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MFN 06-305
Supplement 4

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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 233 Related to ESBWR Design Certification Application – Radiation Protection – RAI Number 12.2-9 S05**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to a portion of the U.S. Nuclear Regulatory Commission Request for Additional Information (RAI) sent by NRC Letter 233 (Reference 1). The GEH response to RAI Number 12.2-9 S05 is addressed in Enclosure 1. The DCD markup pages related to this response are provided in Enclosure 2.

The original RAI 12.2-9 was received from the NRC on June 22, 2006 (Reference 2), and the GEH response was transmitted to the NRC on July 21, 2006 (Reference 3).

Subsequent RAI 12.2-9 Supplements were addressed in References 4 through 9.

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NRO

If you have any questions about the information provided here, please contact me.

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

References:

1. MFN 08-648, *Letter from the U.S. Nuclear Regulatory Commission to Robert E. Brown, Request for Additional Information Letter No. 233, Related To ESBWR Design Certification Application*, dated August 15, 2008
2. MFN 06-199, *Letter from the U.S. Nuclear Regulatory Commission to David Hinds, Request for Additional Information Letter No. 35, Related To ESBWR Design Certification Application*, dated June 22, 2006
3. MFN 06-212, *Response to Portion of NRC Request for Additional Information Letter No. 35 Related to ESBWR Design Certification Application – Radioactive Waste Management/Radiation Protection – RAI Numbers 11.5-22, 12.2-9, and 12.2-10,* dated July 21, 2006
4. MFN 06-383, *Letter from the U.S. Nuclear Regulatory Commission to David Hinds, Request for Additional Information Letter No. 71, Related To ESBWR Design Certification Application*, dated October 10, 2006
5. MFN 06-212 Supplement 2, *Response to Portion of NRC Request for Additional Information Letter No. 71 - Radiation Protection - RAI Number 12.2-9 S01*, dated May 22, 2007
6. MFN 07-433, *Letter from the U.S. Nuclear Regulatory Commission to Robert E. Brown, Economic Simplified Boiling Water Reactor (ESBWR) Chapter 12 Open Items*, dated July 27, 2007
7. MFN 06-450, *Response to Portion of NRC Economic Simplified Boiling Water Reactor (ESBWR) Chapter 12 Open Items [Radiation Protection] Letter – RAI Number 12.2-9 S02 Items a and b, dated August 31, 2007*
8. MFN 08-019, *Response to Portion of NRC Request for Additional Information Letter No. 71 Related to E5BWR Design Certification Application - Radiation Protection - RAI Number 12.2-9 S02, Items C-N,* dated January 17, 2008

9. MFN 08-019 Supplement 1 and MFN 08-222 Supplement 1, *Response to Portion of NRC Request for Additional Information Letter Nos. 150 and 173 Related to E5BWR Design Certification Application - Radiation Protection - RAI Number 12.2-9 S04*, dated May 5, 2008

Enclosures:

1. Response to Portion of NRC Request for Additional Information Letter No. 233, Related to ESBWR Design Certification Application – Radiation Protection – RAI Number 12.2-9 S05
2. Response to Portion of NRC Request for Additional Information Letter No. 233, Related to ESBWR Design Certification Application – Radiation Protection – RAI Number 12.2-9 S05 - DCD Markups

cc:	AE Cubbage	USNRC (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	eDRF	0000-0092-2286

Enclosure 1

MFN 06-305
Supplement 4

Response to Portion of NRC Request for

Additional Information Letter No. 233

Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.2-9 S05

For historical purposes, the original text of RAIs 12.2-9, 12.2-9 S01, 12.2-9 S02, 12.2-9 S03, 12.2-9 S04 and the GEH responses are included. These responses do not include any attachments or DCD mark-ups.

NRC RAI 12.2-9

The estimates of annual airborne releases presented in DCD Tier 2, Table 12.2-16 could not be duplicated using the information presented in Tables 12.2-15, 11.1-1, 11.3-1, 10.4-2, and 9.4-1, using the BWR-GALE Code (NUREG-0016). Please address the following in Table 12.2-15:

a) *Provide the basis for the offgas system flow rate or refer to the appropriate DCD section that presents this information. Reconcile different flow rates for this system, 54 vs 51 m3/hr - see Table 11.3-1.*

b) *Update table to include parameters corresponding to input data cards no. 20 to 28 and 32 to the BWR-GALE code.*

c) *Regarding input cards no. 23 to 24, confirm that the use of charcoal and HEPA filters are consistent with HVAC system descriptions of Section 9.4 and Tables 9.4-3 to 9.4-11.*

d) *Regarding input card no. 32, update entries on mass of charcoals to indicate whether the total amounts are for each operating train and state if only one or both trains will be used in parallel during routine operations.*

e) *Regarding input cards no. 20 to 21 and 25, confirm whether the steam used for the gland seal system is clean steam or main turbine steam. Section 10.3.1 states that main turbine steam is used, but Section 10.4.3 states that clean steam is used. Update table to include the gland seal holdup time and iodine partition factor.*

f) *Reconcile the basis for noble gas release rate, 740 MBq/sec in Table 12.2-15 vs 3700 MBq/sec in Table 11.3.-1 as the average annual or normal operational release rates. Check for consistency with Table 11.1-1.*

In Table 10.4-2:

g) *Update table to include the air ejector holdup time and iodine partitioning factor.*

In Table 11.3-1:

h) *Provide the basis of the major offgas maximum permissible concentrations and its applicability to the analysis.*

Update DCD Tables 12.2-15, 10.4-2 and 11.3-1 accordingly.

GEH Response

(a) The offgas system flow rate of 51 m3/hr (30 scfm) presented in Table 11.3-1 corresponds to the standard flow rate (at 70°F). Table 11.3-1 also provides a gaseous waste stream temperature of 95°F. The adjusted flow rate of 54 m3/hr in Table 12.2-15 corresponds to the higher offgas stream temperature (100°F) assumed for the annual airborne release analysis. For clarification, Table 11.3-1 will be revised to add "standard" to the offgas system flow rate. Table 12.2-15 is also revised to add the assumed offgas stream temperature to differentiate from the standard flow rate provided in Table 11.3-1.

(b) The actual BWR-GALE code (NUREG-0016) was not used in the annual airborne release analysis, however, the methodology of the code was used. The proposed changes to Table 12.2-15 reflects the updated parameters based on the responses to parts (a), and (c) through (h) of this RAI.

(c) Regarding input cards 23 (containment building releases) and 24 (turbine building releases), it is confirmed that use of charcoal and HEPA filters is consistent with HVAC system descriptions of Section 9.4 and the associated tables. No credit is taken for filtration of any radionuclides from containment and the turbine building, as well as the auxiliary (card 27) and radwaste (card 28) buildings. Table 12.2-15 will not be modified to reflect this fact.

(d) Regarding input card 32, Table 12.2-15 provides the correct masses for the charcoal used in the annual airborne release analysis. Each guard tank contains 7,500 kg charcoal, and each adsorber tank contains 27,750 kg charcoal. During normal operations, offgas flow is through one guard tank and all eight adsorber tanks (2 trains of 4 tanks in parallel), which is consistent with DCD Figure 11.3-1. Table 12.2-15 will be revised in the next DCD revision to reflect that the masses provided are for each tank.

(e) Regarding input cards 20, 21, and 25, it was conservatively assumed in the annual airborne release analysis that the steam used for the gland seal system is main turbine steam. The actual source of steam for the gland seal system in DCD Tier 2, Chapter 10 is currently under review and possible revision; however, for the purposes of the annual airborne release, main turbine steam is conservatively used. No gland seal steam flow (input card 20), hold up time (input card 21), or iodine partition factors (input card 25) were used in the annual airborne release analysis. Instead, the DCD Table 12.2-16 turbine gland seal annual airborne release values were generated by applying the annual radioiodine releases from the gland seal condenser exhaust (0.81 Ci/yr per μCi/g of I-131 in the reactor coolant, and 0.22 Ci/yr per μCi/g of I-133 in the reactor coolant, per Section 2.2.6.1 of NUREG-0016)

to the normal iodine coolant concentrations for those two isotopes. DCD Table 12.2-15 will be revised in the next DCD revision to reflect the fact that the NUREG-0016 Section 2.2.6.1 parameters were used.

(f) The noble gas release rate of 740 MBq/sec in Table 12.2-15 is correct, and is the value that was used in the annual airborne release analysis. This is consistent with the normal operation noble gas release rate provided in Table 11.1-1. The design parameter provided for the release rate in Table 11.3-1 ("Design Basis annual average noble radiogas release rate") is contradictory. The words "annual average" will be deleted in the next revision of the DCD. The proposed revised table is provided below.

(g) No steam jet air ejector holdup time (input card 22) was assumed in the annual airborne release analysis. As for the iodine partitioning factor (input card 26), its value is irrelevant, as the offgas from the air ejector enters the offgas system, where the charcoal guard tank and adsorber tanks retain the iodine. As a result, no iodine is released to the environment via the offgas system. This is reflected in DCD Table 12.2-16, where there are no offgas system release values provided for iodine. No changes will be made to either DCD Table 12.2-15 or Table 10.4-2.

(h) The major offgas activity maximum permissible concentration (MPC) in DCD Table 11.3-1 is simply the maximum design capacity source term (450,000 µCi/sec, based on 100 µCi/sec/MWt for 4500 MWt per Branch Technical Position ETSB 11-5 of Standard Review Plan 11.3) divided by the minimum flow of the offgas system (0.17 m3/min, taken from DCD Table 11.3-1). This value is provided in Table 11.3-1 for information only and is not applicable to the annual airborne release analysis. For better clarification, the term is to be changed to "Maximum offgas activity input concentration." The change is reflected in the revised Table 11.3-1 above.

NRC RAI 12.2-9 S01

The estimates of total annual airborne effluent releases presented in DCD Tier 2, Revision 1, Table 12.2-16 could not be duplicated using the information contained GE responses to RAI No. 12.2-9 (MFN-06-212 dated July 21, 2006) and RAIs No. 11.1-1 and 11.1-2 (MFN-06-219 dated July 19, 2006) and the BWR-GALE Code (NUREG-0016). For example, the staff's analyses show results that are inconsistent even after making specific adjustments to results, such as for the assumed primary coolant radionuclide concentrations and plant capacity factor. Please address the following:

a. *Since the BWR-GALE code was not used by GE in deriving total annual effluent releases, provide a description of the alternate method used, including adjustments made to address specific plant processes and/or radionuclides.*

b. *Provide technical discussions describing differences between the method used by GE and NUREG-0016. Include sufficient details in the response to facilitate the staff's review in comparing sources of differences.*

GEH Response

The following below provides an explanation for the values in DCD Tier 2, Revision 3, Table 12.2-16.

Reactor Building Releases

The noble gas and particulate values are calculated by taking the sum of the Containment Building and Auxiliary Building values from NUREG-0016 Table 2-12 and multiplying them by the appropriate adjustment factors. The adjustment factors for noble gas and particulates are calculated by the formulas:

$$\begin{aligned} Noble\ Gases &= \frac{Power}{3400} \times \frac{Availability}{0.80} \times \frac{Env\,Rel}{50000} = 0.621 \\ Particulates &= \frac{Power}{3400} \times \frac{Availability}{0.80} \times \frac{Env\,Rel}{0.0037} = 0.659 \end{aligned} \qquad (1)$$

The adjustment factors are based upon the ratio of 4590 MWth plant power for the ESBWR to 3400 MWth for the NUREG-0016 standard plant; availability (0.92 for ESBWR); ratio of gases released, 20,000 µCi/s for ESBWR compared to 50,000 µCi/s for the NUREG-0016 standard plant; and I-131 reactor water concentrations of 0.00157 µCi/g for ESBWR compared to 0.0037 µCi/g for the NUREG-0016 standard plant.

The release values for the iodines are calculated by starting with the normal operation iodine water source term in DCD Tier 2, Table 11.1-4b. Table 1-2 of NUREG-0016

provides the annual normalized iodine release rate for the Containment Building and Auxiliary Building for both power operation and for outages. Since the ESBWR does not have an Auxiliary Building, this value is added to the Containment Building value to determine the Reactor Building releases. The normal operation releases in Table 1-2 of NUREG-0016 are based on the NUREG- 0016 availability of 80%. These releases are adjusted to the ESBWR availability of 92%, and then multiplied by the DCD Tier 2, Table 11.1-4b iodine water source term values. Similarly, the outage releases in Table 1-2 of NUREG-0016 are adjusted by the ESBWR outage fraction (8%) and multiplied by the DCD iodine source term values.

Tritium is calculated in accordance with Paragraph 2.2.15.1 of NUREG-0016.

Turbine Building Releases

These values for the noble gases and particulates are calculated by taking the Turbine Building values from NUREG-0016 Table 2-12 and multiplying them by the adjustment factors described in Equation (1) above.

The methodology for determining the iodine releases is the same as described above for the Reactor Building, with two exceptions:

- The Turbine Building values from Table 1-2 of NUREG-0016 were used for normalized releases
- The iodine moisture carryover fraction (2%) was applied to the total, in accordance with Section 2.2.4.2 of NUREG-0016

Tritium is calculated in accordance with Paragraph 2.2.15.1 of NUREG-0016.

Radwaste Building Releases

The noble gas and particulate release values are calculated by taking the Radwaste Building values from NUREG-0016 Table 2-12 and multiplying them by the adjustment factors described in Equation (1) above.

The methodology for determining the iodine releases is the same as described above for the Reactor Building, with the only difference being that the Radwaste Building values from Table 1-2 of NUREG-0016 were used for normalized releases.

Mechanical Vacuum Pump

The Xe-133 and Xe-135 values are calculated by taking the values from NUREG-0016 Section 2.2.7.1 and multiplying by the ratio of the ESBWR noble gas release (20,000 μCi/s) by the NUREG-0016 noble gas release (50,000 μCi/s). The I-131 value is calculated by taking the value from NUREG-0016 Section 2.2.7.1, and multiplying it by

the iodine carryover (2.0%) and by the I-131 normal operation water concentration from DCD Tier 2, Table 11.1-4b.

Turbine Seal

As discussed in the previous response to RAI 12.2-9 (MFN 06-212), the DCD Tier 2, Table 12.2- 16 turbine gland seal annual airborne release values are generated by applying the annual radioiodine releases from the gland seal condenser exhaust (0.81 Ci/yr per µCi/g of I-131 in the reactor coolant, and 0.22 Ci/yr per µCi/g of I-133 in the reactor coolant, per Section 2.2.6.1 of NUREG-0016) to the normal iodine coolant concentrations for those two isotopes (DCD Tier 2, Table 11.1-4b).

Offgas System

The holdup times for the offgas system are based on the parameters specified in DCD Tier 2, Table 12.2-15. The normal operation source term for the noble gases entering the offgas system are provided in DCD Tier 2, Table 11.1-2b. The design basis source term for Ar-41 is provided in Section 2.2.23 of NUREG-0016. The normal operation source term for Ar-41 is calculated by multiplying the design basis value by the ratio of the noble gas normal operation source term to the design basis source term (20,000 divided by 100,000, per DCD Table 11.1-1). The offgas system release values in DCD Tier 2, Table 12.2-16 are determined by applying the offgas bed calculated holdup times to the normal operation source terms.

For C-14, guidance is provided for releases from the offgas system in Section 2.2.22.2 of NUREG-0016. Two values in the equation provided in Section 2.2.22.2 of NUREG-0016 are modified to apply to ESBWR:

m (mass of water in the core) = 34,200 kg
p (plant capacity factor) = 0.92

Drywell Releases

The drywell releases are based upon the standard NUREG-0016 assumptions of 2.5 gpm steam and water leaks, and 24 purges per year, with 365 hours between each purge.

The iodine and other equivalent water release is:

$$\mathrm{Rel} = (L_S C + L_W FF) * 63.09 \qquad (2)$$

Where:

Rel is the equivalent water release (grams/sec),

L_S and L_W are the leakage rate for steam and water respectively (2.5 gpm each),

C is the steam carryover fraction (2% for iodines, 0.1% for other nuclides),

FF is the flash fraction for water (0.4), and

63.09 is equal to 3785.412 grams/gallon divided by 60 seconds per minute.

The resulting value for iodines is 66.24 grams/sec and for other nuclides is 63.25 grams/sec.

For tritium the steam carry over is set to 1.0.

For noble gases, the release is:

Noble Gas Environmental Release (20,000 μCi/s) * 63.09 * L_W (2.5 gpm) divided by the steam flow rate of 9650 tons/hr (103 kg/hr). The resulting equivalent release is 1.18 μCi/sec.

In order to determine the noble gas values for DCD Tier 2, Table 12.2-16, the following equation is used:

$$R_i = N_p R_T \frac{A_i}{A_T} \frac{(1-e^{-\lambda_i t})}{\lambda_i} \qquad (3)$$

Where:

R_i = annual release rate for isotope i, in Ci/yr,
N_p = number of purges per year (24 as described above),
R_T = noble gas release rate (1.18 μCi/sec),
A_i/A_T = ratio of design basis steam activity of isotope i to total design basis noble gas steam activity,
λ_i = decay constant,
t = number of seconds in year divided by Np.

The equation for iodines is similar:

$$R_i = N_p \cdot RelI \cdot EnvI_i \cdot (1-0.9) \cdot \frac{(1-e^{-\lambda_i t})}{\lambda_i} \qquad (4)$$

Where:

$RelI$ = iodine water release rate (66.24 grams/sec) described in Equation (2),

$EnvI_i$ = the environmental iodine water concentration for isotope i (µCi/gram), 0.9 = condensation removal factor of 90%.

The equation for other nuclides is:

$$R_i = N_p \cdot RelO \cdot EnvO_i \cdot (1-0.9) \cdot \frac{(1-e^{-\lambda t})}{\lambda_i} \quad (5)$$

Where:

$RelO$ = other nuclide water release rate (63.25 grams/sec) described in Equation (2),
$EnvO_i$ = the environmental other nuclide water concentration for isotope i (µCi/gram).

DCD Impact

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

NRC RAI 12.2-9 S02

Please address the following issues relative to the subject RAI:

a. *The ESBWR design control document (DCD) should describe the performance requirements of adsorbent media for the eight main charcoal beds and two guard charcoal beds, and for the charcoal filters used in building ventilation exhaust systems. The performance of adsorbent media should be consistent with the method used in demonstrating compliance with the requirements of 10 CFR 20.1301 and 20.1302, and Appendix I to 10 CFR Part 50, as described in DCD Rev. 3, Sections 12.2.2.1 and 12.2.2.2. Please update DCD Tier 2 Table 11.3-1 Offgas System Design Parameters, to specify the delay time for Krypton and Argon in addition to Xenon which is already included, and Table 12.2-15 Airborne Sources Calculation, to specify the charcoal filtration efficiency for radioactive iodine.*

b. *In Revision 3 of DCD Tier 2, Section 11.3.1, the applicant states that the design of OGS follows the guidance of IE Bulletin 80-10 Contamination of Non-radioactive Systems and Resulting Potential for Unmonitored, Uncontrolled Release to Environment but does not consider interconnections between plant systems that could become radioactive through improper interfaces with radioactive systems. DCD Rev. 3, Section 11.3.8 does not commit the COL applicant to confirm that the OGS, as installed, fulfills this commitment. Please update the DCD to either (i) make reference to IE Bulletin 80-10 in DCD Sections 11.3.2.2 and 10.4.1.2.3 as they relate to drains designed to capture the contaminated water phase from OGS condensers/coolers, or (ii) create a COL applicant item to address this issue as part of the integration of the final design of the OGS, taking into account specific design features.*

c. *Under the requirements of Sections II.B, II.C, and II.D of Appendix I to Part 50, a COL applicant is responsible for addressing the requirements of 10 CFR 50 Appendix I dose objectives in controlling doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements define dose objectives for liquid effluents, require a cost-benefit analysis in justifying installed processing and treatment systems, as permanently installed equipment and mobile systems. However, DCD Rev. 3, Section 11.3.8 does not commit the COL applicant to address these requirements. Please create a COL applicant item to address this issue and include it in the DCD or justify why a COL action item is not necessary.*

   Regarding methods used to derive estimates of total airborne radioactivity releases, as presented in DCD Tier 2, Rev. 3, Table 12.2-16:
   In GE's May 22, 2007, response (MFN 06-212, Supplement 2) to RAI 12.2-9 S01, the applicant provides new information used in deriving the estimates of total airborne radioactivity releases. The estimates are listed in DCD Tier 2, Rev. 3, Table 12.2-16. The new information presents models, equations, and values for

specific parameters, either given in the new information or extracted from NUREG-0016. Generally, the staff independently confirmed the approach and most results presented in MFN-06-212, except in a few instances where specific results could not be duplicated or clarifications are being requested on the basis of specific assumptions or values used in calculations. The following presents items for which further clarifications are sought in order to resolve these outstanding issues.

d. *The adjustment factors for gaseous effluent source terms presented in equation (1) are based on a rated power levels of 4590 MW, while the basis of all radioactive source terms presented in DCD Table 11.1-3 is defined at 4500 MW. Similarly, the derivation of all liquid effluent source terms is based on 4500 MW (DCD Table 12.2-19a). Provide the justification for using a power rating of 102 percent for the estimation of gaseous effluent source terms.*

e. *The derivation of C-14 activity released is based on 34,200 kg as the mass of water subject to neutron irradiation and production of C-14 (p.3 of 5). This value is smaller than the one (39,000 kg) applied in NUREG-0016 for a generic plant rated at 3400 MW. Provide the justification for using a value of 34,200 kg for a plant rated at 4500 MW and designed with a larger reactor vessel.*

f. *For equation (2), provide the justification for the value of 0.4 as the water flash fraction. The text supporting the use of this equation is silent on the basis of this value. Provide the information justifying this value.*

g. *For equation (3), provide the information with which to derive the Ai /At ratio for noble gases listed in DCD Table 12.2-16. Indicate whether the ratios are based on steam concentration (uCi/g) or steam release rates (uCi/sec at 30 min.). Note that DCD Table 12.2-16 presents source term estimates for Kr-90 and Xe-139, but DCD Tables 11.1-2a and 11.1-2b do not list these two nuclides. Accordingly, update DCD Tables 11.1-2a and 11.1.2b so as to include Kr-90 and Xe-139.*

h. *In support of equation (3), the derivation of noble gas activity released is based on a steam mass flow rate of 9.65 x 10+6 kg/hr, while the basis of all radioactive source terms presented in DCD Table 11.1-3 is defined at a steam flow rate of 8.76 x 10+6 kg/hr. Provide the justification for using a different steam flow rate in this equation.*

i. *For equations (4) and (5), provide the justification for the value of 0.9 as the condensation removal factor. The text supporting the use of this equation is silent on the basis of this value. Provide the information justifying this value.*

j. *In deriving the release rate of Ar-41, provide a justification in using the NUREG-0016 value of 40 uCi/sec as a design basis and then adjusting it downward by a factor of five as a normal operational release rate. In light of the qualifier noted in NUREG-0016, an average release rate of 20 uCi/sec (see Table 2-37) seems more appropriate in characterizing normal operations than the value of 11 uCi/sec used in this calculation. Using the information presented in MFN 06-212, the staff's estimate of the Ar-41 source term is twice than that derived by the applicant, using a hold up time of 1.1 day in charcoal decay tanks.*

k. *In deriving the release rate of Xe-133 and Xe-135, provide a justification for not adjusting the release rates by the ratios of the power levels (4500 vs 3400 MW) and capacity factors (0.92 vs 0.80) of 1.35 and 1.15, respectively. Using the information presented in MFN-06-212, the staff estimates are correspondingly higher for Xe-133 and Xe-135 source terms after making such adjustments. Provide information with which to resolve this discrepancy.*

l. *In confirming radioactivity release rates from the Drywell via equation (5), the staff could not duplicate the results for particulates nuclides, but confirmed those for all radioiodines and tritium. For particulates, the staff's estimates are consistently higher by a factor of 1,000 for the 24 nuclides that were checked. Provide information with which to resolve this discrepancy.*

m. *In confirming radioactivity release rates from the Drywell via equation (5), the staff could not duplicate the results for 13 of the 15 noble gases, excluding Kr-90 and Xe-139. The staff's estimates are both higher and lower than that provided by the applicant by factors ranging from 0.1 to nearly 270. See related issues noted in item (g) on the need for further clarification on derivation of Ai /At ratio for all listed noble gases. Provide information with which to resolve this discrepancy.*

n. *A review of the information presented in MFN 06-212, Sup. 2, indicates that the enclosure presents key and important information supporting the basis, models, and assumptions used in deriving airborne effluent source terms. Regarding the development of the airborne effluent source terms, DCD Section 12.2.2.1 briefly states that "The methodology of NUREG-0016 was used in determining the annual airborne release values in Table 12.2-16. The staff's observation is that the models, assumptions, and parameters presented in MFN 06-212 cannot be inferred from NUREG-0016 alone. Accordingly, it is suggested that the enclosure to MFN 06-212, once revised to address the above noted issues, be appended to DCD Chapter 12.2 and that the text in DCD Section 12.2.2.1 refers the reader to this appendix for specific details and information on the derivation of the airborne source terms. This approach would make the presentation of the supporting information about airborne effluents consistent with the corresponding details provided in the development of the source terms for liquid effluents.*

GEH Response

Item a:
Argon and Krypton delay times, Iodine removal efficiency, and a requirement that the adsorbent media and the process offgas equipment meet or exceed these requirements is being added to Table 11.3-1 in DCD Tier 2, Revision 5.

Item b:

A reference has been made in Subsection 11.3.1 to identify IE Bulletin 80-10 compliance regarding interconnections between plant systems. GEH has identified that the air supply system connections to the offgas system are the only areas where nonradioactive systems could become radioactive through improper connections. A reference to IE Bulletin 80-10 is being added to the description of the air supply connection to offgas. A separate COL item to address Bulletin 80-10 radioactive and non-radioactive interfaces is unnecessary as GEH has identified in the attached markups those interface locations in the Gaseous Waste Management System.

Item c:

A COL applicant item has been created in response to RAIs 12.2-21 and 12.2-22 (provided in GEH letter MFN 07-427, dated August 2, 2007), and now resides in DCD Tier 2, Subsections 12.2.2.2 and 12.2.4 (instead of DCD Tier 2, Section 11.3.8).

Item d:

The value of 4590 MWth was generated as a result of applying the 2% instrument uncertainty per Regulatory Guide (RG) 1.49. Since the liquid effluent releases as well as the source terms in DCD Tier 2, Table 11.1-3 are based on 4500 MWth, the gaseous effluent release source term has been adjusted to 4500 MWth for consistency. This value (instead of the 4590 MWth value) is now cited in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item e:

Since the calculation of C-14 generation in NUREG-0016 is based upon an activation calculation in the core, GEH interprets the parameter "m" (mass of water in reactor core) in the NUREG-0016 Section 2.2.22.2 equation as being the mass of water in the core region (from top of active fuel to bottom of active fuel) at rated power. In review of the ESBWR-specific calculation, it was determined that the mass of water at rated power in the core region is 3.9E+04 kg. The original value GEH had used (3.42E+04 kg) was the mass of water at rated power in the core region for the ABWR. The new ESBWR-specific value (3.9E+04 kg) is now used to determine the C-14 generation. GEH does not know the basis for the 3.9E+04 kg mass of water in the core used in NUREG-0016, as no basis is provided in the document; however, GEH adjusted the C-14 source term

by the ratio of 4500MWth/3400 MWth to account for the difference between the ESBWR and generic plant thermal power levels. This detailed discussion is now cited in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item f:

The flashing fraction of 0.4 is determined by the following formula:

$$FF = \frac{h_t - h_f}{h_s - h_f}$$

Where:
h_t = enthalpy of saturated water at 1050 psia (550.1 Btu/lb)
h_f= enthalpy of saturated water at 14.7 psia (180.2 Btu/lb)
h_s = enthalpy of saturated steam at 14.7 psia (1150.5 Btu/lb)

This formula is consistent with the flash fraction formula provided in Regulatory Guide 1.183, Appendix A, Section 5.4. This information is now cited in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item g:

The ratio A_i / A_T is defined as the ratio of design basis steam activity of isotope i to total design basis noble gas steam activity. The value A_i is calculated by taking the design basis noble gas steam concentration of isotope i from DCD Tier 2, Table 11.1-2a (in units of µCi/g) and multiplying it by the steam flow rate from DCD Tier 2, Table 11.1-3 (8.76E+06 kg/hr) and applying unit conversions to yield A_i in units of µCi/sec. The value A_T is the summation of the individual A_i calculated values. This discussion is now cited in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

In the current evaluation of the airborne effluent source term, the contribution of Kr-90 and Xe-139 activities represents less than 0.5% of the annual noble gas drywell release, and less than 0.00002% of the annual noble gas total release from the plant. Since these isotopes represent a negligible contribution, GEH will delete these two isotopes from DCD Tier 2, Tables 12.2-16 and 12.2-17 in Revision 5, and will be reflected in the change list.

Item h:

The response to RAI 12.2-9 S01 (MFN 06-212, Supplement 2, dated May 22, 2007) quoted a steam flow rate of 9650 tons (103 kg/hr) in support of equation (3). The correct flow rate of 8.76E+06 kg/hr in DCD Tier 2, Table 11.1-3 is used in the revised airborne effluent source term analysis. The revised value, in addition to its downstream effect, is provided in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item i:

The steam from piping and equipment leaks is released in the drywell, which is a quiescent large volume that is cooled by drywell coolers. These coolers are designed to remove the steam from the drywell (to maintain the drywell temperature) and drain the water to the radwaste system. The value of 0.9 in equations (4) and (5) of the response to RAI 12.2-9 S01 (MFN 06-212, Supplement 2, dated May 22, 2007) represents the iodine and other nuclide condensation removal fraction in the drywell. As a basis for this value, the BWR rod drop accident in Regulatory Guide 1.183 assumes plateout in the main steam lines and condenser of 99% for iodines and 99.99% for particulates. One of the mechanisms for the plateout is the condensation due to the temperature differential between the steam and the plateout surfaces. Similarly, Regulatory Guide 1.183, Appendix A, Section 5.5 allows for only 10% of the iodines to become airborne due to engineered safety features (ESF) system leakage. Based on the information above, it is conservative to assume that 90% of the iodines and particulates condense and plate out in the drywell. A brief summary of this explanation is provided in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

It should be noted that in performing the revised airborne effluent source term analysis, it was discovered that the drywell purges are filtered through the Reactor Building HVAC Purge Exhaust Filter Unit. DCD Tier 2, Figure 9.4-10 shows that the Reactor Building Contaminated Area HVAC Subsystem (CONAVS) takes the flow from the Containment Purge Fan through the Reactor Building HVAC Purge Exhaust Filter Unit and out the building. DCD Tier 2, Table 9.4-11 shows that the Purge Exhaust Filter Unit consists of HEPA and carbon filters, both with 99% efficiency. As a result, this 99% filtration term has been added to equations (4) and (5) of the response to RAI 12.2-9 S01 (MFN 06-212, Supplement 2, dated May 22, 2007). A brief summary of this information is provided in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item j:

GEH agrees that the value originally used for the Ar-41 release rate is not consistent with NUREG-0016. The Ar-41 release rate in the revised analysis is 40 μCi/sec, which is conservative. This value will be reflected in DCD Revision 5, Tier 2, Table 11.1-1; markup is attached. In addition, the design basis value for Ar-41 will be removed from

this table, as it is not used in the normal release or accident dose evaluations. The text in DCD Tier 2, Subsection 11.1.2 regarding Ar-41 will also be revised to delete the discussion of the design basis source term. This DCD revision is attached.

Item k:

The release rates for Xe-133 and Xe-135 have been adjusted by the ratios of the power levels (4500 vs. 3400 MWth) and capacity factors (0.92 vs. 0.80) in the revised airborne effluent source term analysis. The values in revised DCD Tier 2, Tables 12.2-16 and 12.2-17 (attached) reflect this adjustment. This adjustment is discussed in DCD Tier 2, Appendix 12B, which is discussed in item n. of this RAI response.

Item l:

The response to RAI 12.2-9 S01 (MFN 06-212, Supplement 2, dated May 22, 2007) stated that the parameter $EnvO_i$ in equation (5) is defined as the environmental other nuclide water concentration for isotope i. While this definition still holds true, the original airborne effluent source term analysis used the steam concentrations in equation (5), not the water concentrations. Using the steam instead of the water concentrations for the other nuclides underestimated the drywell release for the other nuclides by a factor of 1000. The revised airborne effluent source term analysis has remedied this problem, and the updated nuclide concentrations are provided in revised DCD Tier 2, Tables 12.2-16 and 12.2-17.

Item m:

GEH believes that the discrepancies in the noble gas release rates are based upon the issue identified in item g. of this RAI response. The clarification in item g. should clear up the discrepancies the Staff has identified, with respect to the derivation of A_i / A_T ratio for the noble gases.

Item n:

The information provided in the response to RAI 12.2-9 S01 (MFN 06-212, Supplement 2, dated May 22, 2007), along with the information in this RAI response, is included in the newly created DCD Tier 2, Appendix 12B, which is attached. Additionally, since the effluent releases impact the normal operation offsite doses, DCD Tier 2, Table 12.2-18b has been revised and is attached. The meteorology boundary of 800 meters has been deleted in DCD Tier 2, Tables 12.2-15 and 12.2-18a, as the boundary distance is not relevant to the generic ESBWR release or dose analyses; the only meteorologically relevant parameters needed are the long-term X/Q and D/Q values. Lastly, during the revision of the airborne effluent source term analysis, it was discovered that the decay constants for some of the isotopes were erroneous. The table below provides the details:

Isotope	Original λ (sec^{-1})	Revised λ (sec^{-1})
Y-90	7.820E-10	3.005E-06
Rh-103m	2.026E-07	2.063E-04
Rh-106	2.174E-08	2.318E-02
Ag-110m	2.818E-02	3.184E-08
Pr-144	2.821E-08	6.685E-04

DCD Impact

DCD Tier 2, Subsection 11.3.1 and Table 11.3-1 will be revised as noted on the attached markup and will be reflected in DCD Tier 2, Revision 5.

DCD Tier 2, Subsections 11.1.2 and 12.2.2.1; Tables 11.1-1 and 12.2-15 through 12.2-18b; and Appendix 12B will be revised as noted on the attached markup.

NRC RAI 12.2-9 S03

An evaluation of the response to NRC RAI 12.2-9 S02, contained in MFN 08-019, indicates that the staff could not independently confirm some of the revised results presented in that response. Specifically:

a. *Offgas Ar-41 source term: the staff calculates 1960 MBq/yr, while the response indicates 1400 MBq/yr.*

b. *Offgas Kr-85 source term: the staff calculates 5.2E+06 MBq/yr, while the response indicates 4.3E+06 MBq/yr.*

c. *Drywell noble gases: staff results are higher by a factor of two for all nuclides as compared to the response.*

d. *Reactor Bldg K-85m source term: no explanation is given for the increase from 69,000 to 90,000 MBq/yr, while the source terms for all other nuclides are essentially the same.*

Accordingly, provide supporting information and technical details for the staff to understand and resolve these differences.

GEH Response

a. The Ar-41 release rate was assumed to be 40 µCi/sec into the offgas system. The calculation was then performed through each of the tanks. Tank 1 (guard tank) has a charcoal mass of 7500 kg, flow rate of 54 m^3/hr, Kd of 6.4 cm^3/g, which yields a holdup time of 0.89 hours. The flow is then split equally into two parallel banks of four additional tanks (Tanks 2-5). Each of these tanks has a charcoal mass of 27,750 kg with a flow rate of 27 m^3/hr through each bank and a Kd of 6.4 cm^3/g, which yields a holdup time of 6.58 hours for each tank. Decay of the initial Ar-41 flow rate of 40 µCi/sec is split equally through each tank using a simple decay of $e^{\lambda t}$:

   After Tank 1, the total activity flow rate through both banks is 28.2 µCi/sec
   After Tank 2, the total activity flow rate through both banks is 2.34 µCi/sec
   After Tank 3, the total activity flow rate through both banks is 1.94E-01 µCi/sec
   After Tank 4, the total activity flow rate through both banks is 1.60E-02 µCi/sec
   After Tank 5, the total activity flow rate through both banks is 1.33E-03 µCi/sec – this is converted to an annual release of 3.85E-02 Ci/year (assuming a 0.92 availability), which is 1.4E+03 MBq/year.

   The 2 charcoal bank hold-up time is assessed as follows:

   The flow rate of 54 m^3/hr is split between the two banks with 27 m^3/hr flowing through each bank. In calculating the holdup time for the first tank in each bank, the following data is utilized: flow rate (27 m^3/hr), K_d for Ar-41 (6.4 cm^3/g), and the charcoal mass of the tank (27,750 kg). This calculation yields a holdup time of 6.58

hours. Therefore, the holdup time in each tank (regardless of which bank) is 6.58 hours. Even though the flow (and activity rate) is split between the two banks, the tanks. Thus, the 6.58 hour holdup time can be applied to the entire stream of activity.

No changes to the DCD will be made as a result of this response; however, DCD Tier 2, Table 12.2-15 shows the Kd for Ar-41 as 6 cm^3/g. This value will be revised to 6.4 cm^3/g in the table, as this was the value used in the current and previous analyses. Additionally, the Kd for krypton in DCD Tier 2, Table 12.2-15 will be changed to 18.5 as used in the analysis from the rounded value of 19.

b. The previous revision of the offgas gaseous effluent release analysis (supporting the response to RAI 12.2-9 S02) assumed a design basis Kr-85 concentration (at 30 minutes decay) of 20 µCi/sec, which was inconsistent with the 24 µCi/sec value provided in DCD Tier2, Table 11.1-2a. The revised analysis utilized the concentration for Kr-85 (and for all the other noble gases) from DCD Tier 2, Table 11.1-2a as input for the revised evaluation. The revised values are reflected in the "Offgas System" column of DCD Tier 2, Table 12.2-16, which is included with this RAI response.

c. GEH's response to item (g) of RAI 12.2-9 S02 (MFN 08-019, dated January 17, 2008) stated that the value A_T represents the total design basis noble gas steam activity. Item (g) of the response also indicated that the contribution of Kr-90 and Xe-139 activities represented a negligible contribution to the annual noble gas release from the plant. It was resolved in item (g) of the response to delete the two isotopes from DCD Tier 2, Tables 12.2-16 and 12.2-17. While the two isotopes were deleted from the DCD tables, the two isotope activities were still included in the calculation of the value A_T. For the revised analysis supporting this RAI response, the Kr-90 and Xe-139 isotope activities were eliminated in the calculation of the value A_T. The contribution of these two isotopes was approximately 50% of the total value of A_T. This decreased the total value of AT, subsequently increasing the ratio of A_i/A_T, as defined in the response to item (g) of RAI 12.2-9 S02 (MFN 08-019, dated January 17, 2008). The revised drywell noble gas release values are provided in DCD Tier 2, Table 12.2-16, which is included with this RAI response.

d. In the response to RAI 12.2-9 S01 (MFN06-212 Supplement 2, dated May 22, 2007), GEH stated that the Reactor Building noble gas and particulate releases were calculated by the sum of the Containment Building and Auxiliary Building values from NUREG-0016, Table 2-12 and multiplying them by the appropriate adjustment factors. When GEH was performing its analysis to support the response to RAI 12.2-9 S02 (MFN 08-019, dated January 17, 2008), GEH discovered that it had not incorporated the NUREG-0016 Table 2-12 Containment Building Kr-85m release of 1 Ci/yr in its previous evaluations. The analysis supporting the response to RAI 12.2-9 S02 (MFN 08-019, dated January 17, 2008)

remedied this issue, thus increasing the Kr-85m release from the Reactor Building. No DCD changes will be made as a result of this response.

DCD Impact

DCD Tier 2, Tables 12.2-15, 12.2-16, and 12.2-17 will be revised as noted on the attached markup. It should be noted that some of the identified changes to Tables 12.2-16 and 12.2-17 are attributed to the response to RAI 12.2-9 S02 submitted via MFN 08-019 dated January 14, 2008.

NRC RAI 12.2-9 S04

An evaluation of responses to NRC RAI 12.2-9S02 and S03, contained in MFN 08-019 and MFN 08-222, indicates that offsite dose calculation results need to be revised given the updated gaseous effluent source terms presented in MFN 08-222.

Specifically:

1. *Item n. to RAI 12.2-9S02 is not closed, pending GEH's response to update dose calculation results and supporting data presented in DCD Tables 12.2-18a and 12.2- 18b. During the NRC/GEH telecon of March 26, 2008, GEH committed to revise the dose calculations confirming compliance with App. I to Part 50, given that the gaseous effluent source terms were revised in light of updated information presented in GEH responses to NRC RAI 12.2-9S02 and 12.2-9S03.*
2. *The closure of RAI 12.2-9S02 (item n) is also tied to RAI 12.2-25 addressing the inclusion of a qualifier about the basis of long-term atmospheric dispersion and deposition parameters. The parameters are used to calculate doses for Part 50, App. I compliance. Based on a prior NRC/GEH telecon about met data and how this info would be presented in DCD Chapters 2.3.5 and 12.2.2, GEH staff had suggested a statement to the effect that the atmospheric dispersion and deposition parameters noted in Table 12.2-15 reflect typical conditions at existing sites with operating BWR plants.*

Accordingly, update DCD Tier 2, Tables 12.2-15, 12.2-18a, and 12.2-18b with revised dose calculations and appropriate qualifiers for met data used in calculating doses for Part 50, Appendix I dose objective compliance.

GEH Response

The subject offsite annual doses from airborne releases used to demonstrate compliance with 10CFR50 Appendix I requirements as reported in DCD Table 12.2-18b have been recalculated based on data developed to support responses to RAIs 12.2-9 S03 and 2.3-10 S02.

The recalculated doses are in part based on the reevaluation of annual gaseous effluent releases determined in the response to RAI 12.2-9 S03 (MFN 08-222 dated March 22, 2008) and shown on the revised DCD Tier 2 Table 12.2-16 associated with this response. The recalculated doses are also based on the reevaluation and determination of revised meteorological dispersion and deposition parameters performed in response to RAI 2.3-10 S02 (submitted via GEH letter MFN 06-396, Supplement 3, dated April 24, 2008). The response to RAI 2.3-10 S02 provides the updated meteorological dispersion and deposition parameters in the revised DCD Tier 2 Table 12.2-15. The methodology used to calculate the subject doses has not changed from that described in DCD Tier 2 Section 12.2.2.2.

The revised annual doses from airborne releases are shown in the revised and attached markup DCD Tier 2 Table 12.2-18b. DCD Tier 2 Table 12.2-18a is unchanged.

DCD Impact

DCD Tier 2, Table 12.2-18b will be revised as noted on the attached markup in DCD Tier 2, Revision 5.

NRC RAI 12.2-9 S05

A review of MFN 06-305 S02, MFN 08-222, and DCD Tier 2, Revision 5, DCD Tables 12.2-16 and 12.2-18b indicates that the description of assumptions and dose results are inconsistent. Specifically:

(a) A review of DCD Tier 2, Revision 5, DCD Table 12.2-16 indicates that the description of the source terms and equilibrium for a set of 7 nuclides needs to be qualified as to the assumptions used for their stated equilibrium. The nuclides are Sr/Y-90, Zr/Nb-95, Ru-103/Rh-103m, Ru/Rh-106, Mo-99/Tc-99m, Ba/La-140, and Ce/Pr-144 and they should be qualified in estimating the source terms for the Rx/FB, RWB and TB. While the staff generally concurs with MFN 08-222, the applicant is requested to introduce a properly qualified footnote in DCD Table 12.2-16, or text update in Appendix 12B to DCD Section 12.2.2. Note that the staff's SER discussions and analysis of the source terms and doses will based on an assumed 100 percent equilibrium for these radionuclides.

(b) A review of DCD Tier 2, Revision 5, DCD Table 12.2-18b does not include the dose due to plume exposure for the infant. The concern is one of omission of the pathway and consistency with the results for all other age groups listed in this table. The staff finds the proposed deletion of the plume dose to all age groups (adult, teen and child) rather than adding it to the infant an unacceptable solution, given that this is an Appendix I compliance issue. A review of Appendix I, Sections II.B.1 and II.B.2 indicates that the dose objective clearly addresses external radiation exposures to the total body associated with all gaseous effluents. RG 1.109, Table 1 in deriving doses to the total body, refers to Eq. 8 and 10 for the methodology. For ground or mixed mode stack releases, Eq. 10 is applicable as it defines total body dose due to immersion in gaseous effluents, which represents plume exposure. The applicant is requested to revise the dose results for the infant in DCD Tier 2, Table 12.2-18b by adding to it the contribution from plume exposure and not subtract plume dose contributions from all other age groups.

GEH Response

(a) A properly qualified footnote will be introduced to DCD Tier 2, Table 12.2-16 to provide the assumptions used for the set of 7 nuclides, in lieu of a text update to Appendix 12B. In addition, an editorial change will be made to the existing footnote to Table 12.2-16 to correct the misspellings of "building" and "vacuum."

(b) DCD Tier 2, Table 12.2-18b will be revised to delete the "Plume" pathway contribution to the maximum organ doses to the adult, teen, and child. The infant doses will continue to not include the "Plume" doses. In addition, a note will be added to clarify that the total organ doses at the bottom of the table do not include the "Plume" pathway doses. Currently, the organ doses for the adult, teen, and child in DCD Tier 2, Table 12.2-18b include the "Plume" pathway noble gas dose,

while the infant organ doses do not. Per the discussion below, since the "Plume" doses are solely attributed to noble gases, and the maximum organ dose should not include noble gases; the adult, teen, and child organ doses will not include the contribution from the "Plume" pathway.

10 CFR 50 Appendix I Sections II.B.2(a) and (b) state that the total body and skin doses are annual external doses from gaseous effluents. Of the outputs provided in the GASPAR code, the "plume" output is considered to be an external dose. Examining the "plume" dose by radionuclide shows that only the noble gases are considered in the "plume" dose. Therefore, the 10 CFR 50 Appendix I whole body and skin doses are only attributed to the noble gas radionuclides. This is confirmed in Table 1 of Regulatory Guide (RG) 1.109, where the total body and skin doses are listed under the "Gaseous Effluents" subheading in the table. This subheading contains a note (***) which states "Calculated only for noble gases." In addition, Table 1 of RG 1.109 also cites Equations 8 through 11 for the total body and skin doses. A review of RG 1.109 Equations 8 through 11 shows that only the noble gases are considered in calculating the total body and skin doses.

DCD Tier 2, Table 12.2-18b provides total body and skin doses under the "T. Body" and "Skin" headings, respectively. Compliance with 10 CFR 50 Appendix I Sections II.B.2(a) and (b) is demonstrated in the "Plume" row of DCD Tier 2, Table 12.2-18b. The total body and skin annual doses of 0.815 mrem (8.15E-03 mSv) and 1.94 mrem (1.94E-02 mSv) are bounded by the 10 CFR 50 Appendix I limits of 5 mrem and 15 mrem, respectively. The ESBWR annual whole body and skin doses are in compliance with 10 CFR 50 Appendix I Sections II.B.2(a) and (b).

10 CFR 50 Appendix I Section II.C states that the maximum organ dose from all pathways of exposure is attributed to radioactive iodine and radioactive material in particulate form. This does not include noble gases (the "Plume" pathway from GASPAR). This is confirmed in Table 1 of RG 1.109, where the organ doses are listed under the "Radioiodines and Particulates Released to the Atmosphere" subheading in the table. In addition, Table 1 of RG 1.109 also cites Equations 12 through 14 for the organ doses. A review of RG 1.109 Equations 12 through 14 shows that only the iodines and particulates (and not the noble gases) are considered in calculating the organ doses.

DCD Tier 2, Table 12.2-18b provides organ doses under all headings. For simplicity, the total body ("T. Body" heading) is also considered an organ. The organ doses for the adult, teen, child, and infant are provided at the bottom of the table. The maximum organ dose is to the thyroid of a child, and its value of 12.8 mrem (1.19E-01 mSv) is less than the 15 mrem Appendix I limit. The ESBWR annual maximum organ dose is in compliance with 10 CFR 50 Appendix I Section II.C.

To summarize DCD Tier 2, Table 12.2-18b and its relevance to 10 CFR 50 Appendix I:

- The doses in the "Plume" row address the external dose to the total body and skin, which satisfy the 10 CFR 50 Appendix I Sections II.B.2(a) and (b) requirements.
- The doses at the bottom of the table represent the organ doses from all pathways from radioactive iodine and radioactive material in particulate form. Therefore, the values in the "Total" rows for adult, teen, child and infant represent the sum of the "Ground," "Veget" (vegetable), "Meat," "Milk," and "Inhale" doses to the organs. The "Plume" doses are not included in the organ doses for the reasons discussed above. These organ doses satisfy the 10 CFR 50 Appendix I Section II.C requirements.

DCD Impact

DCD Tier 2, Tables 12.2-16 and 12.2-18b will be revised as noted in the attached markup.

Enclosure 2

MFN 06-305
Supplement 4

Response to Portion of NRC Request for

Additional Information Letter No. 233

Related to ESBWR Design Certification Application

Radiation Protection

RAI Number 12.2-9 S05
DCD Markups

Table 12.2-16

Annual Airborne Releases for Offsite Dose Evaluations (MBq)**

Nuclide*	Reactor Building	Turbine Building	Radwaste Building	Mechanical Vacuum Pump	Turbine Seal	Offgas System	Drywell
Kr-83m						1.4E-04	8.5E+01
Kr-85m	9.0E+04	5.6E+05				6.6E+03	3.4E+02
Kr-85						5.2E+06	7.5E+01
Kr-87	4.5E+04	1.4E+06				8.5E-10	3.1E+02
Kr-88	9.0E+04	2.0E+06				1.4E+01	6.9E+02
Kr-89	4.5E+04	1.3E+07	6.5E+05				8.3E+01
Xe-131m						1.5E+05	4.1E+01
Xe-133m						8.1E-01	1.9E+02
Xe-133	2.5E+06	3.4E+06	5.0E+06	2.9E+07		8.5E+05	1.1E+04
Xe-135m	1.4E+06	9.0E+06	1.2E+07				8.5E+01
Xe-135	2.9E+06	7.4E+06	6.3E+06	1.1E+07		4.4E-37	2.6E+03
Xe-137	4.1E+06	2.3E+07	1.9E+06				1.2E+02
Xe-138	1.8E+05	2.3E+07	4.5E+04				2.7E+02
I-131	9.4E+02	5.2E+03	3.4E+02	1.8E+03	4.7E+01		6.8E+01
I-132	8.5E+03	4.6E+04	3.0E+03				9.9E+00
I-133	6.2E+03	3.4E+04	2.2E+03		8.4E+01		6.5E+01
I-134	1.5E+04	8.4E+04	5.5E+03				6.9E+00
I-135	8.6E+03	4.7E+04	3.1E+03				2.9E+01
H-3	1.2E+06	1.2E+06					2.6E+05
C-14						5.3E+05	
Na-24							5.4E+00
P-32							1.3E+00
Ar-41						1.4E+03	
Cr-51	2.6E+01	2.2E+01	1.7E+01				1.1E+02
Mn-54	3.3E+01	1.4E+01	9.6E+01				1.7E+00
Mn-56							1.1E+01
Fe-55							4.7E+01

Table 12.2-16

Annual Airborne Releases for Offsite Dose Evaluations (MBq)**

Nuclide*	Reactor Building	Turbine Building	Radwaste Building	Mechanical Vacuum Pump	Turbine Seal	Offgas System	Drywell
Fe-59	9.3E+00	2.4E+00	7.2E+00				1.2E+00
Co-58	7.2E+00	2.4E+01	4.8E+00				4.4E+00
Co-60	1.2E+02	2.4E+01	1.7E+02				9.4E+00
Ni-63							4.7E-02
Cu-64							6.9E+00
Zn-65	1.2E+02	1.4E+02	7.2E+00				4.6E+01
Rb-89							2.0E-01
Sr-89	1.2E+00	1.4E+02					4.3E+00
Sr-90	2.4E-01	4.8E-01					3.3E-01
Y-90							8.1E-02
Sr-91							6.7E+00
Sr-92							4.6E+00
Y-91							1.7E+00
Y-92							3.7E+00
Y-93							7.2E+00
Zr-95	2.4E+01	9.6E-01	1.9E+01				3.5E-01
Nb-95	2.4E+02	1.4E-01	9.6E-02				3.3E-01
Mo-99	1.6E+03	4.8E+01	7.2E-02				2.4E+01
Tc-99m							2.2E+00
Ru-103	1.0E+02	1.2E+00	2.4E-02				8.2E-01
Rh-103m							3.5E-03
Ru-106							1.4E-01
Rh-106							4.5E-06
Ag-110m	5.7E-02						4.6E-02
Sb-124	1.2E+00	2.4E+00	1.7E+00				
Te-129m							1.6E+00
Te-131m							5.5E-01
Te-132							1.4E-01
Cs-134	1.1E+02	4.8E+00	5.7E+01				1.3E+00
Cs-136	1.2E+01	2.4E+00					5.8E-01
Cs-137	1.4E+02	2.4E+01	9.6E+01				3.4E+00
Cs-138							8.5E-01
Ba-140	5.3E+02	2.4E+02	9.6E-02				1.3E+01
La-140							1.3E+01

Table 12.2-16

Annual Airborne Releases for Offsite Dose Evaluations (MBq)**

Nuclide*	Reactor Building	Turbine Building	Radwaste Building	Mechanical Vacuum Pump	Turbine Seal	Offgas System	Drywell
Ce-141	2.2E+01	2.4E+02	1.7E-01				1.2E+00
Ce-144							1.3E-01
Pr-144							1.6E-04
W-187							1.3E+00
Np-239							8.3E+01

* Table 11.1-5a provides the basis for the airborne releases of the following radionuclide pairs:
Sr-90/Y-90
Zr-95/Nb-95
Mo-99/Tc-99m
Ru-103/Rh-103m
Ru-106/Rh-106
Ba-140/La-140
Ce-144/Pr-144
The coolant concentration of the daughter in Table 11.1-5a is assumed to be that of the parent. The annual airborne release of each radionuclide is determined utilizing the methodology provided in Appendix 12B.

** The releases (as designed in the table column headings) from the building stacks are as follows:
Reactor Building/Fuel Building stack: "Reactor Building~~Buidling~~" and "Drywell"
Turbine Building stack: "Turbine Building", "Mechanical Vacuum ~~Vaccum~~ Pump", "Turbine Seal", and "Offgas System"
Radwaste Building stack: "Radwaste Building"

Table 12.2-18b

ESBWR Annual Average Doses from Airborne Releases

	Annual Dose (mSv/year)							
PATHWAY	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
TOTAL**	Annual Dose (mSv/year)							
ADULT	3.27E-03~~1.14E-02~~	2.99E-03~~1.11E-02~~	4.45E-03~~1.26E-02~~	3.67E-03~~1.18E-02~~	3.03E-03~~1.12E-02~~	4.69E-02~~5.50E-02~~	2.67E-03~~1.09E-02~~	2.69E-03~~2.21E-02~~
TEEN	3.40E-03~~1.15E-02~~	3.11E-03~~1.13E-02~~	5.78E-03~~1.39E-02~~	4.58E-03~~1.27E-02~~	3.55E-03~~1.17E-02~~	6.39E-02~~7.20E-02~~	3.01E-03~~1.13E-02~~	2.84E-03~~2.23E-02~~
CHILD	4.03E-03~~1.22E-02~~	3.51E-03~~1.17E-02~~	1.08E-02~~1.90E-02~~	6.50E-03~~1.46E-02~~	4.75E-03~~1.29E-02~~	1.19E-01~~1.28E-01~~	3.67E-03~~1.19E-02~~	3.45E-03~~2.29E-02~~
INFANT	3.13E-03	2.93E-03	6.97E-03	5.40E-03	3.80E-03	1.15E-01	3.07E-03	3.03E-03

Annual beta air dose = 1.14E-02 mGy
Annual gamma air dose = 1.24E-02 mGy

** Total doses correspond to the organ doses from all pathways of exposure (excluding the plume pathway) due to radioactive iodine and radioactive material in particulate form in accordance with 10 CFR 50, Appendix I, Section II.C