
Nb-95	3.44E-01
Mo-99	8.50E+01
Tc-99m	8.50E+01
Ru-103	8.55E-01
Rh-103m	8.55E-01
Rh-106	1.28E-01
Ag-110m	4.29E-02
Te-129m	1.71E+00
Te-131m	4.24E+00
Te-132	4.26E-01
Ba-140	1.71E+01
La-140	1.71E+01
Ce-141	1.28E+00
Ce-144	1.28E-01
Pr-144	1.28E-01
W-187	1.26E+01
Np-239	3.41E+02
Total	**9.41E+03**

Table 12.2-7

RWCU Demineralizer Activity

Isotopes	Activity (MBq)
Class 2	
I-131	9.85E+06
I-132	1.09E+06
I-133	6.97E+06
I-134	7.77E+05
I-135	3.31E+06
Class 3	
Rb-89	2.30E+04
Cs-134	8.09E+05
Cs-136	6.41E+04
Cs-137	2.33E+06
Cs-138	4.90E+04
Ba-137m	6.56E+01
Class 4	
N-16	6.03E+02
Class 6	
Na-24	6.36E+05
Cr-51	4.29E+07
Mn-54	1.88E+06
Mn-56	1.28E+06
Fe-59	6.54E+05
Co-58	3.08E+06
Co-60	1.26E+07
Cu-64	8.11E+05
Zn-65	5.10E+07

Isotopes	Activity (MBq)
Sr-89	2.47E+06
Sr-91	8.10E+05
Sr-92	5.39E+05
Y-91	1.08E+06
Y-92	4.28E+05
Y-93	8.64E+05
Zr-95	2.33E+05
Nb-95	1.51E+04
Mo-99	2.85E+06
Tc-99m	2.59E+05
Ru-103	3.94E+05
Rh-103m	4.12E+02
Rh-106	5.49E-01
Ag-110m	5.14E+04
Te-129m	6.83E+05
Te-131m	6.44E+04
Te-132	1.68E+04
Ba-140	2.66E+06
La-140	3.49E+05
Ce-141	4.95E+05
Ce-144	1.58E+05
Pr-144	1.88E+01
W-187	1.54E+05
Np-239	9.74E+06
Total	**1.64E+08**

Table 12.2-8

FAPCS Filter

Isotopes	Activity (MBq)
Class 2	
I-131	0.00E+00
I-132	0.00E+00
I-133	0.00E+00
I-134	0.00E+00
I-135	0.00E+00
Class 3	
Rb-89	0.00E+00
Cs-134	0.00E+00
Cs-136	0.00E+00
Cs-137	0.00E+00
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 6	
Na-24	3.80E+04
Cr-51	1.37E+06
Mn-54	2.19E+04
Mn-56	7.65E+04
Fe-59	1.55E+04
Co-58	5.62E+04
Co-60	1.28E+05
Cu-64	4.84E+04
Zn-65	6.21E+05
Sr-89	5.34E+04

Isotopes	Activity (MBq)
Sr-91	4.84E+04
Sr-92	3.22E+04
Y-91	2.18E+04
Y-92	2.56E+04
Y-93	5.16E+04
Zr-95	4.45E+03
Nb-95	3.91E+03
Mo-99	1.70E+05
Tc-99m	1.55E+04
Ru-103	1.00E+04
Rh-103m	2.46E+01
Rh-106	3.28E-02
Ag-110m	6.21E+02
Te-129m	1.93E+04
Te-131m	3.85E+03
Te-132	1.00E+03
Ba-140	1.28E+05
La-140	2.08E+04
Ce-141	1.43E+04
Ce-144	1.87E+03
Pr-144	1.12E+00
W-187	9.17E+03
Np-239	5.82E+05
Total	**3.59E+06**

Table 12.2-8a

FAPCS Demineralizer

Isotopes	Activity (MBq)
Class 2	
I-131	5.88E+05
I-132	6.49E+04
I-133	4.16E+05
I-134	4.64E+04
I-135	1.97E+05
Class 3	
Rb-89	1.37E+03
Cs-134	2.51E+04
Cs-136	3.79E+03
Cs-137	6.94E+04
Cs-138	2.92E+03
Ba-137m	3.92E+00
Class 6	
Na-24	7.60E+03
Cr-51	4.63E+05
Mn-54	1.23E+04
Mn-56	1.53E+04
Fe-59	6.26E+03
Co-58	2.59E+04
Co-60	7.62E+04
Cu-64	9.69E+03
Zn-65	3.43E+05
Sr-89	2.26E+04

Isotopes	Activity (MBq)
Sr-91	9.68E+03
Sr-92	6.44E+03
Y-91	9.54E+03
Y-92	5.11E+03
Y-93	1.03E+04
Zr-95	2.01E+03
Nb-95	1.45E+03
Mo-99	3.41E+04
Tc-99m	3.10E+03
Ru-103	3.90E+03
Rh-103m	4.92E+00
Rh-106	6.56E-03
Ag-110m	3.44E+02
Te-129m	7.05E+03
Te-131m	7.69E+02
Te-132	2.01E+02
Ba-140	3.16E+04
La-140	4.17E+03
Ce-141	5.16E+03
Ce-144	1.04E+03
Pr-144	2.24E-01
W-187	1.83E+03
Np-239	1.16E+05
Total	**2.65E+06**

Table 12.2-8b

FAPCS Heat exchanger tube side

Isotopes	Activity (MBq)
Class 2	
I-131	4.45E+00
I-132	4.17E+01
I-133	3.00E+01
I-134	7.69E+01
I-135	4.32E+01
Class 3	
Rb-89	7.83E+00
Cs-134	5.06E-02
Cs-136	3.37E-02
Cs-137	1.35E-01
Cs-138	1.57E+01
Ba-137m	1.35E-01
Class 6	
Na-24	3.67E+00
Cr-51	5.63E+00
Mn-54	6.56E-02
Mn-56	4.30E+01
Fe-59	5.63E-02
Co-58	1.88E-01
Co-60	3.75E-01
Cu-64	5.48E+00
Zn-65	1.88E+00
Sr-89	1.88E-01

Isotopes	Activity (MBq)
Sr-91	7.24E+00
Sr-92	1.72E+01
Y-91	7.50E-02
Y-92	1.05E+01
Y-93	7.26E+00
Zr-95	1.51E-02
Nb-95	1.51E-02
Mo-99	3.72E+00
Tc-99m	3.72E+00
Ru-103	3.75E-02
Rh-103m	3.75E-02
Rh-106	5.63E-03
Ag-110m	1.88E-03
Te-129m	7.50E-02
Te-131m	1.86E-01
Te-132	1.87E-02
Ba-140	7.49E-01
La-140	7.49E-01
Ce-141	5.63E-02
Ce-144	5.63E-03
Pr-144	5.63E-03
W-187	5.53E-01
Np-239	1.49E+01
Total	**3.48E+02**

Table 12.2-9
FAPCS Backwash Receiving Tank

Isotopes	Activity (MBq)
Class 2	
I-131	0.00E+00
I-132	0.00E+00
I-133	0.00E+00
I-134	0.00E+00
I-135	0.00E+00
Class 3	
Rb-89	0.00E+00
Cs-134	0.00E+00
Cs-136	0.00E+00
Cs-137	0.00E+00
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 6	
Na-24	3.80E+04
Cr-51	1.37E+06
Mn-54	2.19E+04
Mn-56	7.65E+04
Fe-59	1.55E+04
Co-58	5.62E+04
Co-60	1.28E+05
Cu-64	4.84E+04
Zn-65	6.21E+05
Sr-89	5.34E+04

Isotopes	Activity (MBq)
Sr-91	4.84E+04
Sr-92	3.22E+04
Y-91	2.18E+04
Y-92	2.56E+04
Y-93	5.16E+04
Zr-95	4.45E+03
Nb-95	3.91E+03
Mo-99	1.70E+05
Tc-99m	1.55E+04
Ru-103	1.00E+04
Rh-103m	2.46E+01
Rh-106	3.28E-02
Ag-110m	6.21E+02
Te-129m	1.93E+04
Te-131m	3.85E+03
Te-132	1.00E+03
Ba-140	1.28E+05
La-140	2.08E+04
Ce-141	1.43E+04
Ce-144	1.87E+03
Pr-144	1.12E+00
W-187	9.17E+03
Np-239	5.82E+05
Total	**3.59E+06**

Table 12.2-10a

Offgas System

Steam Jet Air Ejector Inventory

Isotope	1st Stage Jet Air Ejector (MBq)	Intercooler Condenser (MBq)	2nd Stage Jet Air Ejector (MBq)
Class 1			
Kr-83m	2.00E-01	5.99E+00	9.57E-02
Kr-85m	3.39E-01	1.02E+01	1.62E-01
Kr-85	1.36E-03	4.07E-02	6.50E-04
Kr-87	1.12E+00	3.34E+01	5.34E-01
Kr-88	1.12E+00	3.35E+01	5.35E-01
Kr-89	7.12E+00	1.91E+02	3.13E+00
Xe-131m	1.12E-03	3.36E-02	5.36E-04
Xe-133m	1.66E-02	4.99E-01	7.97E-03
Xe-133	4.74E-01	1.42E+01	2.27E-01
Xe-135m	1.50E+00	4.39E+01	7.03E-01
Xe-135	1.29E+00	3.87E+01	6.18E-01
Xe-137	8.84E+00	2.42E+02	3.94E+00
Xe-138	5.11E+00	1.50E+02	2.40E+00
Class 2			
I-131	1.22E-01	3.67E+00	4.99E-02
I-132	1.15E+00	3.43E+01	4.66E-01
I-133	8.28E-01	2.48E+01	3.37E-01
I-134	2.12E+00	6.32E+01	8.59E-01
I-135	1.19E+00	3.58E+01	4.86E-01
Class 3			
Rb-89	1.08E-02	3.17E-01	4.31E-03
Cs-134	6.97E-05	2.09E-03	2.84E-05
Cs-136	4.65E-05	1.39E-03	1.89E-05
Cs-137	1.86E-04	5.57E-03	7.56E-05
Cs-138	2.17E-02	6.43E-01	8.75E-03
Ba-137m	1.86E-04	4.86E-03	6.66E-05
Class 4			
N-16	6.70E+00	5.18E+04	8.99E-01
Class-5			
H-3	5.77E+00	1.73E+02	2.35E+00
Class 6			
Na-24	5.05E-03	1.51E-01	2.06E-03
P-32	1.03E-04	3.10E-03	4.21E-05
Cr-51	7.75E-03	2.32E-01	3.16E-03
Mn-54	9.04E-05	2.71E-03	3.69E-05
Mn-56	5.92E-02	1.77E+00	2.41E-02
Fe-55	2.59E-03	7.76E-02	1.06E-03
Fe-59	7.75E-05	2.32E-03	3.16E-05

Table 12.2-10a

Offgas System

Steam Jet Air Ejector Inventory

Isotope	1st Stage Jet Air Ejector (MBq)	Intercooler Condenser (MBq)	2nd Stage Jet Air Ejector (MBq)
Co-58	2.59E-04	7.76E-03	1.06E-04
Co-60	5.16E-04	1.55E-02	2.10E-04
Ni-63	2.59E-06	7.76E-05	1.06E-06
Cu-64	7.55E-03	2.26E-01	3.08E-03
Zn-65	2.59E-03	7.75E-02	1.05E-03
Sr-89	2.59E-04	7.76E-03	1.06E-04
Sr-90	1.81E-05	5.43E-04	7.37E-06
Y-90	1.81E-05	5.40E-04	7.34E-06
Sr-91	9.98E-03	2.99E-01	4.07E-03
Sr-92	2.37E-02	7.09E-01	9.64E-03
Y-91	1.03E-04	3.10E-03	4.21E-05
Y-92	1.44E-02	4.32E-01	5.88E-03
Y-93	9.99E-03	3.00E-01	4.07E-03
Zr-95	2.07E-05	6.22E-04	8.45E-06
Nb-95	2.07E-05	6.22E-04	8.45E-06
Mo-99	5.13E-03	1.54E-01	2.09E-03
Tc-99m	5.13E-03	1.54E-01	2.09E-03
Ru-103	5.16E-05	1.55E-03	2.10E-05
Rh-103m	5.16E-05	1.54E-03	2.09E-05
Ru-106	7.75E-06	2.32E-04	3.16E-06
Rh-106	7.75E-06	1.16E-04	1.66E-06
Ag-110m	2.59E-06	7.76E-05	1.06E-06
Te-129m	1.03E-04	3.10E-03	4.21E-05
Te-131m	2.56E-04	7.67E-03	1.04E-04
Te-132	2.57E-05	7.72E-04	1.05E-05
Ba-140	1.03E-03	3.10E-02	4.21E-04
La-140	1.03E-03	3.10E-02	4.21E-04
Ce-141	7.75E-05	2.32E-03	3.16E-05
Ce-144	7.75E-06	2.32E-04	3.16E-06
Pr-144	7.75E-06	2.28E-04	3.10E-06
W-187	7.62E-04	2.29E-02	3.11E-04
Np-239	2.06E-02	6.17E-01	8.39E-03
Total	**4.52E+01**	**5.29E+04**	**1.79E+01**

Table 12.2-10b

Offgas System

Isotopic Inventory for Preheater through Charcoal Tanks

Isotope	Preheater (MBq)	Recombiner (MBq)	Condenser (MBq)	Cooler Cond. (MBq)	Dryer (MBq)	Guard Bed (MBq)	Tank 1&5 (MBq)	Tank 2&6 (MBq)	Tank 3&7 (MBq)	Tank 4&8 (MBq)
Class 1										
Kr-83m	5.87E+01	2.11E+02	2.44E+04	8.94E+02	4.39E+04	7.29E+05	1.32E+05	9.96E+01	0.00E+00	0.00E+00
Kr-85m	1.07E+02	3.84E+02	4.48E+04	1.65E+03	8.20E+04	1.91E+06	1.24E+06	6.26E+04	3.17E+03	1.60E+02
Kr-85	4.75E-01	1.71E+00	2.00E+02	7.41E+00	3.72E+02	1.14E+04	3.09E+04	3.09E+04	3.09E+04	3.09E+04
Kr-87	2.99E+02	1.08E+03	1.24E+05	4.50E+03	2.19E+05	2.86E+06	2.38E+05	6.20E+00	0.00E+00	0.00E+00
Kr-88	3.47E+02	1.25E+03	1.45E+05	5.33E+03	2.64E+05	5.29E+06	1.86E+06	1.57E+04	1.33E+02	0.00E+00
Kr-89	3.41E+00	1.22E+01	9.73E+02	2.29E+01	5.79E+02	1.60E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	3.89E-01	1.40E+00	1.64E+02	6.08E+00	3.05E+02	1.54E+05	2.64E+05	1.15E+05	5.03E+04	2.19E+04
Xe-133m	5.87E+00	2.11E+01	2.47E+03	9.15E+01	4.59E+03	1.71E+06	6.63E+05	7.69E+03	9.02E+01	0.00E+00
Xe-133	1.65E+02	5.96E+02	6.97E+04	2.58E+03	1.30E+05	5.98E+07	6.12E+07	9.35E+06	1.43E+06	2.18E+05
Xe-135m	1.33E+02	4.80E+02	5.16E+04	1.75E+03	7.50E+04	2.02E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	4.32E+02	1.56E+03	1.82E+05	6.71E+03	3.35E+05	3.77E+07	1.58E+05	0.00E+00	0.00E+00	0.00E+00
Xe-137	1.39E+01	4.97E+01	4.22E+03	1.08E+02	3.04E+03	1.21E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-138	4.11E+02	1.48E+03	1.58E+05	5.31E+03	2.25E+05	5.56E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Class 2										
I-131	2.89E-02	1.04E-01	1.22E+01	8.28E-04	2.66E-03	3.19E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-132	2.70E-01	9.73E-01	1.13E+02	7.58E-03	2.39E-02	3.34E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-133	1.96E-01	7.04E-01	8.23E+01	5.59E-03	1.79E-02	2.31E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-134	4.98E-01	1.79E+00	2.05E+02	1.35E-02	4.15E-02	2.14E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135	2.82E-01	1.01E+00	1.18E+02	8.01E-03	2.56E-02	1.06E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12.2-10b

Offgas System

Isotopic Inventory for Preheater through Charcoal Tanks

Isotope	Preheater (MBq)	Recombiner (MBq)	Condenser (MBq)	Cooler Cond. (MBq)	Dryer (MBq)	Guard Bed (MBq)	Tank 1&5 (MBq)	Tank 2&6 (MBq)	Tank 3&7 (MBq)	Tank 4&8 (MBq)
Class 3										
Rb-89	2.49E-03	8.98E-03	9.61E-01	5.94E-05	1.62E-04	2.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	1.65E-05	5.93E-05	6.94E-03	4.71E-07	1.51E-06	1.69E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-136	1.10E-05	3.95E-05	4.63E-03	3.14E-07	1.01E-06	1.96E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	4.38E-05	1.58E-04	1.85E-02	1.25E-06	4.03E-06	6.62E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-138	5.07E-03	1.82E-02	2.05E+00	1.34E-04	3.98E-04	1.23E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-137m	3.85E-05	1.38E-04	1.01E-02	3.88E-07	5.49E-07	4.89E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Class 4										
N-16	2.60E+00	8.35E+00	4.20E+01	2.58E-11	1.39E-12	5.24E-30	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Class 5										
H-3	1.36E+00	4.91E+00	5.75E+02	3.90E-02	1.25E-01	5.94E-01	3.39E+04	0.00E+00	0.00E+00	0.00E+00
Class 6										
Na-24	1.19E-03	4.30E-03	5.02E-01	3.41E-05	1.09E-04	1.02E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
P-32	2.44E-05	8.78E-05	1.03E-02	6.98E-07	2.24E-06	4.87E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr-51	1.83E-03	6.59E-03	7.72E-01	5.24E-05	1.68E-04	6.99E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-54	2.14E-05	7.69E-05	9.01E-03	6.12E-07	1.96E-06	9.18E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-56	1.40E-02	5.03E-02	5.84E+00	3.93E-04	1.24E-03	1.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	6.11E-04	2.20E-03	2.58E-01	1.75E-05	5.62E-05	8.26E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	1.83E-05	6.59E-05	7.72E-03	5.24E-07	1.68E-06	1.13E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-58	6.11E-05	2.20E-04	2.58E-02	1.75E-06	5.62E-06	6.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	1.22E-04	4.39E-04	5.14E-02	3.49E-06	1.12E-05	3.21E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	6.11E-07	2.20E-06	2.58E-04	1.75E-08	5.62E-08	3.07E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12.2-10b

Offgas System

Isotopic Inventory for Preheater through Charcoal Tanks

Isotope	Preheater (MBq)	Recombiner (MBq)	Condenser (MBq)	Cooler Cond. (MBq)	Dryer (MBq)	Guard Bed (MBq)	Tank 1&5 (MBq)	Tank 2&6 (MBq)	Tank 3&7 (MBq)	Tank 4&8 (MBq)
Cu-64	1.78E-03	6.42E-03	7.50E-01	5.08E-05	1.63E-04	1.29E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zn-65	6.10E-04	2.20E-03	2.57E-01	1.75E-05	5.61E-05	2.04E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	6.11E-05	2.20E-04	2.58E-02	1.75E-06	5.62E-06	4.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	4.27E-06	1.54E-05	1.80E-03	1.22E-07	3.93E-07	6.18E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-90	4.25E-06	1.53E-05	1.79E-03	1.22E-07	3.90E-07	1.56E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	2.36E-03	8.49E-03	9.91E-01	6.71E-05	2.15E-04	1.29E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-92	5.59E-03	2.01E-02	2.34E+00	1.57E-04	4.98E-04	8.19E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-91	2.44E-05	8.80E-05	1.03E-02	6.99E-07	2.25E-06	1.96E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-92	3.41E-03	1.23E-02	1.43E+00	9.63E-05	3.06E-04	6.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-93	2.36E-03	8.50E-03	9.93E-01	6.73E-05	2.15E-04	1.35E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zr-95	4.90E-06	1.76E-05	2.07E-03	1.40E-07	4.51E-07	4.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nb-95	4.90E-06	1.76E-05	2.07E-03	1.40E-07	4.51E-07	2.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mo-99	1.21E-03	4.36E-03	5.11E-01	3.47E-05	1.11E-04	4.60E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99m	1.21E-03	4.36E-03	5.09E-01	3.44E-05	1.10E-04	4.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	1.22E-05	4.39E-05	5.14E-03	3.49E-07	1.12E-06	6.64E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-103m	1.21E-05	4.27E-05	1.38E-03	9.82E-09	4.59E-09	3.67E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-106	1.83E-06	6.59E-06	7.72E-04	5.24E-08	1.68E-07	9.24E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rh-106	9.58E-07	3.35E-06	7.35E-05	1.32E-10	3.97E-11	1.27E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ag-110m	6.11E-07	2.20E-06	2.58E-04	1.75E-08	5.62E-08	2.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-129m	2.44E-05	8.80E-05	1.03E-02	6.99E-07	2.25E-06	1.14E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-131m	6.04E-05	2.18E-04	2.54E-02	1.73E-06	5.54E-06	1.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-132	6.08E-06	2.19E-05	2.56E-03	1.74E-07	5.58E-07	2.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 12.2-10b

Offgas System

Isotopic Inventory for Preheater through Charcoal Tanks

Isotope	Preheater (MBq)	Recombiner (MBq)	Condenser (MBq)	Cooler Cond. (MBq)	Dryer (MBq)	Guard Bed (MBq)	Tank 1&5 (MBq)	Tank 2&6 (MBq)	Tank 3&7 (MBq)	Tank 4&8 (MBq)
Ba-140	2.44E-04	8.78E-04	1.03E-01	6.98E-06	2.24E-05	4.28E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	2.44E-04	8.78E-04	1.03E-01	6.97E-06	2.24E-05	5.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ce-141	1.83E-05	6.59E-05	7.72E-03	5.24E-07	1.68E-06	8.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ce-144	1.83E-06	6.59E-06	7.72E-04	5.24E-08	1.68E-07	7.14E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-144	1.80E-06	6.46E-06	7.02E-04	4.41E-08	1.23E-07	1.91E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
W-187	1.80E-04	6.49E-04	7.58E-02	5.15E-06	1.65E-05	2.45E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Np-239	4.86E-03	1.75E-02	2.05E+00	1.39E-04	4.46E-04	1.56E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total	**1.98E+03**	**7.13E+03**	**8.08E+05**	**2.90E+04**	**1.38E+06**	**1.11E+08**	**6.58E+07**	**9.58E+06**	**1.51E+06**	**2.71E+05**

Table 12.2-11

Turbine Condenser Inventory

Isotope	MBq	Isotope	MBq
Class 1		**Class 6**	
Kr-83m	8.82E+03	Na-24	5.32E+01
Kr-85m	1.49E+04	P-32	1.09E+00
Kr-85	5.98E+01	Cr-51	8.16E+01
Kr-87	4.93E+04	Mn-54	9.52E-01
Kr-88	4.93E+04	Mn-56	6.24E+02
Kr-89	3.14E+05	Fe-55	2.73E+01
Xe-131m	4.93E+01	Fe-59	8.16E-01
Xe-133m	7.32E+02	Co-58	2.73E+00
Xe-133	2.09E+04	Co-60	5.44E+00
Xe-135m	6.58E+04	Ni-63	2.73E-02
Xe-135	5.68E+04	Cu-64	7.95E+01
Xe-137	3.89E+05	Zn-65	2.73E+01
Xe-138	2.25E+05	Sr-89	2.73E+00
		Sr-90	1.90E-01
Class 2		Y-90	1.90E-01
I-131	1.29E+03	Sr-91	1.05E+02
I-132	1.21E+04	Sr-92	2.50E+02
I-133	8.72E+03	Y-91	1.09E+00
I-134	2.23E+04	Y-92	1.52E+02
I-135	1.26E+04	Y-93	1.05E+02
		Zr-95	2.18E-01
Class 3		Nb-95	2.18E-01
Rb-89	1.14E+02	Mo-99	5.40E+01
Cs-134	7.34E-01	Tc-99m	5.40E+01
Cs-136	4.89E-01	Ru-103	5.44E-01
Cs-137	1.95E+00	Rh-103m	5.44E-01
Cs-138	2.28E+02	Ru-106	8.16E-02
Ba-137m	1.95E+00	Rh-106	8.16E-02
		Ag-110m	2.73E-02
Class 4		Te-129m	1.09E+00
N-16	1.26E+08	Te-131m	2.69E+00
Class 5		Te-132	2.71E-01
H-3	6.08E+04	Ba-140	1.09E+01
		La-140	1.09E+01
		Ce-141	8.16E-01
		Ce-144	8.16E-02
		Pr-144	8.16E-02
		W-187	8.03E+00
		Np-239	2.17E+02
		Total	**1.27E+08**

Table 12.2-12

Isotopic inventory in the ion exchanger filter

Isotope	Activity (MBq)
Class 2	
I-131	1.94E+06
I-132	2.15E+05
I-133	1.41E+06
I-134	1.52E+05
I-135	6.57E+05
Class 3	
Rb-89	2.28E+02
Cs-134	9.10E+03
Cs-136	1.18E+03
Cs-137	2.52E+04
Cs-138	9.55E+02
Ba-137m	6.48E-01
Class 6	
Sr-89	3.86E+03
Sr-90	4.93E+02
Y-90	3.17E-01
Sr-91	1.58E+03
Sr-92	1.05E+03
Y-91	1.66E+03
Y-92	8.39E+02
Y-93	1.66E+03
Zr-95	3.50E+02
Nb-95	2.47E+02
Mo-99	5.61E+03
Tc-99m	5.06E+02
Ru-103	6.68E+02
Rh-103m	7.93E-01
Ru-106	1.93E+02
Rh-106	1.06E-03
Te-129m	1.21E+03
Te-131m	1.26E+02
Te-132	3.30E+01
Ba-140	5.18E+03
La-140	6.82E+02
Ce-141	8.76E+02
Ce-144	1.88E+02
Pr-144	3.67E-02
Np-239	1.91E+04
Total	**4.47E+06**

Table 12.2-13a

Liquid Waste Management System Equipment Drain Collection Tank Activity

Source Volume = 140 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	6.89E+02
I-132	6.58E+01
I-133	5.51E+02
I-134	4.38E+01
I-135	2.19E+02
Class 3	
Rb-89	1.25E+00
Cs-134	7.36E+01
Cs-136	7.25E+00
Cs-137	2.09E+02
Cs-138	5.62E+00
Ba-137m	3.71E-03
Class 5	
H-3	9.73E+01
Class 6	
Na-24	4.74E+01
P-32	1.98E+01
Cr-51	2.61E+03
Mn-54	9.83E+01
Mn-56	7.59E+01
Fe-55	3.08E+03
Fe-59	3.82E+01
Co-58	1.76E+02
Co-60	6.25E+02
Ni-63	3.24E+00
Cu-64	5.92E+01
Zn-65	2.65E+03

Isotope	Activity Concentration (MBq/m^3)
Sr-89	1.43E+02
Sr-90	2.23E+01
Y-90	6.95E-01
Sr-91	5.68E+01
Sr-92	3.25E+01
Y-91	6.28E+01
Y-92	2.67E+01
Y-93	5.98E+01
Zr-95	1.34E+01
Nb-95	8.76E+00
Mo-99	2.07E+02
Tc-99m	1.72E+01
Ru-103	2.39E+01
Rh-103m	2.33E-02
Ru-106	8.17E+00
Rh-106	2.95E-05
Ag-110m	2.67E+00
Te-129m	4.29E+01
Te-131m	4.85E+00
Te-132	1.21E+00
Ba-140	1.75E+02
La-140	2.62E+01
Ce-141	2.97E+01
Ce-144	7.86E+00
Pr-144	1.03E-03
W-187	1.15E+01
Np-239	7.17E+02
Total	**1.31E+04**

Table 12.2-13b

Liquid Waste Management System Equipment Drain Sample Tank Activity

Source Volume = 140 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	5.72E-01
I-132	1.01E-08
I-133	9.84E-02
I-134	6.03E-20
I-135	1.05E-03
Class 3	
Rb-89	0.00E+00
Cs-134	7.34E-01
Cs-136	6.47E-02
Cs-137	2.09E+00
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 5	
H-3	9.73E+01
Class 6	
Na-24	0.00E+00
P-32	0.00E+00
Cr-51	0.00E+00
Mn-54	0.00E+00
Mn-56	0.00E+00
Fe-55	0.00E+00
Fe-59	0.00E+00
Co-58	0.00E+00
Co-60	0.00E+00
Ni-63	0.00E+00
Cu-64	0.00E+00
Zn-65	0.00E+00

Isotope	Activity Concentration (MBq/m^3)
Sr-89	1.39E-01
Sr-90	2.23E-02
Y-90	3.98E-04
Sr-91	1.40E-03
Sr-92	5.31E-08
Y-91	0.00E+00
Y-92	0.00E+00
Y-93	0.00E+00
Zr-95	0.00E+00
Nb-95	0.00E+00
Mo-99	1.21E-01
Tc-99m	4.37E-05
Ru-103	0.00E+00
Rh-103m	0.00E+00
Ru-106	0.00E+00
Rh-106	0.00E+00
Ag-110m	0.00E+00
Te-129m	4.11E-02
Te-131m	1.47E-03
Te-132	7.62E-04
Ba-140	1.56E-01
La-140	0.00E+00
Ce-141	0.00E+00
Ce-144	0.00E+00
Pr-144	0.00E+00
W-187	0.00E+00
Np-239	3.80E-01
Total	**1.02E+02**

Table 12.2-13c

Liquid Waste Management System Floor Drain Collection Tank Activity

Source Volume = 130 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	3.24E-01
I-132	9.72E-02
I-133	6.32E-01
I-134	6.74E-02
I-135	2.88E-01
Class 3	
Rb-89	1.97E-03
Cs-134	4.36E-03
Cs-136	2.55E-03
Cs-137	1.16E-02
Cs-138	8.76E-03
Ba-137m	5.86E-06
Class 5	
H-3	3.64E-01
Class 6	
Na-24	5.60E-02
P-32	5.82E-03
Cr-51	4.44E-01
Mn-54	5.79E-03
Mn-56	1.11E-01
Fe-55	1.63E-01
Fe-59	4.55E-03
Co-58	1.60E-02
Co-60	3.23E-02
Ni-63	1.64E-04
Cu-64	7.11E-02
Zn-65	1.63E-01

Isotope	Activity Concentration (MBq/m^3)
Sr-89	1.58E-02
Sr-90	1.13E-03
Y-90	6.26E-04
Sr-91	7.07E-02
Sr-92	4.74E-02
Y-91	6.36E-03
Y-92	3.80E-02
Y-93	7.40E-02
Zr-95	1.27E-03
Nb-95	1.25E-03
Mo-99	1.83E-01
Tc-99m	2.29E-02
Ru-103	3.10E-03
Rh-103m	3.58E-05
Ru-106	4.71E-04
Rh-106	4.66E-08
Ag-110m	1.63E-04
Te-129m	6.22E-03
Te-131m	5.34E-03
Te-132	9.99E-04
Ba-140	5.72E-02
La-140	2.74E-02
Ce-141	4.48E-03
Ce-144	4.70E-04
Pr-144	1.61E-06
W-187	1.30E-02
Np-239	6.79E-01
Total	**4.14E+00**

Table 12.2-13d

Liquid Waste Management System Floor Drain Sample Tank Activity

Source Volume = 130 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	2.09E-05
I-132	0.00E+00
I-133	1.08E-06
I-134	0.00E+00
I-135	9.56E-11
Class 3	
Rb-89	0.00E+00
Cs-134	2.17E-05
Cs-136	9.72E-06
Cs-137	5.82E-05
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 5	
H-3	3.63E-02
Class 6	
Na-24	0.00E+00
P-32	0.00E+00
Cr-51	0.00E+00
Mn-54	0.00E+00
Mn-56	0.00E+00
Fe-55	0.00E+00
Fe-59	0.00E+00
Co-58	0.00E+00
Co-60	0.00E+00
Ni-63	0.00E+00
Cu-64	0.00E+00
Zn-65	0.00E+00

Isotope	Activity Concentration (MBq/m^3)
Sr-89	1.48E-06
Sr-90	1.13E-07
Y-90	1.68E-08
Sr-91	1.12E-09
Sr-92	1.01E-19
Y-91	0.00E+00
Y-92	0.00E+00
Y-93	0.00E+00
Zr-95	0.00E+00
Nb-95	0.00E+00
Mo-99	5.15E-06
Tc-99m	1.71E-12
Ru-103	0.00E+00
Rh-103m	0.00E+00
Ru-106	0.00E+00
Rh-106	0.00E+00
Ag-110m	0.00E+00
Te-129m	5.61E-07
Te-131m	3.19E-08
Te-132	3.37E-08
Ba-140	4.34E-06
La-140	0.00E+00
Ce-141	0.00E+00
Ce-144	0.00E+00
Pr-144	0.00E+00
W-187	0.00E+00
Np-239	1.52E-05
Total	**3.66E-02**

Table 12.2-13e

Liquid Waste Management System Chemical Collection Tank Activity

Source Volume = 4 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	7.56E+00
I-132	7.42E+00
I-133	3.22E+01
I-134	5.14E+00
I-135	2.12E+01
Class 3	
Rb-89	1.50E-01
Cs-134	8.73E-02
Cs-136	5.62E-02
Cs-137	2.33E-01
Cs-138	6.68E-01
Ba-137m	4.47E-04
Class 5	
H-3	7.28E+00
Class 6	
Na-24	3.31E+00
P-32	1.27E-01
Cr-51	9.31E+00
Mn-54	1.16E-01
Mn-56	8.48E+00
Fe-55	3.27E+00
Fe-59	9.36E-02
Co-58	3.25E-01
Co-60	6.48E-01
Ni-63	3.27E-03
Cu-64	4.48E+00
Zn-65	3.27E+00

Isotope	Activity Concentration (MBq/m^3)
Sr-89	3.25E-01
Sr-90	2.26E-02
Y-90	1.91E-02
Sr-91	4.85E+00
Sr-92	3.62E+00
Y-91	1.30E-01
Y-92	2.90E+00
Y-93	5.02E+00
Zr-95	2.60E-02
Nb-95	2.59E-02
Mo-99	5.51E+00
Tc-99m	1.71E+00
Ru-103	6.40E-02
Rh-103m	2.73E-03
Ru-106	9.45E-03
Rh-106	3.55E-06
Ag-110m	3.27E-03
Te-129m	1.29E-01
Te-131m	2.26E-01
Te-132	2.85E-02
Ba-140	1.26E+00
La-140	1.01E+00
Ce-141	9.33E-02
Ce-144	9.45E-03
Pr-144	1.23E-04
W-187	6.17E-01
Np-239	2.17E+01
Total	**1.65E+02**

Table 12.2-13f

Liquid Waste Management System Detergent Collection Tank Activity

Source Volume = 15 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	1.71E+01
I-132	6.59E+00
I-133	4.15E+01
I-134	4.57E+00
I-135	1.96E+01
Class 3	
Rb-89	1.33E-01
Cs-134	2.18E-01
Cs-136	1.32E-01
Cs-137	5.82E-01
Cs-138	5.94E-01
Ba-137m	3.98E-04
Class 5	
H-3	1.82E+01
Class 6	
Na-24	3.76E+00
P-32	3.00E-01
Cr-51	2.26E+01
Mn-54	2.90E-01
Mn-56	7.54E+00
Fe-55	8.17E+00
Fe-59	2.30E-01
Co-58	8.04E-01
Co-60	1.62E+00
Ni-63	8.19E-03
Cu-64	4.80E+00
Zn-65	8.14E+00

Isotope	Activity Concentration (MBq/m^3)
Sr-89	7.98E-01
Sr-90	5.64E-02
Y-90	3.61E-02
Sr-91	4.79E+00
Sr-92	3.22E+00
Y-91	3.20E-01
Y-92	2.58E+00
Y-93	5.01E+00
Zr-95	6.42E-02
Nb-95	6.31E-02
Mo-99	1.05E+01
Tc-99m	1.56E+00
Ru-103	1.57E-01
Rh-103m	2.43E-03
Ru-106	2.36E-02
Rh-106	3.16E-06
Ag-110m	8.14E-03
Te-129m	3.15E-01
Te-131m	3.37E-01
Te-132	5.63E-02
Ba-140	2.96E+00
La-140	1.67E+00
Ce-141	2.27E-01
Ce-144	2.35E-02
Pr-144	1.09E-04
W-187	8.40E-01
Np-239	3.96E+01
Total	**2.43E+02**

Table 12.2-13g

Liquid Waste Management System Detergent Sample Tank Activity

Source Volume = 15 m^3

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	1.24E+01
I-132	9.11E-12
I-133	2.07E+00
I-134	0.00E+00
I-135	1.79E-03
Class 3	
Rb-89	0.00E+00
Cs-134	2.17E-01
Cs-136	1.08E-01
Cs-137	5.82E-01
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 5	
H-3	1.82E+01
Class 6	
Na-24	0.00E+00
P-32	0.00E+00
Cr-51	0.00E+00
Mn-54	0.00E+00
Mn-56	0.00E+00
Fe-55	0.00E+00
Fe-59	0.00E+00
Co-58	0.00E+00
Co-60	0.00E+00
Ni-63	0.00E+00
Cu-64	0.00E+00
Zn-65	0.00E+00

Isotope	Activity Concentration (MBq/m^3)
Sr-89	7.58E-01
Sr-90	5.64E-02
Y-90	1.36E-02
Sr-91	7.60E-03
Sr-92	2.72E-10
Y-91	0.00E+00
Y-92	0.00E+00
Y-93	0.00E+00
Zr-95	0.00E+00
Nb-95	0.00E+00
Mo-99	4.12E+00
Tc-99m	4.75E-05
Ru-103	0.00E+00
Rh-103m	0.00E+00
Ru-106	0.00E+00
Rh-106	0.00E+00
Ag-110m	0.00E+00
Te-129m	2.92E-01
Te-131m	4.23E-02
Te-132	2.53E-02
Ba-140	2.42E+00
La-140	0.00E+00
Ce-141	0.00E+00
Ce-144	0.00E+00
Pr-144	0.00E+00
W-187	0.00E+00
Np-239	1.31E+01
Total	**5.44E+01**

Table 12.2-14a

Solid Waste Management System High Activity Resin Holdup Tank Activity

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	5.01E+05
I-132	5.53E+04
I-133	3.54E+05
I-134	3.95E+04
I-135	1.68E+05
Class 3	
Rb-89	1.17E+03
Cs-134	1.10E+05
Cs-136	3.26E+03
Cs-137	3.49E+05
Cs-138	2.49E+03
Ba-137m	3.33E+00
Class 6	
Na-24	3.23E+04
P-32	
Cr-51	2.29E+06
Mn-54	2.23E+05
Mn-56	6.51E+04
Fe-55	
Fe-59	3.92E+04
Co-58	2.20E+05
Co-60	1.82E+06
Ni-63	
Cu-64	4.12E+04
Zn-65	5.70E+06
Sr-89	1.54E+05

Isotope	Activity Concentration (MBq/m^3)
Sr-90	
Y-90	
Sr-91	4.12E+04
Sr-92	2.74E+04
Y-91	7.07E+04
Y-92	2.17E+04
Y-93	4.39E+04
Zr-95	1.60E+04
Nb-95	1.04E+03
Mo-99	1.45E+05
Tc-99m	1.32E+04
Ru-103	2.28E+04
Rh-103m	2.09E+01
Ru-106	
Rh-106	2.79E-02
Ag-110m	5.80E+03
Te-129m	3.79E+04
Te-131m	3.27E+03
Te-132	8.56E+02
Ba-140	1.35E+05
La-140	1.77E+04
Ce-141	2.72E+04
Ce-144	1.84E+04
Pr-144	9.53E-01
W-187	7.81E+03
Np-239	4.95E+05
Total	**1.33E+07**

Table 12.2-14b

Solid Waste Management System Low Activity Resin Holdup Tank Activity

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	1.46E+05
I-132	4.37E-04
I-133	5.17E+03
I-134	2.60E-15
I-135	4.56E+01
Class 3	
Rb-89	1.61E-63
Cs-134	3.87E+05
Cs-136	3.47E+03
Cs-137	1.34E+06
Cs-138	3.18E-27
Ba-137m	0.00E+00
Class 6	
Na-24	4.17E+01
P-32	
Cr-51	3.89E+05
Mn-54	5.99E+04
Mn-56	6.24E-04
Fe-55	
Fe-59	8.28E+03
Co-58	5.09E+04
Co-60	5.52E+05
Ni-63	
Cu-64	3.27E+01
Zn-65	1.46E+06
Sr-89	1.68E+05

Isotope	Activity Concentration (MBq/m^3)
Sr-90	
Y-90	
Sr-91	6.19E+01
Sr-92	2.29E-03
Y-91	1.61E+04
Y-92	9.25E-03
Y-93	1.55E+01
Zr-95	3.66E+03
Nb-95	1.58E+03
Mo-99	1.25E+04
Tc-99m	1.89E+00
Ru-103	4.72E+03
Rh-103m	4.51E-18
Ru-106	
Rh-106	0.00E+00
Ag-110m	1.49E+03
Te-129m	3.78E+04
Te-131m	9.12E+01
Te-132	8.93E+01
Ba-140	6.10E+04
La-140	1.58E+02
Ce-141	5.04E+03
Ce-144	4.61E+03
Pr-144	9.14E-57
W-187	2.85E+01
Np-239	3.49E+04
Total	**9.50E+06**

Table 12.2-14c

Solid Waste Management System High Activity Sludge Phase Separator Tank Activity

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	0.00E+00
I-132	0.00E+00
I-133	0.00E+00
I-134	0.00E+00
I-135	0.00E+00
Class 3	
Rb-89	0.00E+00
Cs-134	0.00E+00
Cs-136	0.00E+00
Cs-137	0.00E+00
Cs-138	0.00E+00
Ba-137m	0.00E+00
Class 6	
Na-24	2.51E+04
P-32	
Cr-51	4.95E+06
Mn-54	2.86E+05
Mn-56	4.50E+04
Fe-55	
Fe-59	7.45E+04
Co-58	3.56E+05
Co-60	2.38E+06
Ni-63	
Cu-64	3.04E+04
Zn-65	7.21E+06
Sr-89	1.19E+04

Isotope	Activity Concentration (MBq/m^3)
Sr-90	
Y-90	
Sr-91	2.83E+04
Sr-92	1.86E+04
Y-91	1.24E+05
Y-92	1.50E+04
Y-93	3.07E+04
Zr-95	2.68E+04
Nb-95	1.68E+04
Mo-99	9.25E+04
Tc-99m	9.03E+03
Ru-103	4.61E+04
Rh-103m	1.39E+01
Ru-106	
Rh-106	1.17E-03
Ag-110m	7.34E+03
Te-129m	4.60E+03
Te-131m	2.24E+03
Te-132	5.20E+02
Ba-140	3.89E+04
La-140	2.20E+04
Ce-141	5.69E+04
Ce-144	2.24E+04
Pr-144	6.05E-01
W-187	7.23E+03
Np-239	3.25E+05
Total	**1.63E+07**

Table 12.2-14d

Solid Waste Management System Condensate Resin Holdup Tank Activity

Isotope	Activity Concentration (MBq/m^3)
Class 2	
I-131	2.30E+05
I-132	2.54E+04
I-133	1.67E+05
I-134	1.80E+04
I-135	7.78E+04
Class 3	
Rb-89	2.70E+01
Cs-134	1.08E+03
Cs-136	1.40E+02
Cs-137	2.98E+03
Cs-138	1.13E+02
Ba-137m	7.67E-02
Class 6	
Na-24	0.00E+00
P-32	
Cr-51	0.00E+00
Mn-54	0.00E+00
Mn-56	0.00E+00
Fe-55	
Fe-59	0.00E+00
Co-58	0.00E+00
Co-60	0.00E+00
Ni-63	
Cu-64	0.00E+00
Zn-65	0.00E+00
Sr-89	4.57E+02

Isotope	Activity Concentration (MBq/m^3)
Sr-90	
Y-90	
Sr-91	1.87E+02
Sr-92	1.24E+02
Y-91	1.96E+02
Y-92	9.93E+01
Y-93	1.96E+02
Zr-95	4.14E+01
Nb-95	2.92E+01
Mo-99	6.64E+02
Tc-99m	5.99E+01
Ru-103	7.91E+01
Rh-103m	9.38E-02
Ru-106	
Rh-106	1.25E-04
Ag-110m	0.00E+00
Te-129m	1.43E+02
Te-131m	1.49E+01
Te-132	3.91E+00
Ba-140	6.13E+02
La-140	8.07E+01
Ce-141	1.04E+02
Ce-144	2.22E+01
Pr-144	4.34E-03
W-187	0.00E+00
Np-239	2.26E+03
Total	**5.27E+05**

Table 12.2-14e

Solid Waste Management System Concentrate Waste Tank Activity

Isotope	Activity Concentration (MBq/m³)
Class 2	
I-131	1.38E+00
I-132	1.83E-17
I-133	2.57E-02
I-134	1.01E-43
I-135	2.24E-06
Class 3	
Rb-89	8.31E-156
Cs-134	6.19E-01
Cs-136	1.91E-02
Cs-137	1.93E+00
Cs-138	5.87E-71
Ba-137m	0.00E+00
Class 6	
Na-24	9.47E-05
P-32	
Cr-51	1.54E+00
Mn-54	1.33E-01
Mn-56	3.10E-16
Fe-55	
Fe-59	2.61E-02
Co-58	1.44E-01
Co-60	1.02E+00
Ni-63	
Cu-64	4.36E-05
Zn-65	3.37E+00
Sr-89	5.11E-01

Isotope	Activity Concentration (MBq/m³)
Sr-90	
Y-90	
Sr-91	2.62E-05
Sr-92	2.37E-15
Y-91	4.73E-02
Y-92	7.31E-13
Y-93	8.17E-06
Zr-95	1.05E-02
Nb-95	5.50E-03
Mo-99	1.67E-01
Tc-99m	3.99E-08
Ru-103	1.56E-02
Rh-103m	7.80E-45
Ru-106	
Rh-106	0.00E+00
Ag-110m	3.43E-03
Te-129m	1.34E-01
Te-131m	7.94E-04
Te-132	1.19E-03
Ba-140	4.22E-01
La-140	1.78E-03
Ce-141	1.83E-02
Ce-144	1.04E-02
Pr-144	2.17E-134
W-187	1.82E-04
Np-239	4.57E-01
Total	**1.20E+01**

RAI 12.4-14:

DCD Tier 2, Figure 12.3-9, Note 2, states "zoning increase [of the vessel head lay down area] in the presence of the vessel head", however, no indication of the magnitude of the dose is provided. What dose rates are expected to be accessible to plant staff in this area with the vessel head stored in the lay down area (Elevation 34000 mm)? What design considerations have been implemented to ensure that the dose to plant workers will be ALARA?

GE Response:

The radiation level in the vessel head laydown area at elevation 34000 of the Reactor Building increases with the presence of the cover of the reactor vessel. Internal contamination by non-soluble activation products, including important contributions by isotopes such as ^{54}Mn and ^{60}Co, is typically found on the cover. The concentration of surface activity on the vessel cover progressively increases as reactor-operating time increases.

Initial estimated contamination values in the laydown area are 6.24×10^5 Bq/cm^2 for ^{54}Mn and 1.59×10^7 Bq/cm^2 for ^{60}Co, distributed evenly over the inner face of the cover. Considering these values, the dose rate closest to the vessel head storage area is 4.63×10^{-1} mSv/h, whereas the dose rate at floor level between the concrete stand and the inner face of the vessel is 2.63 Sv/h.

In order to ensure that the doses to personnel are ALARA, the following considerations are applied to the design:

- A circular stand prevents contamination from inside the vessel cover spreading to the outside of the cover when resting in its storage place;
- The vessel cover storage area is located in an area where personnel passage restrictions can be established;

Operational considerations used to keep personnel doses ALARA are :

- Plasticizing the floor inside the stand and the area of the cover storage point to control potential contamination releases;
- Identifying a vessel head handling route to minimize travel from the initial position of the head to the storage location such that the doses to maintenance personnel are minimized.

During the plant operations, additional ALARA measures may be put into effect to further minimize projected radiation doses.

No DCD changes will be made in response to this RAI.

RAI 12.4-19:

DCD Tier 2, Figure 12.3-10 indicates that several low dose areas adjacent to the incline fuel transfer tube system, including several open corridors in the Fuel Building, become Zone F (100 mrem/hr) during fuel transfer. Provide detailed radiation shielding calculation showing peak dose rates for each area adjacent to the incline fuel transfer tube system in the Reactor Building and Fuel Building during fuel transfer. Include all input parameters and assumptions used in the analytical model for these calculations. Provide justification for not including added shielding for these areas in the ESBWR design.

GE Response:

The inclined fuel transfer tube connects the pool located at EL +27000 in the Reactor Building with the pit at EL -10000 in the Fuel Building, which connects to the spent fuel storage pool.

The inclined fuel transfer tube runs through a number of areas and is adjacent to others, in both the Reactor Building and the Fuel Building.

The inclined tube leaves the pool in room 18P2, which is flooded during fuel transfer, with the inclined bottom at EL +22500. This pit borders on the East with a room in the Reactor Building separated by 160 cm normal concrete shielding that has an expected dose rate of $4x10^{-2}$ mrem/h. Additionally, the pit borders with room 2600 "HVAC Penthouse A" in the Fuel Building that has a wall thickness of 150 cm that provides concrete shielding with an expected dose rate of $1.2x10^{-3}$ mSv/h

Passing through the inclined bottom of room 18P2, the tube runs continues through a 100-cm-thick normal concrete slab to room 1702 "Inclined Fuel Tube Transfer Room". This room has an access plug from the adjacent room 1703 "Standby Liquid Control Pump Room". The thickness of the concrete shielding between the two rooms is 200 cm, with an expected dose rate of $8x10^{-6}$ mSv/h. The thickness of the shielding between room 1702 and pool 17P1 "Gravity Driven Cooling System Pool B/C" in the drywell is also 200 cm of concrete, although this room is not considered accessible. Room 1702 is also adjacent to high radiation zones and non-accessible parts of room 2400 in the Fuel Building, near the rail supports of the main crane in the Fuel Building.

At EL 13570, the tube is completely sheathed in concrete bordering on the general area 1600 in the Reactor Building by means of thicknesses of 260 cm of concrete and more than 300 cm with the Wetwell, thus making the dose rates insignificant. Along the access stairs to the crane in the Fuel Building, the minimum thickness of the shielding is 200 cm, with expected dose rates of $8x10^{-6}$ mSv/h.

At the height of EL +9060, the tube goes in the trapezoidal room bordering on the transfer trolley area at EL +4850 (general room 2400, "Rail Car Way") through a minimum thickness of 50 cm and maximum of 225 cm. Bordering rooms are room 1502 "Electrical Equipment Room B" at EL +9080 in the Reactor Building, with a shielding thickness of 200 cm of concrete and an expected dose rate of $8 \cdot 10^{-4}$ mrem/h, and room 1401 at EL +4650 "CRD B Panel Room" in the Reactor Building, with 150 cm thick shielding and an expected dose rate of $1.2x10^{-3}$ mSv/h.

The passage of the tube through EL +4650 is shielded with a minimum of 50 cm of concrete and 200 cm in terms of the Fuel Building (general room 2400) with subsequent expected maximum

dose rates of $3.6x10^{+1}$ mSv/h in the area close the south wall, near to the border of pit 21P1, and with 150 cm of concrete with respect to room 2190 "Commodity Chase" in the Reactor Building.

Passing through EL +4650, the inclined tube enters room 21P1, the non-accessible, flooded area transfer pit that connects to the spent fuel storage pool and extends down to EL -10000. The concrete shielding of this transfer pit with respect to the adjacent areas is as follows: 200 cm with respect to the "Commodity Chase" 2190, with an expected dose rate of $8x10^{-6}$ mSv/h (actually less if one considers the water shielding), 200 cm with respect to the Reactor Building, room 1331 RMU Panel Area and an expected dose rate of $8x10^{-6}$ mSv/h, and 150 cm with respect to general area 2300 in the Fuel Building, with an expected dose rate of $1.6x10^{-3}$ mSv/h. These concrete shielding thicknesses are maintained at EL -6400 with respect to the neighboring areas of the Reactor Building (room 1230) and Fuel Building (Commodity Chase, room 2190, and general area room 2200), thus making the expected dose rates identical to the ones before them.

At EL -10000, the pit 21P1 is adjacent to room 2190 "Commodity Chase" and separated by 200 cm-thick concrete walls, providing an expected dose rate of $8x10^{-6}$ mSv/h. It is also adjacent to the stairwell at EL +2100 and separated by 150 cm of concrete, with an expected dose rate of $1.2x10^{-3}$ mSv/h. With respect to the cask pit 21P2, it is separated by 100 cm of concrete, with a dose rate of $1.8x10^{+1}$ mSv/h.

The inclined transfer tube has been modeled using software program QAD-CGGP by means of a cylindrical tube with an inner diameter of 81.3 cm and 2.54 cm thick, equivalent to the guard pipe. Inside is the tube itself, with an inner diameter of 76.2 cm and 2.54 cm of steel thickness. Inside the water-filled tube a fuel element has been modeled measuring 13.8 x 13.8 x 424.5 cm

The whole set is surrounded by normal concrete thicknesses with a density of 2.35 g/cm^3 of up to 200 cm having arranged detectors at 50 cm, 100 cm, 150 cm, and 200 cm to assess the various thicknesses of concrete bordering on accessible areas.

The intensity of the radiation source in a fuel element used is shown in attached Table 12.4-19(1)

In calculating the dose rates, the source intensity has been conservatively multiplied by two. The density of the fuel element homogenized in water is 4.26 g/cm^3, and the percent composition is: UO2-59.9%, Steel-1.9%, Zircaloy-2-25%, and water-13.2%.

Personnel access control measures to areas immediately adjacent to the IFTS are provided in response to RAI 12.2-20.

Additional lead blocks shielding could be added, if necessary, on the wall of the inclined transfer tube to room 2400 to reduce dose in this room 2400 area during IFTS operations.

No DCD changes will be made in response to this RAI.

Table 12.4-19(1)

Spent Fuel Element Radiation Source Intensity

Energy, MeV	MeV/s
0.8	6.02E+16
1.3	3.99E+15
1.7	1.14E+16
2.5	1.19E+15
4.0	5.37E+12
5.0	4.08E+10
6.4	1.02E+10