ArevaEPRDCPEm Resource

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Cc: WILLIFORD Dennis C (AREVA NP INC); ROMINE Judy (AREVA NP INC)
Subject: Draft RAI 301 Supplement 4
Attachments: RAI 301 Supplement 4 Response US EPR DC- DRAFT.pdf

Getachew,

Attached is draft Supplement 4 for RAI 301. Earlier today AREVA provided a final date of July 8 to submit the RAI response to allow time for the staff to review. Let me know if an interaction is needed to address any questions.

Thanks,

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Response to

Request for Additional Information No. 301 (3802), Supplement 4, Revision 1

10/6/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 11.02 - Liquid Waste Management System
SRP Section: 11.03 - Gaseous Waste Management System

Application Sections: 11.2 and 11.3

QUESTIONS for Health Physics Branch (CHPB)

Question 11.02-17:

In its evaluation, the staff cannot duplicate the estimates of doses due to radioactive liquid effluent releases, as presented in FSAR Rev. 1, Tables 11.2-6 and 11.2-10. The evaluation identified a number of inconsistencies associated with assumptions and parameters used in the calculations described in FSAR Rev. 1, Sections 11.2.3.4 and 11.2.4.1. Without such clarifications and corrections, the staff cannot complete its evaluation and conclude, with reasonable assurance, that the design features and supporting analyses demonstrate compliance with Part 20.1301 and 20.1302, and design objectives of Appendix I to Part 50. The following observations should be reviewed by the applicant and corrected or justified in the next revision of the FSAR. Specifically, the observations include:

1. A review of Table 11.2-5 indicates that a number of parameters used in the LADTAP II code are not listed. While the FSAR references LADTAP II as a source of information, the applicant is responsible for documenting and justifying all input parameters in calculating doses. At a minimum, the applicant is requested to expand the tabulation to include the following parameters:
    a. ALARA analysis:
        i) dilution factors for the following exposure pathways: aquatic food, boating, swimming, shoreline, and drinking water for the maximum individual.
        ii) Transit times for drinking water, and “other pathways,” as a category.
    b. Irrigated food pathways:
        i) fraction of animal feed and water provided from non-contaminated irrigation water, as they relate to the meat and milk exposure pathways.
        ii) water usage transit times for the leafy vegetables, vegetables, milk, and meat exposure pathways.
2. A review of Table 11.2-5 indicates that the results are based on a discharge flow rate of 100 ft^3/s. In demonstrating compliance with the effluent concentration limits of Appendix B to Part 20, FSAR Section 11.2.3.5 applies a dilution flow rate of 20 ft^3/s. In calculating population doses for the same effluents and discharge path, FSAR Table 11.2-9 uses a discharge flow rate of 39.3 ft^3/s. The applicant is requested to describe in the FSAR the underlying assumptions and justify the use of different values in estimating doses from the same effluent and discharge path.
3. A review of Table 11.2-6 indicates that dose results are presented only for the total body and thyroid, with only one reference identifying the infant as the critical age group for thyroid exposure. Also, the age group is not specified for the reported total body dose listed in the table. It is not possible from this information to compare doses among the four age groups of Regulatory Guide 1.109 and confirm that the infant is the limiting age group for the thyroid and that no other age group and organ are limiting. The applicant is requested to expand the presentation of the results in Table 11.2-6 to include all four age groups and eight organs of Regulatory Guide 1.109, and provide a summation of doses given that the LADTAP II code automatically provide all such results.
4. A review of Table 11.2-9 indicates that a number of parameters used in the LADTAP II code are presented without any supporting assumptions and justifications. For example, Table 11.2-9 list values for population distributions, time spent as recreational activities in

surrounding locations impacted by liquid effluent releases, commercial and sport fishing production rates, and other supporting parametric values. While the FSAR references LADTAP II as a source of information, the applicant is responsible for documenting and justifying all input parameters in calculating doses. The applicant is requested to describe in the FSAR the underlying assumptions and justify the use of different values in estimating population doses. Note that the information on population doses is also needed by the staff in confirming the results of the cost-benefit analysis presented in FSAR Section 11.2.4. At a minimum, the applicant is requested to:

a. provide justifications or appropriate references supporting the values listed in Table 11.2-9.

b. explain the rationale for applying a “saltwater site” (see Table 11.2-9) in estimating population doses and using a “freshwater site” (see Table 11.2-5) in estimating doses for Part 50, Appendix I compliance. Provide a description of exposure pathways and usage or consumption parameters that would characterize a saltwater site.

c. explain the basis for a single dilution value of 365, listed in Table 11.2-9, in estimating population doses. Confirm that a single dilution factor is adequate in characterizing exposures for the various listed activities, including shoreline, boating, swimming, commercial fishing (fish and invertebrate), and sport fishing (fish and invertebrate).

d. provide the transit times for the listed activities, including shoreline, boating, swimming, commercial fishing (fish and invertebrate, if different), and sport fishing (fish and invertebrates, if different).

Note that the requested clarification on the basis of population doses is also needed by the staff in confirming the results of the cost-benefit analysis presented in FSAR Rev. 1, Section 11.2.4.

5. On an associated topic on liquid effluent releases and offsite impacts, a review of FSAR Rev. 1, Section 11.2.3.7 indicates that there is insufficient information for the staff to conduct an independent evaluation of the results presented in Table 11.2.8. At a minimum, the applicant is requested to describe the radioactive source term contained in the radwaste tank assumed to have failed; explain why other long-lived radionuclides (e.g., Cs-137, Sr-90, etc.) and environmentally mobile radionuclides (e.g., C-14, Tc-99, I-129, etc.) were not considered in the analysis; describe the application of design features, if any, used in mitigating such releases; and provide information describing the groundwater flow regime characterizing the movement, retardation, and dilution of the release from the selected plant building to the unrestricted area.

Response to Question 11.02-17:

This response supersedes the prior Response to RAI 301, Question 11.02-17.

Response to Question 11.02-17(1)(a):

The requested ALARA analysis input parameters used in LADTAP II for the maximally exposed individual (MEI) are summarized in Table 11.02-17-1.

Response to Question 11.02-17(1)(b):

The requested irrigated food pathways input parameters used in LADTAP II for MEI are summarized in Table 11.02-17-2.

U.S. EPR FSAR Tier 2, Table 11.2-5 will be revised to include the additional LADTAP II input parameters used in the calculation of MEI doses.

Response to Question 11.02-17(2):

The discharge flow rate used for the dose analysis for the MEI, 100 cfs, was coupled with a downstream dilution of unity (i.e., no dilution) for the aquatic food, drinking water, and shoreline activity pathways to provide a conservative overall dilution and mixing value for a generic site. This value allows the COL applicant to provide discharge flow via cooling tower blowdown, dilution pumps, other plant discharges, or a combination of these discharge streams. If a COL applicant's design discharge flow is less than 100 cfs, the applicant could compensate by applying site-specific dilution factors that would confirm that the effective dilution is equal to or greater than that provided by 100 cfs discharge and no downstream dilution.

A value of 20 cfs (9,000 gpm) was used in the analysis to determine effluent concentrations to compare with the limits in 10 CFR Part 20, Appendix B. This analysis used a conservative low discharge volumetric flow rate to demonstrate that the limits in 10 CFR Part 20, Appendix B could be met with the lowest discharge expected for any site, even without further dilution. The value chosen represents the lowest expected cooling tower blowdown rate.

The cost-benefit analysis and supporting population doses will be removed from U.S. EPR FSAR Tier 2, Section 11.2.4, and a COL item added requiring a COL applicant to perform a site-specific cost-benefit analysis.

U.S. EPR FSAR Tier 2, Table 11.2-5 will be revised to include the basis for the discharge flow rates. COL items will be added to U.S. EPR FSAR Tier 2, Table 1.8-2 and Section 11.2 requiring a COL applicant that references the U.S. EPR design certification to describe site-specific data, including the liquid effluent release pathway, discharge flow rate, and dilution factors, and to confirm that site-specific parameters used in the calculation of off-site liquid effluent concentrations and doses to the members of the public are bounded by those provided in U.S. EPR FSAR Tier 2, Section 11.2. For site-specific parameters that exceed the values provided in U.S. EPR FSAR Tier 2, Section 11.2, a COL applicant will need to provide site-specific analyses to demonstrate compliance with the effluent concentration limits of 10 CFR Part 20, Appendix B, Table 2, dose limits of 10 CFR Part 20.1301, 20.1302 and 20.1301(e) and 40 CFR Part 190 in unrestricted areas and design objectives of 10 CFR Part 50, Appendix I, Sections II.A and II.D.

Response to Question 11.02-17(3):

The limiting total body dose of 2.18 mrem/yr in U.S. EPR FSAR Tier 2, Table 11.2-6 represents the child age group.

Table 11.02-17-3 shows the dose results for the four age groups and the organs of RG 1.109. The LADTAP II code does not include the infant age group when calculating doses to individuals from the irrigated food pathways. A separate calculation was performed to determine the dose for the infant age group from the milk pathway using the total body dose and thyroid dose for the child as calculated using LADTAP II, along with the ratio of infant to child ingestion dose factors. This number was added to the dose from the only other non-zero pathway (i.e., drinking water) to determine the overall infant dosage for both total body and thyroid. The thyroid is the only organ analyzed for the infant, which was based on relatively high thyroid dose from drinking water relative to the other organs.

U.S. EPR FSAR Tier 2, Table 11.2-6 will be revised to include the age group associated with the limiting total body dose. U.S. EPR FSAR Tier 2, Table 11.2-13 will be added to provide a breakdown of dose results for the four age groups and eight organs.

Response to Questions 11.02-17(4)(a) to 11.02-17(4)(d):

The cost-benefit analysis and supporting tables will be removed from U.S. EPR FSAR Tier 2, Section 11.2, and a COL item added requiring a COL applicant to perform a site-specific cost-benefit analysis.

Response to Question 11.02-17(5):

A postulated liquid storage tank failure resulting in the release of radioactive materials into the unrestricted area was evaluated using the guidance provided in Branch Technical Position (BTP) 11-6. The scenario evaluated involves the instantaneous unmitigated release into groundwater of the entire contents of the reactor coolant storage tank. This tank has a total volume of 4061 ft^3 and is assumed to be filled with primary coolant. The radionuclides chosen for the radioactive source term were selected based on the guidance provided in draft Interim Staff Guidance (ISG) DC/COL-ISG-013 and include those radionuclides having the highest potential exposure consequences to potential users, including long-lived fission and activation products and environmentally mobile radionuclides. The radionuclide concentrations for the fission products are conservatively based on a 0.25 percent failed fuel fraction, exceeding the 0.12 percent fraction prescribed in BTP 11-6. The groundwater pathway includes the components of advection, decay, and retardation during transport and dilution in the receiving body of water, prior to reaching the potable water supply location. The radionuclide concentrations, half-lives, and partition coefficients that were used in the analysis are provided in Table 11.02-17-4. U.S. EPR FSAR Tier 2, Table 11.2-14 will be added to reflect the input parameters used in the liquid waste tank failure evaluation. A travel period of 200 days is assumed, along with a soil density of 1.75 g/cm^3, an effective soil porosity of 0.37, and a dilution factor of 5.0E-04 to account for mixing in the receiving body of water. These parameters were selected to bound the conditions of actual sites.

Table 11.02-17-5 shows the resulting radionuclide concentrations at the potable water supply in comparison to the effluent concentration limits of 10 CFR Part 20 Appendix B, Table 2 for a postulated rupture and unmitigated release of the entire contents of the reactor coolant storage tank. The resulting sum-of-the-ratios is 0.6, which is below the allowable value of 1.0 in accordance with 10 CFR Part 20.

U.S. EPR FSAR Tier 2, Section 11.2.3.7 will be revised as described in the response. A COL item will be added to U.S. EPR FSAR Tier 2, Table 1.8-2 and Section 11.2.3.7 requiring a COL applicant that references the U.S. EPR design certification to confirm that the site-specific data (such as distance from release location to unrestricted area, contaminant migration time, and discharge flow rate) are bounded by those specified in U.S. EPR FSAR Tier 2, Section 11.2.3.7.

For site-specific parameters that exceed the values provided in U.S. EPR FSAR Tier 2, Section 11.2.3.7, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis to demonstrate that the resulting water concentrations in the unrestricted area would meet the concentration limits of 10 CFR Part 20, Appendix B, Table 2.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 1.8, 11.2.1, 11.2.3, 11.2.4, 11.2.5 and Tables 11.2-5, 11.2-6, 11.2-8, 11.2-9, 11.2-10 and 11.2-11 will be revised as described in the response and indicated on the enclosed markup. U.S. EPR FSAR Tier 2, Tables 11.2-13 and 11.2-14 will be added as described in the response and indicated on the enclosed markup.

Table 11.02-17-1—Additional LADTAP II Input Parameters for ALARA Analysis for MEI Dose

Exposure Pathway	Dilution Factor	Transit Time (hr)
Aquatic food	1	24
Boating	1	0
Swimming	1	0
Shoreline	1	0
Drinking water	1	12

Table 11.02-17-2—Additional LADTAP II Input Parameters for Irrigated Food Pathways for MEI Dose

Irrigated Food Pathway	Fraction of Animal Feed from Non-contaminated Irrigation Water	Fraction of Animal Drinking Water from Non-contaminated Irrigation Water	Water Usage Transit Time (hr)
Vegetable	na	na	0
Leafy Vegetable	na	na	0
Milk	0	0	0
Meat	0	0	0

Table 11.02-17-3—Detailed Dose Commitment Results By Age Group and Organs Due to Liquid Effluent Releases (2 Sheets)

Pathway	Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Fish								
Adult		2.10E-01	3.87E-01	2.90E-01	2.56E-01	1.46E-01	6.10E-02	6.74E-02
Teen		2.21E-01	3.92E-01	1.70E-01	2.37E-01	1.44E-01	6.35E-02	5.13E-02
Child		2.74E-01	3.42E-01	7.41E-02	2.45E-01	1.21E-01	5.07E-02	2.71E-02
Drinking								
Adult		6.61E-03	8.21E-01	8.18E-01	1.40E+00	8.20E-01	8.13E-01	8.68E-01
Teen		6.44E-03	5.80E-01	5.76E-01	1.08E+00	5.79E-01	5.73E-01	6.14E-01
Child		1.87E-02	1.12E+00	1.10E+00	2.35E+00	1.11E+00	1.10E+00	1.14E+00
Infant		2.20E-02	1.10E+00	1.08E+00	3.05E+00	1.09E+00	1.08E+00	1.10E+00
Shoreline								
Adult	1.75E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
Teen	9.79E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03
Child	2.05E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03
Irrigated Foods								
Vegetables								
Adult		6.99E-03	2.98E-01	2.96E-01	3.77E-01	2.94E-01	2.90E-01	3.56E-01
Teen		1.18E-02	3.69E-01	3.59E-01	4.84E-01	3.62E-01	3.55E-01	4.39E-01
Child		2.82E-02	5.86E-01	5.65E-01	8.19E-01	5.74E-01	5.62E-01	6.28E-01
Leafy Vegetables								
Adult		9.50E-04	3.69E-02	3.65E-02	6.96E-02	3.64E-02	3.57E-02	4.43E-02
Teen		8.69E-04	2.47E-02	2.40E-02	5.09E-02	2.43E-02	2.37E-02	2.96E-02
Child		1.56E-03	2.94E-02	2.84E-02	6.86E-02	2.89E-02	2.82E-02	3.16E-02
Milk								
Adult		5.36E-03	1.82E-01	1.79E-01	3.35E-01	1.76E-01	1.73E-01	1.74E-01
Teen		9.57E-03	2.40E-01	2.31E-01	4.82E-01	2.31E-01	2.26E-01	2.26E-01
Child		2.27E-02	3.82E-01	3.61E-01	8.65E-01	3.66E-01	3.58E-01	3.57E-01
Infant				5.45E-01	1.78E+00			
Meat								
Adult		1.11E-02	6.22E-02	6.33E-02	6.68E-02	8.18E-02	6.13E-02	7.39E-01

Table 11.02-17-3—Detailed Dose Commitment Results By Age Group and Organs Due to Liquid Effluent Releases (2 Sheets)

Pathway	Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Teen		9.30E-03	3.73E-02	3.79E-02	4.05E-02	5.38E-02	3.66E-02	4.59E-01
Child		1.75E-02	4.52E-02	4.65E-02	5.03E-02	6.70E-02	4.43E-02	3.02E-01
Total								
Adult	1.75E-03	2.43E-01	1.79E+00	1.68E+00	2.51E+00	1.56E+00	1.44E+00	2.25E+00
Teen	9.79E-03	2.67E-01	1.65E+00	1.41E+00	2.38E+00	1.40E+00	1.29E+00	1.83E+00
Child	2.05E-03	3.64E-01	2.51E+00	2.18E+00	4.40E+00	2.27E+00	2.14E+00	2.49E+00
Infant				1.63E+00	4.83E+00			

Table 11.02-17-4—Input Parameters for Postulated Releases Due to Liquid-Containing Tank Failure (2 Sheets)

Radionuclide	Half-life (days)	Partition Coefficient (L/kg)	Activity Concentration in Reactor Coolant Storage Tank (µCi/cm^3)
H-3	4510	N/A	1
Cr-51	27.7	30	2.0E-03
Mn-54	313	50	1.0E-03
Mn-56	0.107	50	N/A
Fe-55	986	165	7.6E-04
Fe-59	44.5	165	1.9E-04
Co-58	70.8	60	2.9E-03
Co-60	1.93E+03	60	3.4E-04
Zn-65	244	200	3.2E-04
Br-84	2.21E-02	15	1.7E-02
Rb-88	1.24E-02	55	1.0E+00
Sr-89	5.05E+01	15	6.4E-04
Sr-90	1.06E+04	15	3.3E-05
Sr-91	3.96E-01	15	1.0E-03
Y-91	5.85E+01	170	8.1E-05
Y-92	1.48E-01	170	1.4E-04
Y-93	4.21E-01	170	6.5E-05
Y-91m	3.45E-02	170	5.2E-04
Zr-95	6.40E+01	600	9.3E-05
Nb-95	3.52E+01	160	9.4E-05
Mo-99	2.75E+00	10	1.1E-01
Tc-99m	2.51E-01	0.1	4.6E-02
Tc-99	7.78E+07	0.1	1.1E-09
Ru-103	3.93E+01	55	7.8E-05
Ru-106	3.68E+02	55	2.7E-05
Ag-110m	2.50E+02	90	2.0E-07
Te-129m	3.36E+01	125	1.5E-03
Te-129	4.83E-02	125	2.4E-03
Te-131	1.74E-02	125	2.6E-03
Te-131m	1.25E+00	125	3.7E-03
Te-132	3.26E+00	125	4.1E-02
I-129	5.73E+09	1	4.6E-08
I-131	8.04E+00	1	7.4E-01
I-132	9.58E-02	1	3.7E-01
I-133	8.67E-01	1	1.3E+00
I-134	3.65E-02	1	2.4E-01
I-135	2.75E-01	1	7.9E-01
Cs-134	7.53E+02	270	1.7E-01
Cs-136	1.31E+01	270	5.3E-02

Table 11.02-17-4—Input Parameters for Postulated Releases Due to Liquid-Containing Tank Failure (2 Sheets)

Radionuclide	Half-life (days)	Partition Coefficient (L/kg)	Activity Concentration in Reactor Coolant Storage Tank ($\mu Ci/cm^3$)
Cs-137	1.10E+04	270	1.1E-01
Ba-140	1.27E+01	N/A	6.2E-04
La-140	1.68E+00	N/A	1.6E-04
Ce-141	3.25E+01	500	8.9E-05
Ce-143	1.38E+00	500	7.6E-05
Ce-144	2.84E+02	500	6.9E-05
W-187	9.96E-01	N/A	1.8E-03
Np-239	2.36E+00	5	8.7E-04

Table 11.02-17-5—Unrestricted Area Water Concentration from Unmitigated Liquid Release

Nuclide[1]	Critical Receptor Concentration (uCi/ml)	10 CFR Part 20 Appendix B, Table 2 Effluent Concentration Limit (uCi/ml)	Fraction of Concentration Limit
H-3	4.8E-04	1.E-03	4.8E-01
Cs-134	5.6E-08	9.E-07	6.2E-02
Cs-137	4.2E-08	1.E-06	4.2E-02
		Total	**0.6**

Notes:

1. Nuclides less than 1.0E-03 in fraction of concentration limit are excluded.

Question 11.03-15:

In its evaluation, the staff duplicated the estimates of yearly doses to the maximally exposed individual (MEI) due to radioactive airborne effluent releases, but could not duplicate the results for population doses. Also, the evaluation identified a number of inconsistencies in the presentation of the results and assumptions and parameters used in the calculations described in FSAR Rev. 1, Sections 11.3.3.4 and 11.3.4.1. Without such clarifications and corrections, the staff cannot complete its evaluation and conclude, with reasonable assurance, that the design features and supporting analyses demonstrate compliance with Part 20.1301 and 20.1302, and design objectives of Appendix I to Part 50. These observations should be reviewed by the applicant and corrected or justified in the next revision of the FSAR. Specifically, the observations include:

a. A review of Table 11.3-4 indicates that a number of parameters used in the GASPAR II code are presented without any supporting assumptions and justifications. For example, Table 11.3-4 list values for the atmospheric dispersion and deposition parameters, but does not specify as the basis for the parameters nor references FSAR Rev. 1, Section 2.3.5 on the development of long-term atmospheric dispersion estimates for routine airborne effluent releases. The scope of exposure locations should be expanded to include the nearest residence. The reference of Table 11.2-4 for the airborne source term is wrong since this table presents the source term for liquid effluents - the proper citation is Table 11.3-3. At a minimum, the applicant is requested to describe in the FSAR the underlying assumptions, provide all appropriate references or identify the source of the information within the FSAR for all parameters presented in Table 11.3-4, add the missing exposure location for the MEI, and provide the proper citation for the table listing the airborne effluent source term.

b. While the staff duplicated the dose results presented in Table 11.3-5, a review indicates that results for the MEI are presented only for the total body and thyroid, with only one reference identifying the infant as the critical age group for thyroid exposure. Also, the age group is not specified for the reported total body dose listed in the table. It is not possible from this information to compare doses among the four age groups of Regulatory Guide 1.109 and confirm that the infant is the limiting age group for the thyroid and that no other age group and organ are limiting. The applicant is requested to expand the presentation of the results in Table 11.3-5 to include all four age groups and eight organs of Regulatory Guide 1.109, and provide a summation of doses given that the GASPAR II code automatically provide all such results.

c. A review of Table 11.3-7 indicates that a number of parameters used in the GASPAR II code are presented without any supporting assumptions and justifications. In addition, the table and FSAR Rev. 1, Section 11.3.4.1 do not include information for the staff to conduct an independent evaluation of population dose results. For example, Table 11.3-7 list values for a population within a 50-mile radius of the plant, an atmospheric dispersion parameter, and agricultural production data, but does not specify as the basis for the parameters nor references the applicable FSAR sections on the development of these parameters. In addition, the entries for the average humidity and temperature are inconsistent with the code input requirements, as the code requires that the relative humidity (%) be specified whenever a temperature value is inserted over the code default value. Finally, FSAR Section 11.3.4.1 and Table 11.3-7 do not provide any information as to how population data and agricultural production data were distributed against long-term atmospheric dispersion parameters by sectors in the 50-mile radius. At a minimum, the applicant is requested to describe in the FSAR the underlying assumptions, insert all appropriate references or identify the source of the information within the FSAR for all parameters presented in Table 11.3-7, provide the missing information for the staff to conduct its own analysis, revise the citation for the table referencing the basis of the airborne effluent source term, and change in Section 11.3.4.1 the table citation from 11.3-4 to 11.3-7 since Table 11.3-4 is for MEI doses and Table 11.3-7 is for population doses. Note that the requested clarification on the basis of population doses is also needed by the staff in confirming the results of the cost-benefit analysis presented in FSAR Rev. 1, Section 11.3.4.2.

Response to Question 11.03-15:

This response supersedes the prior response to RAI 301, Question 11.03-15.

Response to Question 11.03-15(a):

The GASPAR parameters are provided in Table 11.03-15-1.

In determining doses, the most conservative location was selected for each of the applicable dose pathways. The nearest residence is conservatively assumed to be located just outside the site boundary, and would be the dose receptor location for doses from the plume, ground, and inhalation. This assumption was made in the dose analysis.

The reference to U.S. EPR FSAR Tier 2, Table 11.2-4 in U.S. EPR FSAR Tier 2, Table 11.3-4 will be corrected to reference U.S. EPR FSAR Tier 2, Table 11.3-3.

U.S. EPR FSAR Tier 2, Table 11.3-4 will be revised to include the references and assumptions for the GASPAR II input parameters used in calculating doses to the maximally exposed individual, and the added parameter for the nearest residence. COL items will be added to U.S. EPR FSAR Tier 2, Table 1.8-2 and Section 11.3 requiring a COL applicant that references the U.S. EPR design certification to describe site-specific data, including the onsite vent stack design, gaseous effluent release point(s), and atmospheric dispersion/deposition factors, and to confirm that site-specific parameters used in the calculation of offsite gaseous effluent concentrations and doses to the members of the public are bounded by those provided in the U.S. EPR FSAR Tier 2, Section 11.3. For site-specific parameters that exceed the values provided in U.S. EPR FSAR Tier 2, Section 11.3, a COL applicant will need to provide site-specific analyses to demonstrate compliance with the effluent concentration limits of 10 CFR Part 20, Appendix B, Table 2, dose limits of 10 CFR Part 20.1301, 20.1302 and 20.1301(e) and 40 CFR Part 190 in unrestricted areas and design objectives of 10 CFR Part 50, Appendix I, Sections II.B and II.C, and II.D.

Response to Question 11.03-15 (b):

Table 11.03-15-2 presents results for the age groups and the organs of RG 1.109. Table 11.03-15-2 shows that the total body dose and the skin dose are the same for the age groups.

U.S. EPR FSAR Tier 2, Table 11.3-11 will be added to provide a dose breakdown by age group and organs.

Response to Question 11.03-15 (c):

The cost-benefit analysis and supporting population doses will be removed from U.S. EPR FSAR Tier 2, Section 11.3.4, and a COL item added requiring a COL applicant to perform a site-specific cost-benefit analysis.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 1.8, 11.3.1, 11.3.3,11.3.4 and 11.3.5, and Tables 11.3-4, 11.3-7, 11.3-8 and 11.3-9 will be revised as described in the response and indicated on the enclosed markup. U.S. EPR FSAR Tier 2, Table 11.3-11 will be added as described in the response and indicated on the enclosed markup.

Table 11.03-15-1—Source References/Justification for GASPAR II Input Parameters Used in Calculating Annual Offsite Does to MEI from Gaseous Releases

Parameter	Value	Justification
Distance from reactor centerline to site boundary	0.5 miles	Represents a conservative location for a site boundary (other than a boundary adjacent to a water body). This distance is expected to bound site boundary distances for potential COL applicants.
Distance from reactor centerline to nearest vegetable garden	0.5 miles	Assumes the most conservative (closest) location possible (i.e., just outside the site boundary)
Distance from reactor centerline to nearest meat animal	0.5 miles	Assumes the most conservative (closest) location possible (i.e., just outside the site boundary)
Distance from reactor centerline to nearest milk animal	0.5 miles	Assumes the most conservative (closest) location possible (i.e., just outside the site boundary)
Milk animal considered	Goat	Choices are goat or cow. Because consumption of goat milk results in higher doses than consumption of cow milk (based on higher dose conversion factors) for the same consumption volume, goat was selected.
Annual average atmospheric dispersion factor	5.0E-06 sec/m^3	Conservative estimate based on a mixed-mode release
Annual average ground deposition factor	5.0E-08 m^{-2}	Conservative estimate based on a mixed-mode release
[Add: nearest residence]	0.5 miles	Assumes the most conservative (closest) location possible (i.e., just outside the site boundary)

Table 11.03-15-2—Detailed Dose Commitment Results by Age Group and Organs Due to Gaseous Effluent Releases

(2 Sheets)

PATHWAY	TOTAL BODY (external exposure)	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN (external exposure)
	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr
PLUME	1.04E+00							9.79E+00
GROUND	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	8.28E-03
VEGETABLES								
ADULT		2.52E-01	1.13E+00	2.51E-01	2.51E-01	1.03E+00	2.47E-01	
TEEN		3.88E-01	1.82E+00	3.89E-01	3.89E-01	1.36E+00	3.82E-01	
CHILD		8.89E-01	4.33E+00	8.96E-01	8.95E-01	2.71E+00	8.85E-01	
MEAT								
ADULT		8.46E-02	3.90E-01	8.35E-02	8.34E-02	1.18E-01	8.31E-02	
TEEN		6.97E-02	3.30E-01	6.92E-02	6.91E-02	9.39E-02	6.89E-02	
CHILD		1.28E-01	6.19E-01	1.28E-01	1.28E-01	1.65E-01	1.27E-01	
COW MILK								
ADULT		9.86E-02	4.32E-01	1.02E-01	1.03E-01	1.07E+00	9.76E-02	
TEEN		1.74E-01	7.96E-01	1.82E-01	1.83E-01	1.72E+00	1.73E-01	
CHILD		4.12E-01	1.95E+00	4.26E-01	4.28E-01	3.48E+00	4.11E-01	
INFANT		8.45E-01	3.81E+00	8.78E-01	8.74E-01	8.31E+00	8.45E-01	
GOAT MILK								
ADULT		1.12E-01	4.41E-01	1.20E-01	1.19E-01	1.28E+00	1.11E-01	

Table 11.03-15-2—Detailed Dose Commitment Results by Age Group and Organs Due to Gaseous Effluent Releases

(2 Sheets)

PATHWAY	TOTAL BODY (external exposure)	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN (external exposure)
TEEN		1.92E-01	8.09E-01	2.07E-01	2.05E-01	2.05E+00	1.91E-01	
CHILD		4.39E-01	1.98E+00	4.67E-01	4.62E-01	4.12E+00	4.40E-01	
INFANT		8.86E-01	3.86E+00	9.47E-01	9.26E-01	9.84E+00	8.88E-01	
INHALATION								
ADULT		2.06E-02	3.84E-04	2.06E-02	2.07E-02	4.80E-02	2.08E-02	
TEEN		2.08E-02	4.67E-04	2.09E-02	2.10E-02	5.59E-02	2.12E-02	
CHILD		1.83E-02	5.70E-04	1.85E-02	1.86E-02	6.04E-02	1.87E-02	
INFANT		1.05E-02	2.97E-04	1.07E-02	1.07E-02	4.92E-02	1.08E-02	
TOTALS								
ADULT	1.05E+00	4.76E-01	1.97E+00	4.82E-01	4.81E-01	2.48E+00	4.69E-01	9.80E+00
TEEN	1.05E+00	6.78E-01	2.97E+00	6.93E-01	6.91E-01	3.57E+00	6.70E-01	9.80E+00
CHILD	1.05E+00	1.48E+00	6.94E+00	1.52E+00	1.51E+00	7.06E+00	1.48E+00	9.80E+00
INFANT	1.05E+00	9.04E-01	3.87E+00	9.65E-01	9.44E-01	9.90E+00	9.06E-01	9.80E+00

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Table 1.8-2—U.S. EPR Combined License Information Items
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Item No.	Description	Section	~~Action Required by COL Applicant~~	~~Action Required by COL Holder~~
11.2-1	A COL applicant that references the U.S. EPR design certification will perform ~~confirm that the liquid waste management system cost-benefit analysis for the typical site is applicable to their site; if it is not, provide~~ a site-specific liquid waste management system cost-benefit analysis.	11.2.4	~~Y~~ 11.02-17	
11.2-2	A COL applicant that references the U.S. EPR design certification will provide site-specific information on the release pathway, including a detailed description of the discharge path and sources of dilution, the discharge flow rate, and dilution factors.	11.2.3.3		
11.2-3	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific parameters are bounded by those provided in Table 11.2-5 and the dose pathways provided in Section 11.2.3.4.1. For site-specific parameters that are not bounded by the values provided in Table 11.2-5 and the dose pathways provided in Section 11.2.3.4.1, a COL applicant that references the U.S. EPR design certification will perform a site-specific liquid pathway dose analysis following the guidance provided in RG 1.109 and RG 1.113, and compare the doses to the numerical design objectives of 10 CFR Part 50, Appendix I and demonstrate compliance with requirements of 10 CFR Part 20.1302 and 40 CFR Part 190.	11.2.3.4.2		
11.2-4	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific annual average liquid effluent concentrations are bounded by those specified in Table 11.2-7. For site-specific annual average liquid effluent concentrations that exceed the values provided in Table 11.2-7, a COL applicant that references the U.S. EPR design certification will demonstrate that the annual average liquid effluent concentrations for expected and design basis conditions meet the limits of 10 CFR Part 20, Appendix B, Table 2.	11.2.3.5		

Table 1.8-2—U.S. EPR Combined License Information Items
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Item No.	Description	Section	~~Action Required by COL Applicant~~	~~Action Required by COL Holder~~
11.2-5	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific data (such as distance from release location to unrestricted area, contaminant migration time, and discharge flow rate) are bounded by those specified in Section 11.2.3.7. For site-specific parameters that exceed the values provided in Section 11.2.3.7, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis to demonstrate that the resulting water concentrations in the unrestricted area would meet the concentration limits of 10 CFR Part 20, Appendix B, Table 2.	11.2.3.7	11.02-17	
11.2.6	A COL applicant that references the U.S. EPR design certification and that chooses to install and operate mobile skid-mounted processing systems connected to permanently installed LWMS processing equipment will include plant and site-specific information describing how design features and implementation of operating procedures for the LWMS will address the requirements of 10 CFR Part 20.1406(b) and guidance of SRP Section 11.2, RG 4.21 and 1.143, IE Bulletin 80-10, and NEI 08-08.			
11.3-1	A COL applicant that references the U.S. EPR design certification will ~~confirm that the~~perform a site-specific gaseous waste management system cost-benefit analysis ~~for the typical site is applicable to their site; if not, provide a site-specific cost-benefit analysis~~.	11.3.4	~~Y~~ 11.03-15	
11.3-2	A COL applicant that references the U.S. EPR design certification will provide a discussion of the onsite vent stack design parameters and site-specific release point characteristics.	11.3.3.3		

Table 1.8-2—U.S. EPR Combined License Information Items
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Item No.	Description	Section	~~Action Required by COL Applicant~~	~~Action Required by COL Holder~~
11.3-3	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific parameters are bounded by those provided in Table 11.3-4 and the dose pathways provided in Section 11.3.3.4. For site-specific parameters that are not bounded by the values provided in Table 11.3-4 and the dose pathways provided in Section 11.3.3.4, a COL applicant that references the U.S. EPR design certification will perform a site-specific gaseous pathway dose analysis following the guidance provided in RG 1.109 and RG 1.111, and compare the doses to the numerical design objectives of 10 CFR Part 50, Appendix I and demonstrate compliance with requirements of 10 CFR Part 20.1302 and 40 CFR Part 190.	11.3.3.4	11.03-15	
11.3-4	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific annual average gaseous effluent concentrations are bounded by those specified in Table 11.3-6. For site-specific annual average gaseous effluent concentrations that exceed the values provided in Table 11.3-6, a COL applicant that references the U.S. EPR design certification will demonstrate that the annual average gaseous effluent concentrations for expected and design basis conditions meet the limits of 10 CFR Part 20, Appendix B, Table 2.	11.3.3.5		
11.3-5	A COL applicant that references the U.S. EPR design certification will confirm that the site-specific accident atmospheric dispersion data is bounded by the values provided in Table 2.1-1. For site-specific accident atmospheric dispersion data that exceed the values provided in Table 2.1-1, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis demonstrating that the resulting dose at the exclusion area boundary associated with a radioactive release due to gaseous waste system leak or failure does not exceed 0.1 rem in accordance with BTP 11-5.	11.3.3.6		

RG 1.143 acknowledges that although the impact of the liquid waste storage and processing systems on safety is limited, the design for these systems includes some functions to limit the uncontrolled releases of radioactivity to the environment. The guidance identifies a radwaste classification for differentiation of applicable radwaste system design requirements based on the total design basis unmitigated radiological release (considering the maximum inventory of a given radwaste system) at the boundary of the unprotected area. Based on calculation of the total design basis unmitigated radiological release from either the liquid waste storage or liquid waste processing systems, these systems are assigned to RG 1.143 classification RW-IIa (High Hazard).

11.02-17

Calculations of doses and radioactive releases are performed consistent with the methodologies described in BTP-11-6 and RGs 1.109, 1.112, and 1.113.

Design features are provided to control and collect radioactive material spills from liquid tanks outside containment. The tanks are housed in rooms with drains to collect any spills and to prevent any uncontrolled release to the environment. In addition, these rooms have no doors leading directly to the outside environment.

Consistent with the requirements of 10 CFR 20.1406, the U.S. EPR, including the liquid waste management system, is designed to minimize, to the extent practicable, contamination of the facility and the environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste. The LWMS design also incorporates features which address NRC concerns identified in IE Bulletin 80-10. Minimization of contamination and radioactive waste generation is described in Section 12.3.6.

11.2.1.1 Design Objectives

In addition to fulfilling their primary design functions, the liquid waste storage and liquid waste processing systems meet the following design objectives:

- Selectively segregate influent liquid wastes according to chemical composition and radioactivity of the source stream.
- Allow analysis of the contents of each liquid waste storage tank.
- Discharge sludge and concentrated wastes to the radioactive concentrates processing system. The radioactive concentrates processing system is an element of solid waste management and is addressed in Section 11.4.
- Prevent unintentional discharge of clean wastewater. Locked discharge valves subject to administrative control prevent discharge of treated wastewater from the monitoring tanks unless the radionuclide concentration of that wastewater has been demonstrated to be within administrative limits.

11.2.2.6 Instrumentation Design

Instrumentation readout is available in the main control room (MCR) and on a local control panel for major components. Instrumentation display for other components is available on a local control panel.

Releases to the environment are monitored using radiation sensors and flow sensors to limit and control offsite releases. See Section 11.2.1.2.3 for a description of this instrumentation.

In accordance with the guidelines of RG 1.143, each tank has level instrumentation that actuates an alarm on detection of high liquid level, allowing action to be taken to divert the flow to a backup tank to avoid a tank overflow. A summary of the tank level indication and associated alarms is provided in Table 11.2-12.

11.2.3 Radioactive Effluent Releases

For the U.S. EPR, releases of radioactive effluent via the liquid pathway only occurs by discharges from the monitoring tanks in the liquid waste storage system. Most of the activity carried into the liquid waste storage and processing systems is removed from the waste stream by a combination of chemical treatments, evaporation, inertial separation, and demineralization and filtration. These treatments may be performed repeatedly, with continuing concentration and chemical treatment cycles, until the wastewater meets release limits. Contaminants removed from the wastewater are transferred to the solid waste management system (see Section 11.4).

Treated wastewater held in the monitoring tanks must be sampled and analyzed in the laboratory before its release can be authorized. The laboratory analysis confirms that the activity of the wastewater in the monitoring tanks is within release limits. Once the laboratory results have been reviewed and confirmed to be within release limits, release is authorized. During the release, two radiation sensors in the activity-measurement tank and two flow sensors downstream of the tank continually monitor and record the discharge. If the sensors detect activity or an activity release rate in excess of release limits, or if a significant discrepancy exists between the two activity measurements or the two flow measurements, the sensors signal automatic valve closure, which terminates the release. After the isolation valves of the liquid waste storage system, the treated wastewater travels through a double-walled pipe to the discharge canal. The treated waste water is diluted with water from the lined retention pond. The treated wastewater environmental interface occurs at the discharge structure. The discharges from the liquid waste storage system do not interact with the Circulating Water System (CWS).

11.02-17 The physical release location and discharge configuration for treated effluent are site-specific. Refer to Section 11.2.3.3 for the related COL item.

11.02-17

~~Site-specific dilution factors for radioactive liquid effluent are included as part of the program description provided by the COL applicant as described in Section 11.5.2.~~The physical release location and dilution factors for treated effluent are site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information on the release pathway including a detailed description of the discharge path and sources of dilution, the discharge flow rate and dilution factors.

11.2.3.4 Estimated Doses

11.2.3.4.1 Liquid Pathways

The LADTAP II computer program (Reference 2) was used to calculate doses to the maximally exposed individual (MEI) from liquid effluents. LADTAP II implements the exposure methodology described in RG 1.109. The program considers the following exposure pathways:

- Ingestion of aquatic foods.
- External exposure to shoreline.
- External exposure to water through boating and swimming.
- Ingestion of drinking water.
- Ingestion of irrigated terrestrial food crops.

Inputs and assumptions are conservatively selected to represent a bounding condition for all pathways. Input parameters used by the LADTAP II code (Reference 2) are presented in Table 11.2-5—Input Parameters for LADTAP II Computer Code.

11.2.3.4.2 Liquid Pathway Doses

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The doses calculated by the LADTAP II code meet the 10 CFR Part 50, Appendix I, ALARA design objectives. The dose calculation is based on a dilution flow rate of 100 cfs. The detailed dose commitment results by age group and organs due to liquid effluent releases are provided in Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ Due to Liquid Effluent Releases. Table 11.2-6—Dose Commitment Due to Liquid Effluent Releases summarizes the dose commitment calculation and regulatory requirements.

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific parameters are bounded by those provided in Table 11.2-5 and the dose pathways provided in Section 11.2.3.4.1. For site-specific parameters that are not bounded by the values provided in Table 11.2-5 and the dose pathways provided in Section 11.2.3.4.1, a COL applicant that references the U.S. EPR design certification will perform a site-specific liquid pathway dose analysis following the guidance

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provided in RG 1.109 and RG 1.113, and compare the doses to the numerical design objectives of 10 CFR Part 50, Appendix I and demonstrate compliance with requirements of 10 CFR Part 20.1302 and 40 CFR Part 190.

11.2.3.5 Maximum Release Concentrations

Using annual release data generated by the GALE code and presented in Table 11.2-4, annual average concentrations of radioactive materials released in liquid effluents to the discharge point have been determined by dividing the release rates (Ci/yr) by the annual average dilution flow. Annual average concentrations were determined in the immediate vicinity of the discharge point. No further mixing, dilution, or transport was assumed to occur.

A dilution flow of 9000 gallons per minute (gpm) was used in performing the maximum release concentration analysis. This flowrate is based on the dilution flow being provided by cooling tower blowdown, which operates continuously during plant operation. A capacity factor of 80 percent is used to determine the annual duration of cooling tower blowdown operation, and therefore annual dilution flow.

For each radionuclide released, the average concentration has been compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. Table 11.2-7—Comparison of Annual Average Liquid Release Concentrations with 10 CFR Part 20 Concentration Limits, presents the results of this comparison. For the annual average radionuclide release concentrations for expected releases, the overall fraction of the effluent concentration limit is 0.12, which is well below the allowable value of 1.0.

Average liquid effluent concentrations for each radionuclide based on design basis conditions (one percent failed fuel fraction) have also been determined and compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. The expected release concentrations were upwardly adjusted by a multiplication factor[1] that represents the ratio of design basis fuel failure primary coolant activity to expected fuel failure primary coolant activity. Table 11.2-7 presents the results of this comparison. For the annual average radionuclide release concentrations for design basis releases, the overall fraction of the effluent concentration limit is 0.62, which is below the allowable value of 1.0.

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A COL applicant that references the U.S. EPR design certification will confirm that the site-specific annual average liquid effluent concentrations are bounded by those specified in Table 11.2-7. For site-specific annual average liquid effluent concentrations that exceed the values provided in Table 11.2-7, a COL applicant that references the U.S. EPR design certification will demonstrate that the annual average liquid effluent concentrations for expected and design basis conditions meet the limits of 10 CFR Part 20, Appendix B, Table 2.

11.2.3.6 Radioactive Liquid Waste System Leak or Failure

The U.S. EPR liquid waste management system receives degasified liquids in the storage tanks. These tanks are continuously vented to the radioactive waste processing building ventilation system (refer to Section 9.4.8) so that any generation of gaseous activity is continually removed. Thus, no significant levels of gaseous activity from a liquid waste system leak or failure is expected. An evaluation later in this section addresses the radiological consequences of the leak or failure of a tank containing radioactive liquids from the liquid waste management system.

11.2.3.7 Postulated Radioactive Releases due to Liquid-Containing Tank Failures

11.02-17(5)

A postulated liquid storage tank failure resulting in the release of radioactive materials into the unrestricted area was evaluated using the guidance provided in Branch Technical Position (BTP) 11-6. The results shown in Table 11.2-8 indicate that a release of radioactive materials due to a postulated failure of liquid-containing tanks outside of containment during normal operations or anticipated operational occurrences would not result in release concentrations exceeding the effluent concentration limits specified in 10 CFR Part 20, Appendix B, Table 2 using the unity rule and sum-of-the-fractions.

The scenario evaluated involves the instantaneous unmitigated release into groundwater of the entire contents of the reactor coolant storage tank. This tank has a total volume of 4061 ft^3 and is assumed to be filled with primary coolant. The radionuclides chosen for the radioactive source term were selected based on the guidance provided in draft Interim Staff Guidance (ISG) DC/COL-ISG-013 and include those radionuclides having the highest potential exposure consequences to potential users, including long-lived fission and activation products and environmentally mobile radionuclides. The radionuclide concentrations for the fission products are conservatively based on a 0.25 percent failed fuel fraction, exceeding the 0.12 percent fraction prescribed in BTP 11-6. The groundwater pathway includes the processes of advection, decay and retardation during transport, and dilution within the receiving body of water, prior to reaching the potable water supply location. The radionuclide concentrations, half-lives, and partition coefficients are provided in Table 11.2-14. A travel period of 200 days is assumed along with a soil density of 1.75 g/cm^3, an effective soil porosity of 0.37, and a dilution factor of 5.0E-04 to account for mixing within the receiving body of water. These parameters were selected to bound the conditions of actual sites.

Table 11.2-8 shows the resulting radionuclide concentrations at the potable water supply in comparison to the effluent concentration limits of 10 CFR Part 20, Appendix B, Table 2 for a postulated rupture and unmitigated release of the entire contents of the reactor coolant storage tank. The resulting sum-of-the-ratios is 0.6, which is below the allowable value of 1.0 in accordance with 10 CFR Part 20.

11.02-17(5)

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific data (such as distance from release location to unrestricted area, contaminant migration time, and discharge flow rate) are bounded by those specified in Section 11.2.3.7. For site-specific parameters that exceed the values provided in Section 11.2.3.7, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis to demonstrate that the resulting water concentrations in the unrestricted area would meet the concentration limits of 10 CFR Part 20, Appendix B, Table 2. In addition, as addressed in Section 11.5.2, the COL applicant will fully describe the elements of the radioactive effluent monitoring program (REMP) as part of the Offsite Dose Calculation Manual (ODCM). The REMP will reflect recent nuclear industry initiatives and NRC assessments of existing nuclear reactors related to groundwater contamination and monitoring.

~~The U.S. EPR incorporates design features to prevent the contamination of the facility and the environment consistent with the requirements of 10 CFR 20.1406 (refer to Section 12.3.6). In the unlikely event of a liquid waste storage tank failure, with resulting release to the environment, the contamination travels via ground water to the nearest water source. The U.S. EPR meets the concentration limits of 10 CFR Part 20, Appendix B, as shown in Table 11.2-8—Unrestricted Area Water Concentration from Unmitigated Liquid Release, in accordance with NUREG-0800, BTP 11-6 (Reference 3). This calculation is based on:~~

- ~~A distance of 1200 feet from the Auxiliary Building to the unrestricted area.~~
- ~~A travel rate of 0.0012 feet/day for cesium and strontium, and 0.083 feet/day for nuclides other than cesium and strontium.~~
- ~~The presence of hydrogen-3, iron-55, and cobalt-60 as the only significant nuclides at the unrestricted area due to half-lives relative to travel time.~~
- ~~Discharge concentrations are at a location in the immediate vicinity of the discharge point.~~
- ~~Discharge concentrations are based on a dilution flow rate of 9000 gpm.~~

~~As addressed in Section 11.5.2, the COL applicant will fully describe the elements of the Radioactive Effluent Monitoring Program (REMP) as part of the Offsite Dose Calculation Manual (ODCM). The REMP will reflect recent nuclear industry initiatives and NRC assessments of existing nuclear reactors related to groundwater contamination and monitoring.~~

11.2.3.8 Quality Assurance

The quality assurance program governing design, fabrication, procurement, and installation of the liquid waste storage and processing systems ~~meets the requirements~~

ofconform to RG 1.143, as described in Chapter 17indicated in Table 3.2.2-1. Implementation of the quality assurance program is described in Chapter 17.

11.2.4 Liquid Waste Management System Cost-Benefit Analysis

10 CFR Part 50, Appendix I requires that plant designs consider additional items based on a cost-benefit analysis. Specifically, the design must include all items of reasonably demonstrated cleanup technology that, when added to the liquid waste processing system sequentially and in order of diminishing cost-benefit return, can, at a favorable cost-benefit ratio, reduce the dose to the population reasonably expected to be within 50 miles of the reactor. A COL applicant that references the U.S. EPR design certification will perform a site-specific liquid waste management system cost-benefit analysis.The cost-benefit analysis presented in this section is for a typical site and results demonstrate that additional cleanup technology is not warranted. A COL applicant that references the U.S. EPR design certification will confirm that the liquid waste management system cost-benefit analysis for the typical site is applicable to their site; if it is not, provide a site-specific cost-benefit analysis.

11.02-17(4)

The liquid waste processing base system case evaluated for the U.S. EPR is an evaporator processing Group I wastes and a centrifuge processing Group II wastes. The treated wastewater from these two components is directed to the monitoring tanks where it is eventually released for discharge to the environment.

The augmented case evaluated in the cost-benefit analysis adds a waste demineralizer subsystem to the liquid waste processing equipment from the base system case. The system is aligned so that, for Group I wastes, the evaporator distillate is routed to the waste demineralizer for further treatment, and for Group II wastes, the treated wastewater from the centrifuge is routed to the waste demineralizer for further treatment prior to being routed to the monitoring tanks for eventual discharge to the environment.

11.2.4.1 Calculation of Population Doses

The source term for each equipment configuration option in the analysis for this addition was generated using the GALE code (Reference 1) and system parameters from Table 11.2-3. The only GALE input parameters that differ between the base system case and the augmented case are the decontamination factors for the applicable waste streams. The augmented case uses typical values for waste demineralizer decontamination factors, which are multiplied by the decontamination of the other component in series (either the evaporator or centrifuge) to determine the overall decontamination factor for each waste stream. All other input values into the GALE code remain the same.

The LADTAP II code (Reference 2) was used to provide population dose results using typical site parameters and the source term calculated by GALE. LADTAP II

(Reference 2) inputs are shown in Table 11.2-9—Table DeletedInput Parameters for the LADTAP II Computer Code used in Liquid Waste Cost-Benefit Analysis. The source term entered into LADTAP II (Reference 2) is the release rate unadjusted by the 0.16 Ci/yr that is added to account for anticipated operational occurrences (AOOs). This entry was necessary so that an adequate and unskewed comparison could be made between the base system and augmented cases. As such, the dose values reported are based on the GALE unadjusted source term, and should not be used to project actual population doses. The dose benefit (i.e., the difference in doses between the two cases) is the objective of the analysis.

11.2.4.2 Dose Benefit and Augment Costs

The cost-benefit analysis uses a value of $2000 per person-rem as a favorable cost-benefit threshold based on NUREG-1530 (Reference 4). The cost basis for the additional equipment option is taken from RG 1.110 and reported in 1975 non-escalated dollars, which provides a conservatively low estimate of the equipment cost compared to present dollars. The analysis uses a 60-year operating period, since the U.S. EPR is designed for a 60-year operating life.

The dose reduction effects for the sequential addition of the next logical liquid waste processing component (i.e., waste demineralizer) results in a reduction in the 50-mile population total body exposure of 0.06 person-rem as shown in Table 11.2-10—Table DeletedObtainable Dose Benefits for Liquid Waste System Augment.

The total body dose reduction has a dollar equivalent benefit value of $7200. However, the estimated cost to purchase, operate and maintain this equipment over its operating life is conservatively estimated (low) as $446,000. This calculation results in a total body effective benefit to cost ratio of less than 1.0 (and therefore not justified on an ALARA basis of dose savings to the public). Table 11.2-11—Table DeletedLiquid Waste Management Cost-Benefit Analysis summarizes the cost-benefit evaluation.

The favorable benefit in reduced thyroid dose associated with the addition of a waste demineralizer system is 0.46 person-thyroid-rem and has a dollar equivalent benefit value of $55,200. The estimated cost to purchase, operate and maintain this equipment over its operating life is the same as shown for the total body dose assessment above, $446,000. This calculation results in a thyroid effective benefit to cost ratio of less than 1.0, and therefore it is not justified on an ALARA basis of dose savings to the public. Table 11.2-11 summarizes the cost-benefit evaluation.

11.2.4.3 Alternative Analysis

An alternate bounding cost benefit assessment is presented to determine if demonstrated technologies exist that could be added to the plant design at a favorable cost-benefit ratio. The bounding evaluation demonstrates that there is insufficient collective dose savings available to warrant the additional equipment cost. For the

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~~bounding total body collective dose estimate, if an equipment option could reduce the base case population dose to zero, the maximum potential savings in collective dose is equivalent to $2000 per person-rem times the lifetime integrated total body population dose associated with base condition (i.e., 0.177 person-rem/yr x 60 yrs x $2000 per person-rem = $21,240). For the thyroid collective dose, the savings is equivalent to $2000 per person-thyroid-rem times the life time integrated thyroid population dose associated with base condition (i.e., 0.682 person-rem/yr x 60 yrs x $2000 per person-rem = $81,840).~~

~~The assumption of achieving a zero dose does not take into account that tritium in effluents contributes to the dose and that current available treatment options are ineffective to remove it. Since the benefit value for both the total body and thyroid to reduce the dose to zero is significantly less than the direct and 60-year O&M cost of the waste demineralizer subsystem option or other options from RG 1.110 not already incorporated in the plant design, the bounding assessment indicates that there are no likely equipment additions that could be justified on an ALARA basis for liquid waste processing. Although the dose analysis is based upon the unadjusted GALE source term, even after factoring in the 0.16 Ci/yr correction, the resulting collective dose savings is still significantly less than the direct and 60-year operational and maintenance (O&M) cost of the waste demineralizer subsystem augment.~~

~~Even though it is not warranted on a population dose savings basis, a waste demineralizer subsystem has been included in the plant design. This demineralizer may be used to further process distillate from the evaporator and treated wastewater from the centrifuge. The demineralizer provides plant operators with greater flexibility to process waste liquids by different processes to best match waste stream characteristics, such as chemical form and radioactivity concentration, with the waste process treatment method that most cost effectively handles the waste.~~

11.2.5 References

1. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors PWR-GALE Code," Revision 1, U.S. Nuclear Regulatory Commission, April 1985.

2. NUREG/CR-4013, "LADTAP II – Technical Reference and User Guide," U.S. Nuclear Regulatory Commission, April 1986.

3. NUREG-0800, BTP 11-6, "Postulated Radioactive Releases Due To Liquid-Containing Tank Failures," Revision 3, U.S. Nuclear Regulatory Commission, March 2007.

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4. Deleted.~~NUREG-1530, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy," U.S. Nuclear Regulatory Commission, 1995.~~

Table 11.2-5—Input Parameters for LADTAP II Computer Code

Parameter[1]	Value
Source Term	GALE (Table 11.2-4)
	(Total as Adjusted)
Shore-width factor	1.0
Discharge flow rate	100 cfs
Impoundment reconcentration model	None
Irrigation rate	50 liters/m^2-month
Dilution factor for aquatic food, boating, shoreline, swimming and drinking water	1
Dilution factor for irrigation water usage location	2
Site type	Freshwater
Exposure Pathway:	
• Transit time - aquatic food	24 hrs
• Transit time – boating	0
• Transit time – swimming	0
• Transit time – shoreline	0
• Transit time – drinking water	12 hrs
• Transit time – irrigated crops	0
• Transit time – milk/meat animal water usage	0
Fraction of crops irrigated using non-contaminated water	0
Fraction of milk/meat animal feed irrigated using non-contaminated water	0
Fraction of milk/meat animal drinking water from non-contaminated water	0

Notes:

1. All other values are LADTAP II default values.

~~Parameter[1]~~	~~Value~~
~~Source Term~~	~~GALE (Table 11.2-4) (Total as Adjusted)~~
~~Shore-Width Factor~~	~~1.0~~
~~Discharge Flow Rate~~	~~100 cfs~~
~~Impoundment Reconcentration Model~~	~~None~~
~~Irrigation Rate~~	~~50 liters/m^2-month~~
~~Dilution Factor for Irrigation Water Usage Location~~	~~2~~
~~Site Type~~	~~Freshwater~~

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Next File

~~Note:~~

1. ~~All other values are LADTAP II default values.~~

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Table 11.2-6—Dose Commitment Due to Liquid Effluent Releases

Type of Dose	Calculated (mrem/yr)	10 CFR Part 50, Appendix I ALARA Design Objective (mrem/yr)
Total Body Dose	2.18 (child)	3
Organ Dose	4.83 (infant thyroid)	10

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Table 11.2-8—Unrestricted Area Water Concentration from Unmitigated Liquid Release

Nuclide[1]	Critical Receptor Concentration (µCi/ml)	10 CFR Part 20 Appendix B, Table 2 Effluent Concentration Limit (µCi/ml)	Fraction of Concentration Limit
H-3	4.8E-04	1.E-03	4.8E-01
Cs-134	5.6E-08	9.E-07	6.2E-02
Cs-137	4.2E-08	1.E-06	4.2E-02
		Total	**0.6**

Notes:

1. Nuclides less than 1.0E-03 in fraction of concentration limit are excluded.

~~Nuclide~~	~~Water Concentration (µCi/ml)~~	~~10 CFR Part 20, Appendix B Concentration Limit (µCi/ml)~~
~~H-3~~	~~2.45E-04~~	~~1.00E-03~~
~~Fe-55~~	~~5.84E-09~~	~~1.00E-04~~
~~Co-60~~	~~3.39E-07~~	~~3.00E-06~~

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Table 11.2-9—Table Deleted~~Input Parameters for the LADTAP II Computer Code used in Liquid Waste Cost-Benefit Analysis~~

~~Parameter~~	~~Value~~
~~Source Term (Unadjusted)~~	~~GALE (Table 11.2-4, "Total Unadjusted")~~
~~50-Mile Population~~	~~8.1E+06~~
~~Shoreline Activity (person-hours per year)~~	~~3.8E+07~~
~~Boating (person-hours per year)~~	~~4.4E+07~~
~~Swimming (person-hours per year)~~	~~3.0E+07~~
~~Commercial Fishing Harvest (kg per year)~~	~~1.5E+08~~
~~Commercial Invertebrate Harvest (kg per year)~~	~~2.6E+07~~
~~Sport Fishing Harvest (kg per year)~~	~~1.3E+06~~
~~Sport Invertebrate Harvest (kg per year)~~	~~1.6E+06~~
~~Shore-Width Factor~~	~~1.0~~
~~Discharge Flow Rate~~	~~39.3 cfs~~
~~Impoundment Reconcentration Model~~	~~None~~
~~Site Type~~	~~Saltwater~~
~~Dilution factor~~	~~365~~

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Table 11.2-10—Table DeletedObtainable Dose Benefits for Liquid Waste System Augment

Augment	Population Total Body Dose (Person-rem)	Population Thyroid Dose (Person-rem)
Demineralizer not used	0.177[1]	0.682[1]
Demineralizer used	0.121[1]	0.222[1]
Obtainable dose benefit	0.06	0.46

Note:

1. Because the source term used in obtaining the doses does not include the 0.16 Ci/yr adjustment factor for AOOs, this population dose is used only for the cost-benefit analysis for purposes of obtaining a dose benefit achieved by the augmented liquid waste processing system.

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Table 11.2-11—Table Deleted~~Liquid Waste Management Cost-Benefit Analysis~~

~~Calculation~~	~~Whole Body Dose~~	~~Thyroid Dose~~
~~Annual dose reduction to the population within 50 miles of site due to addition of a waste demineralizer subsystem~~	~~0.06 person-rem~~	~~0.46 person-rem~~
~~Nominal dose over 60 years of operation~~	~~3.6 person-rem~~	~~27.6 person-rem~~
~~Obtainable benefit from addition of radwaste processing and control option~~	~~$7200~~	~~$55,200~~
~~Total cost over 60 years of operation (direct cost + O&M×60 years)~~	~~$446,000~~	~~$446,000~~
~~Benefit/Cost Ratio (values greater than 1.0 should be included in plant system design)~~	~~0.016~~	~~0.12~~

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Table 11.2-12—Liquid Waste Storage System Tank Level Indication, Alarms, and Overflows

Tank	Level Indication Location	Alarm Location	Alarm	Overflow To
Liquid Waste Storage Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant storage tank in series (2) Secondary – Room drains, which are pumped to waste storage tanks.
Monitoring Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant monitoring tank in series. (2) Secondary – Room drains, which are pumped to waste storage tanks.
Concentrate Tank	MCR Local Control Panel	MCR Local Control Panel	High	(1) Primary – Redundant concentrate tank in series. (2) Secondary – Room drains, which are pumped to waste storage tanks.

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Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ due to Liquid Effluent Releases
Sheet 1 of 2

Pathway	Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Fish								
Adult		2.10E-01	3.87E-01	2.90E-01	2.56E-01	1.46E-01	6.10E-02	6.74E-02
Teen		2.21E-01	3.92E-01	1.70E-01	2.37E-01	1.44E-01	6.35E-02	5.13E-02
Child		2.74E-01	3.42E-01	7.41E-02	2.45E-01	1.21E-01	5.07E-02	2.71E-02
Drinking								
Adult		6.61E-03	8.21E-01	8.18E-01	1.40E+00	8.20E-01	8.13E-01	8.68E-01
Teen		6.44E-03	5.80E-01	5.76E-01	1.08E+00	5.79E-01	5.73E-01	6.14E-01
Child		1.87E-02	1.12E+00	1.10E+00	2.35E+00	1.11E+00	1.10E+00	1.14E+00
Infant		2.20E-02	1.10E+00	1.08E+00	3.05E+00	1.09E+00	1.08E+00	1.10E+00
Shoreline								
Adult	1.75E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03	1.50E-03
Teen	9.79E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03
Child	2.05E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03	1.75E-03
Irrigated Foods								
Vegetables								
Adult		6.99E-03	2.98E-01	2.96E-01	3.77E-01	2.94E-01	2.90E-01	3.56E-01
Teen		1.18E-02	3.69E-01	3.59E-01	4.84E-01	3.62E-01	3.55E-01	4.39E-01
Child		2.82E-02	5.86E-01	5.65E-01	8.19E-01	5.74E-01	5.62E-01	6.28E-01
Leafy Vegetables								
Adult		9.50E-04	3.69E-02	3.65E-02	6.96E-02	3.64E-02	3.57E-02	4.43E-02
Teen		8.69E-04	2.47E-02	2.40E-02	5.09E-02	2.43E-02	2.37E-02	2.96E-02
Child		1.56E-03	2.94E-02	2.84E-02	6.86E-02	2.89E-02	2.82E-02	3.16E-02

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Table 11.2-13—Detailed Dose Commitment Results by Age Group and Organ due to Liquid Effluent Releases Sheet 2 of 2

Pathway	Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Milk								
Adult		5.36E-03	1.82E-01	1.79E-01	3.35E-01	1.76E-01	1.73E-01	1.74E-01
Teen		9.57E-03	2.40E-01	2.31E-01	4.82E-01	2.31E-01	2.26E-01	2.26E-01
Child		2.27E-02	3.82E-01	3.61E-01	8.65E-01	3.66E-01	3.58E-01	3.57E-01
Infant				5.45E-01	1.78E+00			
Meat								
Adult		1.11E-02	6.22E-02	6.33E-02	6.68E-02	8.18E-02	6.13E-02	7.39E-01
Teen		9.30E-03	3.73E-02	3.79E-02	4.05E-02	5.38E-02	3.66E-02	4.59E-01
Child		1.75E-02	4.52E-02	4.65E-02	5.03E-02	6.70E-02	4.43E-02	3.02E-01
Total								
Adult	1.75E-03	2.43E-01	1.79E+00	1.68E+00	2.51E+00	1.56E+00	1.44E+00	2.25E+00
Teen	9.79E-03	2.67E-01	1.65E+00	1.41E+00	2.38E+00	1.40E+00	1.29E+00	1.83E+00
Child	2.05E-03	3.64E-01	2.51E+00	2.18E+00	4.40E+00	2.27E+00	2.14E+00	2.49E+00
Infant				1.63E+00	4.83E+00			

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Table 11.2-14—Parameters used in Liquid Tank Failure Evaluation Sheet 1 of 2

Radionuclide	Half-life (days)	Partition Coefficient (L/kg)	Activity Concentration in Reactor Coolant Storage Tank ($\mu Ci/cm^3$)
H-3	4510	N/A	1
Cr-51	27.7	30	2.0E-03
Mn-54	313	50	1.0E-03
Mn-56	0.107	50	N/A
Fe-55	986	165	7.6E-04
Fe-59	44.5	165	1.9E-04
Co-58	70.8	60	2.9E-03
Co-60	1.93E+03	60	3.4E-04
Zn-65	244	200	3.2E-04
Br-84	2.21E-02	15	1.7E-02
Rb-88	1.24E-02	55	1.0E+00
Sr-89	5.05E+01	15	6.4E-04
Sr-90	1.06E+04	15	3.3E-05
Sr-91	3.96E-01	15	1.0E-03
Y-91	5.85E+01	170	8.1E-05
Y-92	1.48E-01	170	1.4E-04
Y-93	4.21E-01	170	6.5E-05
Y-91m	3.45E-02	170	5.2E-04
Zr-95	6.40E+01	600	9.3E-05
Nb-95	3.52E+01	160	9.4E-05
Mo-99	2.75E+00	10	1.1E-01
Tc-99m	2.51E-01	0.1	4.6E-02
Tc-99	7.78E+07	0.1	1.1E-09
Ru-103	3.93E+01	55	7.8E-05
Ru-106	3.68E+02	55	2.7E-05
Ag-110m	2.50E+02	90	2.0E-07
Te-129m	3.36E+01	125	1.5E-03
Te-129	4.83E-02	125	2.4E-03
Te-131	1.74E-02	125	2.6E-03
Te-131m	1.25E+00	125	3.7E-03

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Table 11.2-14—Parameters used in Liquid Tank Failure Evaluation
Sheet 2 of 2

Radionuclide	Half-life (days)	Partition Coefficient (L/kg)	Activity Concentration in Reactor Coolant Storage Tank (μCi/cm^3)
Te-132	3.26E+00	125	4.1E-02
I-129	5.73E+09	1	4.6E-08
I-131	8.04E+00	1	7.4E-01
I-132	9.58E-02	1	3.7E-01
I-133	8.67E-01	1	1.3E+00
I-134	3.65E-02	1	2.4E-01
I-135	2.75E-01	1	7.9E-01
Cs-134	7.53E+02	270	1.7E-01
Cs-136	1.31E+01	270	5.3E-02
Cs-137	1.10E+04	270	1.1E-01
Ba-140	1.27E+01	N/A	6.2E-04
La-140	1.68E+00	N/A	1.6E-04
Ce-141	3.25E+01	500	8.9E-05
Ce-143	1.38E+00	500	7.6E-05
Ce-144	2.84E+02	500	6.9E-05
W-187	9.96E-01	N/A	1.8E-03
Np-239	2.36E+00	5	8.7E-04

waste processing system is designed to fulfill these primary design functions under modes of normal plant operation. The gaseous waste processing system is not designed to mitigate DBAs.

Using the methodology contained in RG 1.143, the gaseous waste processing system is classified as RW-IIa (High Hazard). This classification is based on calculation of the limiting total design basis unmitigated radiological release and considers the maximum inventory of a given radwaste system at the boundary of the unprotected area.

11.03-15(c)

Calculations of doses and radioactive releases are performed consistent with the methodologies of BTP-11-5 and of Regulatory Guides 1.109, 1.111, and 1.112.

The GWMS is designed in compliance with the regulatory position contained in RG 1.140 as it pertains to the design, testing, and maintenance of normal ventilation exhaust system air filtration and adsorption units. Further description of the U.S. EPR design as it relates to RG 1.140 can be found in Section 9.4.

Consistent with the requirements of 10 CFR 20.1406, the U.S. EPR, including the gaseous waste management system, is designed, to the extent practicable, to minimize contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, the generation of radioactive waste. The GWMS design also incorporates features consistent with the applicable guidance of RG 4.21 and which address NRC concerns identified in IE-BL-80-10. Minimization of contamination and radioactive waste generation is described in Section 12.3.6.

11.3.1.1 Design Objectives

In addition to fulfilling its primary design functions, the gaseous waste processing system meets the following design objectives:

- Compensate for level deviations in the free gas atmosphere of tanks that are connected to the system by adding or removing the free gas.
- Maintain a negative system pressure to prevent the escape of radioactive gases from components connected to the building air.
- Limit the hydrogen and oxygen concentrations in the system and connected systems to less than the flammability limits of the respective gas mixtures.
- Minimize the release of radioactive gases to the environment by injecting the processed purge gas back into the quasi-closed loop.
- Handle excess gas flow rates due to the movement of reactor coolant during plant startup and shutdown.
- Maintain a positive pressure in the delay system to improve the adsorption properties of the activated charcoal.

11.3.3.2 Estimated Annual Releases

The annual average airborne releases of radionuclides from the U.S. EPR are determined using the PWR-GALE code (Reference 1). The GALE code (Reference 1) models releases using realistic source terms derived from data obtained from the experience of many operating reactors, field and laboratory tests, and plant-specific design considerations incorporated to reduce the quantity of radioactive materials that may be released to the environment during normal operation, including AOOs. The code input values used in the analysis to model the U.S. EPR are provided in Table 11.2-3—Liquid and Gaseous Effluent Input Parameters for the GALE Computer Code. The expected annual releases for a single unit site are presented in Table 11.3-3—Gaseous Release (Ci/yr) Calculated by GALE Code.

11.3.3.3 Release Points

Gaseous effluents originating from the U.S. EPR are released at the top of the plant stack at an elevation of 212~~211~~ ft above grade and approximately 100 ft above the top of the adjacent Fuel Building roof and 7 ft above the top of the Reactor. The inner diameter of the stack is approximately 12.5 ft at the point of release. In accordance with typical normal effluent modeling of releases, no elevated effluent temperatures are assumed. Effluent discharged from the delay system of the gaseous waste processing system is directed to the filtration system of the nuclear auxiliary building ventilation system. Exhaust air from the containment purge “full flow purge” (used only during plant outage periods and containment entries), along with exhaust air from the safeguard building controlled area ventilation, fuel building ventilation, radioactive waste processing building ventilation, and nuclear auxiliary building ventilation systems, is processed by the filtration system of the nuclear auxiliary building ventilation system before release from the stack. The combined flowrate of all the ventilation exhaust systems from the plant stack during normal operations that was used for gaseous effluent release evaluations was conservatively calculated to be approximately 242,500 cfm. The corresponding effluent exit velocity is approximately 1988 fpm during normal operations. The filtration system of the nuclear auxiliary building ventilation system continuously uses a prefilter and a HEPA filter. Iodine-adsorbent activated charcoal delay beds and a downstream HEPA filter are added to the flow path if radiation sensors in the stack detect elevated activity levels in exhaust gases. The containment purge “low flow purge” exhausts air from the Reactor Building through a dedicated filter path that includes two HEPA filters and an activated charcoal holdup bed into the nuclear auxiliary building ventilation system for discharge via the stack.

11.03-15(a)

A COL applicant that references the U.S. EPR design certification will provide a discussion of the onsite vent stack design parameters and site-specific release point characteristics.

11.3.3.4 Estimated Doses

The GASPAR II computer program (Reference 2) was used to calculate doses to the maximally exposed individual (MEI) from gaseous releases. GASPAR II (Reference 2) implements the exposure methodology described in RG 1.109 for radioactive releases in gaseous effluent. The program considers the following exposure pathways:

- External exposure to contaminated ground.
- External exposure to noble gas radionuclides in the airborne plume.
- Inhalation of air.
- Ingestion of farm products grown in contaminated soil.

Inputs and assumptions are conservatively selected to represent a bounding condition for all dose pathways. The site boundary (where the MEI is assumed to reside for external exposure doses and inhalation doses) is assumed to be located at a distance of 0.5 miles from the reactor centerline. The dose receptors for the farm products (i.e., the nearest garden, nearest meat animal, and nearest milk animal) are also assumed to be located at a distance of 0.5 miles from the reactor centerline. The atmospheric dispersion and ground deposition factors are based on conservative values for a distance of 0.5 miles and a mixed-mode release from the plant stack. Inputs used by the GASPAR II code are presented in Table 11.3-4—Input Parameters for the GASPAR II Computer Code used in Calculating Annual Offsite Doses to the Maximally Exposed Individual from Gaseous Releases.

11.03-15(b)

The detailed dose commitment results by age group and organ due to gaseous effluent releases are provided in Table 11.3-11—Detailed Dose Commitment Results by Age Group and Organ due to Gaseous Effluent Releases. ~~The~~A summary of the U.S. EPR offsite dose to the MEI in an unrestricted area from gaseous effluent releases is presented in Table 11.3-5—Dose Commitment Due to Gaseous Effluent Releases. This table also compares these results to the limits specified in the 10 CFR Part 50 ALARA design objectives. U.S. EPR values are less than limiting values.

11.03-15(a)

A COL applicant that references the U.S. EPR design certification will confirm that the site-specific parameters are bounded by those provided in Table 11.3-4 and the dose pathways provided in Section 11.3.3.4. For site-specific parameters that are not bounded by the values provided in Table 11.3-4 and the dose pathways provided in Section 11.3.3.4, a COL applicant that references the U.S. EPR design certification will perform a site-specific gaseous pathway dose analysis following the guidance provided in RG 1.109 and RG 1.111, and compare the doses to the numerical design objectives of 10 CFR Part 50, Appendix I and demonstrate compliance with requirements of 10 CFR Part 20.1302 and 40 CFR Part 190.

11.3.3.5 Maximum Release Concentrations

Using annual release data generated with the GALE code (Reference 1) and presented in Table 11.3-3, annual average concentrations of radioactive materials released in gaseous effluents to the discharge point have been determined. This analysis was based on an annual average atmospheric dispersion factor of 5.0E-06 sec/m^3. This value represents a conservative value for a distance of 0.5 miles from the reactor centerline, based on a mixed-mode release. For each radionuclide released, the average concentration has been compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. The results of this comparison are presented in Table 11.3-6—Comparison of Annual Average Gaseous Release Concentrations with 10 CFR Part 20 Concentration Limits. For the annual average radionuclide release concentrations for expected releases, the overall fraction of the effluent concentration limit is 0.02, which is well below the allowable value of 1.0.

Average gaseous effluent concentrations for each radionuclide based on one percent failed fuel fraction have also been determined and compared to the limiting value for that radionuclide specified in 10 CFR Part 20, Appendix B, Table 2. The concentrations for the expected failed fuel case were upwardly adjusted by a multiplication factor. For noble gases and iodine isotopes, the multiplication factor is the ratio of the primary coolant activity for the maximum expected fuel failure to the expected primary coolant activity. The maximum primary coolant activity for noble gases and iodine isotopes is controlled by Technical Specifications (TS). Corrosion products are not affected by the percentage of fuel defects and do not need a multiplication factor. Similarly, Carbon-14 and Argon-41 release rates are also independent of fuel defect level. Tritium is adjusted using the ratio of the primary coolant activity for maximum failed fuel defect (1 percent failed fuel) to expected primary coolant concentration. The release rate for all other isotopes is conservatively adjusted upward by a factor of 1,000.~~the ratio of design basis fuel failure primary coolant activity to expected fuel failure primary coolant activity, except for specific radionuclides in which Technical Specifications (TS) limit the maximum primary coolant activity~~. The results of the design basis case are also presented in Table 11.3-6. For the annual average radionuclide release concentrations for design basis (one percent failed fuel) releases, the overall fraction of the effluent concentration limit is 0.10, which is well below the allowable value of 1.0.

~~-~~For both normal and maximum defined fuel failure cases, individual site boundary concentrations for the U.S. EPR are less than the applicable limits specified in 10 CFR Part 20, Appendix B, Table 2.

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A COL applicant that references the U.S. EPR design certification will confirm that the site-specific annual average gaseous effluent concentrations are bounded by those specified in Table 11.3-6. For site-specific annual average gaseous effluent concentrations that exceed the values provided in Table 11.3-6, a COL applicant that

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references the U.S. EPR design certification will demonstrate that the annual average gaseous effluent concentrations for expected and design basis conditions meet the limits of 10 CFR Part 20, Appendix B, Table 2.

11.3.3.6 Radioactive Gaseous Waste System Leak or Failure

The purge system of the gaseous waste processing system operates at sub-atmospheric pressures, thus preventing leakage from the purge section to the building atmosphere. The positive pressure section of the system is designed to be leak tight, thus limiting the potential for leakage. The leak tightness of the system is verified by pre-operational testing as described in Section 11.3.2.5.2.

The gaseous waste processing system is capable of detecting leaks by monitoring the system operating parameters for abnormalities. For example, if a leak were to exist in the purge section of the system. the upstream O_2 instrument would detect a higher than normal oxygen concentration due to building air ingress. If a leak were to exist in the positive pressure section, the system instrumentation would indicate flow rates and pressures outside the normal operating range. Once identified through system instrumentation and controls (I&C), the operator can take appropriate action to isolate the leak.

A bounding analysis was performed for the hypothetical event where an operator error leads to an inadvertent bypass of the delay beds and the exhaust from the coolant degasification system is released directly to the environment. Based on a one-hour release to the environment, the exposure at the exclusion area boundary is less than 0.1 rem, in accordance with BTP 11-5 (Reference 3).

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A COL applicant that references the U.S. EPR design certification will confirm that the site-specific accident atmospheric dispersion data is bounded by the values provided in Table 2.1-1. For site-specific accident atmospheric dispersion data that exceed the values provided in Table 2.1-1, a COL applicant that references the U.S. EPR design certification will provide a site-specific analysis demonstrating that the resulting dose at the exclusion area boundary associated with a radioactive release due to gaseous waste system leak or failure does not exceed 0.1 rem in accordance with BTP 11-5.

11.3.3.7 Quality Assurance

The quality assurance program governing design, fabrication, procurement, and installation of the gaseous waste processing system ~~meets the requirements of~~ conforms to RG 1.143 as ~~described in Chapter 17~~indicated in Table 3.2.2-1. Implementation of the quality assurance program is described in Chapter 17. For the containment isolation valves and associated piping, the quality assurance program meets the requirements of Appendix B to 10 CFR Part 50 and Section III-ND of the ASME Boiler and Pressure Vessel Code (Reference 4).

11.3.4 Gaseous Waste Management System Cost-Benefit Analysis

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10 CFR Part 50, Appendix I requires that plant designs consider additional items based on a cost-benefit analysis. Specifically, the design must include all items of reasonably demonstrated cleanup technology that, when added to the gaseous waste processing system sequentially and in order of diminishing cost-benefit return, can, at a favorable cost-benefit ratio, reduce the dose to the population reasonably expected to be within 50 miles of the reactor. A COL applicant that references the U.S. EPR design certification will perform a site-specific gaseous waste management system cost-benefit analysis. ~~The cost-benefit analysis presented in this section is for a typical site and results demonstrate that additional cleanup technology is not warranted. A COL applicant that references the U.S. EPR design certification will confirm that the gaseous waste management system cost-benefit analysis for the typical site is applicable to their site; if it is not, provide a site-specific cost-benefit analysis.~~

~~The next logical gaseous waste processing component for the U.S. EPR is the addition of a charcoal delay bed to the waste gas holdup subsystem. The original design contains three delay bed vessels, and the augmented design contains four delay bed vessels. All other features and parameters of the system are assumed to remain the same.~~

11.3.4.1 ~~Calculation of Population Doses~~

~~The source term for each equipment configuration option in this analysis was generated using the NUREG-0017 GALE code (Reference 1) and system parameters from Table 11.2.3. All input parameters to the GALE code (Reference 1) are the same for the base and augmented cases except for those parameters affected by the addition of a delay bed. The only GALE (Reference 1) input parameters affected by the design change are the holdup times for krypton and xenon. Holdup times are increased in proportion to the increase in mass of charcoal adsorber.~~

~~The GASPAR II code (Reference 2) was used to determine the population doses for both cases. Input parameters are given in Table 11.3-4. GASPAR II (Reference 2) input values for a typical site were used. These parameters include data within 50 miles of the reactor for population, meteorological dispersion, milk production, meat production, and vegetable production. Although entered by sector and distance for the actual analysis, total values for population and production data are provided in Table 11.3-4.~~

11.3.4.2 ~~Dose Benefits and Augment Cost~~

~~The cost-benefit analysis uses a value of $2000 per person-rem as a favorable cost-benefit threshold based on NUREG-1530 (Reference 5). The cost basis for the equipment option is taken from RG 1.110 and reported in 1975 non-escalated dollars, which provides a conservatively low estimate of the equipment cost compared to~~

present dollars. The analysis uses a 60-year operating period, since the U.S. EPR is designed for a 60-year operating life.

The dose reduction effects for the sequential addition of the next logical gaseous waste processing component (i.e., addition of a charcoal delay bed to the waste gas holdup subsystem) results in a reduction in the 50 mile population total body and thyroid dose of 0.03 person-rem. Table 11.3-8—Table DeletedObtainable Dose Benefits for Gaseous Waste System Augment shows the population dose associated with both the base case equipment configuration and that associated with the augmented delay system. Table 11.3-8 also shows the dose benefit achieved from the augmented delay system. Table 11.3-9—Table DeletedGas Waste Management Cost-Benefit Analysis compares the estimated total body and thyroid dose reduction or savings achieved with the addition of the extra delay bed along with a conservative estimated cost for the purchase of this equipment. Operating and maintenance (O&M) cost associated with this passive subsystem is negligible. The cost basis for the equipment option is taken from RG 1.110 and reported in 1975 non-escalated dollars which provides a conservatively low estimate of the equipment cost compared to present value.

Table 11.3-9 shows that the favorable benefit in reduced dose associated with the additional charcoal delay bed has a dollar equivalent benefit value of $3600. However, the estimated cost to purchase this equipment is conservatively (low) estimated as $67,000. This analysis results in a total body effective benefit to cost ratio of less than 1.0 (and therefore a gaseous waste system augment is not justified on an ALARA basis of dose savings to the public).

The sources of gaseous effluents to the environment include waste streams processed through the gaseous waste processing system, containment purge exhaust, condenser air ejector exhaust, and building ventilation exhaust from the Safeguard Building, Nuclear Auxiliary Building, Radioactive Waste Processing Building, and Fuel Building. The gaseous waste processing system is designed such that little activity is released to the environment. The gaseous effluent source term is based upon a specified amount of primary coolant leakage. Radioactivity in this leakage is released to the environment via the building ventilation systems. Unlike the effluents from the gaseous waste processing system, which have the opportunity to decay through the charcoal delay beds before being released, the building ventilation releases do not benefit from holdup. Therefore, these building ventilation waste streams contain a significantly higher amount of activity than releases from the gaseous waste processing system. As such, an augment to the gaseous waste processing system provides little reduction to the overall activity released from all sources of gaseous effluents.

An alternative analysis was performed in Section 11.2.4 to demonstrate the potential benefit of providing a hypothetical augment to the liquid waste processing system that could eliminate all activity. For liquid effluents, all liquid waste streams containing radioactivity are processed via the liquid waste processing system, and the resulting

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~~total release to the environment in the bounding case is reduced to zero. Since the releases from the gaseous waste processing system represent a relatively small percentage of the total gaseous releases to the environment, if an augment were available that could reduce to zero the amount of activity released from the gaseous waste processing system, the reduction realized has little benefit compared to the overall gaseous release. Thus an alternative analysis for the gaseous waste processing system has not been performed, since only a small percentage of total gaseous effluents released to the environment is affected by such an augment.~~

11.3.5 References

1. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors PWR-GALE Code," Revision 1, U.S. Nuclear Regulatory Commission, April 1985.

2. NUREG/CR-4653, "GASPAR II – Technical Reference and User Guide," U.S. Nuclear Regulatory Commission, March 1987.

3. NUREG-0800, BTP 11-5, "Postulated Radioactive Releases Due To A Waste Gas System Leak or Failure," Revision 3, U.S. Nuclear Regulatory Commission, March 2007.

4. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, 2004.

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5. Deleted.~~NUREG-1530, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy," U.S. Nuclear Regulatory Commission, December 1995.~~

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Table 11.3-4—Input Parameters for the GASPAR II Computer Code used in Calculating Annual Offsite Doses to the Maximally Exposed Individual from Gaseous Releases

Parameter	Value
Source Term	GALE (Table 11.3-3, Total as Adjusted)
Distance from Reactor Centerline to[1]:	
• Site Boundary	0.5 miles
• Nearest Vegetable Garden	0.5 miles
• Nearest Meat Animal	0.5 miles
• Nearest Milk Animal	0.5 miles
• Nearest Residence	0.5 miles
Milk Animal Considered	Goat[2]
Annual Average Atmospheric Dispersion Factor[3]	5.0E-06 s/m^3
Annual Average Ground Deposition Factor[3]	5.0E-08 m^{-2}

Notes:

1. The most conservative location was assumed for each of the applicable dose pathways.
2. Doses from goat milk consumption are higher than for cow milk consumption.
3. Conservative estimate based on a mixed-mode release.
4. All other values are GASPAR II default values.

~~Parameter~~	Value
~~Source Term~~	~~GALE (Table 11.2-4, Total as Adjusted)~~
~~Distance to Reactor Centerline from:~~	
• ~~Site Boundary~~	~~0.5 miles~~
• ~~Nearest Vegetable Garden~~	~~0.5 miles~~
• ~~Nearest Meat Animal~~	~~0.5 miles~~
• ~~Nearest Milk Animal~~	~~0.5 miles~~
~~Milk Animal Considered~~	~~Goat (Note 1)~~
~~Annual Average Atmospheric Dispersion Factor~~	~~5.0E-06 s/m^3~~
~~Annual Average Ground Deposition Factor~~	~~5.0E-08 m^{-2}~~

~~**Notes:**~~

1. ~~Doses from goat milk consumption are higher than for cow milk consumption.~~
2. ~~All other values are GASPAR II default values.~~

Table 11.3-7—Table Deleted.~~Input Parameters for the GASPAR II Computer Code used in Gaseous Waste Cost-Benefit Analysis~~

~~Parameter~~	~~Value~~
~~Source Term~~	~~GALE (Table 11.2-4, "Total as Adjusted")~~
~~50-Mile Population~~	~~8.1E+06~~
~~**Production Data**~~	
~~Cow Milk~~	~~2.3E+08[1] kg/yr~~
~~Meat~~	~~3.6E+07 kg/yr~~
~~Vegetable~~	~~1.7E+09 kg/yr~~
~~Fraction of Year that Animals are on Pasture~~	~~0.583~~
~~Average Humidity over Growing Season~~	~~8.4 g/m^3~~
~~Average Temperature over Growing Season~~	~~66.8°F~~
~~Atmospheric Dispersion Factors (highest 0.5 mile value)~~	~~5.0E-06 s/m^3~~

~~**Note:**~~

1. ~~All other values are GASPAR II default values.~~

Table 11.3-8—Table Deleted~~Obtainable Dose Benefits for Gaseous Waste System Augment~~

	~~Population Total Body Dose (Person-rem)~~	~~Population Thyroid Dose (Person-rem)~~
~~Baseline Configuration~~	~~5.52~~	~~5.80~~
~~Extra Carbon Delay Bed~~	~~5.49~~	~~5.77~~
~~Obtainable dose benefit by augment~~	~~0.03~~	~~0.03~~

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Table 11.3-9—Table DeletedGas Waste Management Cost-Benefit Analysis

Calculation	Whole Body/Thyroid Dose
Annual dose reduction to the population within 50 miles of site due to addition of a charcoal delay bed to the waste gas holdup subsystem	0.03 person-rem
Nominal dose over 60 years of operation	1.8 person-rem
Obtainable benefit from addition of charcoal delay bed	$3600
Total cost over 60 years of operation (direct cost + O&M×60 years)	$67,000
Benefit/Cost Ratio (values greater than 1.0 should be included in plant system design)	0.053

Table 11.3-11—Detailed Dose Commitment Results by Age Group and Organ due to Gaseous Effluent Releases
Sheet 1 of 2

Pathway	Total Body (External Exposure)	Gi-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin (External Exposure)
	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr	mrem/yr
Plume	1.04E+00							9.79E+00
Ground	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	7.06E-03	8.28E-03
Vegetables								
Adult		2.52E-01	1.13E+00	2.51E-01	2.51E-01	1.03E+00	2.47E-01	
Teen		3.88E-01	1.82E+00	3.89E-01	3.89E-01	1.36E+00	3.82E-01	
Child		8.89E-01	4.33E+00	8.96E-01	8.95E-01	2.71E+00	8.85E-01	
Meat								
Adult		8.46E-02	3.90E-01	8.35E-02	8.34E-02	1.18E-01	8.31E-02	
Teen		6.97E-02	3.30E-01	6.92E-02	6.91E-02	9.39E-02	6.89E-02	
Child		1.28E-01	6.19E-01	1.28E-01	1.28E-01	1.65E-01	1.27E-01	
Cow Milk								
Adult		9.86E-02	4.32E-01	1.02E-01	1.03E-01	1.07E+00	9.76E-02	
Teen		1.74E-01	7.96E-01	1.82E-01	1.83E-01	1.72E+00	1.73E-01	
Child		4.12E-01	1.95E+00	4.26E-01	4.28E-01	3.48E+00	4.11E-01	
Infant		8.45E-01	3.81E+00	8.78E-01	8.74E-01	8.31E+00	8.45E-01	
Goat Milk								
Adult		1.12E-01	4.41E-01	1.20E-01	1.19E-01	1.28E+00	1.11E-01	
Teen		1.92E-01	8.09E-01	2.07E-01	2.05E-01	2.05E+00	1.91E-01	
Child		4.39E-01	1.98E+00	4.67E-01	4.62E-01	4.12E+00	4.40E-01	

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Table 11.3-11—Detailed Dose Commitment Results by Age Group and Organ due to Gaseous Effluent Releases
Sheet 2 of 2

Pathway	Total Body (External Exposure)	Gi-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin (External Exposure)
Infant		8.86E-01	3.86E+00	9.47E-01	9.26E-01	9.84E+00	8.88E-01	
Inhalation								
Adult		2.06E-02	3.84E-04	2.06E-02	2.07E-02	4.80E-02	2.08E-02	
Teen		2.08E-02	4.67E-04	2.09E-02	2.10E-02	5.59E-02	2.12E-02	
Child		1.83E-02	5.70E-04	1.85E-02	1.86E-02	6.04E-02	1.87E-02	
Infant		1.05E-02	2.97E-04	1.07E-02	1.07E-02	4.92E-02	1.08E-02	
Totals								
Adult	1.05E+00	4.76E-01	1.97E+00	4.82E-01	4.81E-01	2.48E+00	4.69E-01	9.80E+00
Teen	1.05E+00	6.78E-01	2.97E+00	6.93E-01	6.91E-01	3.57E+00	6.70E-01	9.80E+00
Child	1.05E+00	1.48E+00	6.94E+00	1.52E+00	1.51E+00	7.06E+00	1.48E+00	9.80E+00
Infant	1.05E+00	9.04E-01	3.87E+00	9.65E-01	9.44E-01	9.90E+00	9.06E-01	9.80E+00

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