## ArevaEPRDCPEm Resource

**From:** Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
**Sent:** Thursday, November 05, 2009 8:11 PM
**To:** Tesfaye, Getachew
**Cc:** BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); WILLIFORD Dennis C (AREVA NP INC); SLIVA Dana (AREVA NP INC)
**Subject:** Response to U.S. EPR Design Certification Application RAI No. 301, FSAR Ch. 11
**Attachments:** RAI 301 Response US EPR DC.pdf

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 301 Response US EPR DC.pdf" provides technically correct and complete responses to 2 of the 2 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 301 Question11.03-15(a) and (c).

A complete FSAR markup is not provided for Question 11.02-17 and 11.03-15. As agreed by NRC staff during an FSAR Chapter 11 audit on October 7, 2009, FSAR markups may be submitted after Phase 2 completion to support Staff review to close confirmatory items. Therefore, a complete FSAR markup for this portion of the question will be provided as indicated in the following table:

| Question # | Supplement Date (providing FSAR Markup) |
|---|---|
| RAI 301 — 11.02-17 | March 31, 2010 |
| RAI 301 — 11.03-15 | March 31, 2010 |

The following table indicates the respective pages in the response document, "RAI 301 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

| Question # | Start Page | End Page |
|---|---|---|
| RAI 301 — 11.02-17 | 2 | 12 |
| RAI 301 — 11.03-15 | 13 | 28 |

This concludes the formal AREVA NP response to RAI 301, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

*Ronda Pederson*
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
**AREVA NP Inc.**
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**From:** Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
**Sent:** Tuesday, October 06, 2009 6:12 PM
**To:** ZZ-DL-A-USEPR-DL
**Cc:** Dehmel, Jean-Claude; Frye, Timothy; Jennings, Jason; Colaccino, Joseph; ArevaEPRDCPEm Resource
**Subject:** U.S. EPR Design Certification Application RAI No. 301 (3802,3803),FSAR Ch. 11

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 24, 2009, and discussed with your staff on October 6, 2009. No changes were made to the draft RAI as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

**Hearing Identifier:** AREVA_EPR_DC_RAIs
**Email Number:** 945

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**Response to**

**Request for Additional Information No. 301 (3802), 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(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 updated 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 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 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.

In determining population doses, data from an actual site was used. The site-specific discharge flow rate for this site was 17,632 gpm (39.3 cfs). Site-specific dilution factors were also used in the population dose analysis. Although not part of the population dose calculation, it is noted that the smallest dilution factor at this site used in the dose analysis for the MEI was 13.3 (for aquatic food consumption and boating activity). This provides an equivalent dilution that is much higher than the conservatively chosen 100 cfs with no downstream dilution for these pathways, which were used in the dose analysis for the MEI.

U.S. EPR FSAR Tier 2, Tables 11.2-5 and 11.2-9 will be updated to include the basis for the discharge flow rates.

**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 is for the child age group.

Table 11.02-17-3 shows the dose results for all four age groups and all 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 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 updated to include additional dose results for these four age groups and additional organs.

**Response to Question 11.02-17(4)(a):**

The population doses in the U.S. EPR FSAR Tier 2, Chapter 11 are provided for performing a cost benefit analysis. The 50-mile parameters were obtained from a saltwater site. Table 11.02-17-4 lists the site parameters.

**Response to Question 11.02-17(4)(b):**

A freshwater site was selected to demonstrate 10 CFR Part 50, Appendix I compliance for the maximally exposed individual due to the inclusion of more potential dose pathways (e.g., drinking water and irrigated food crops). A population dose calculation (which is required to perform the cost-benefit analysis as stipulated by 10 CFR Part 50, Appendix I) is highly dependent upon the individual site (e.g., population density, population distribution relative to the site, land use, agricultural activity, livestock patterns). A saltwater site was selected because the data available for the population dose evaluation was associated with a saltwater site with population and usage activity on which to perform the dose calculations. The COL applicant is required to perform these calculations for the specific site on which the plant will be built.

Exposure pathways characterizing a saltwater site include:

- Ingestion of fish.
- Ingestion of invertebrates.
- Exposure from shoreline activity.
- Exposure from boating activity.
- Exposure from swimming activity.

Usage or consumption parameters are site-specific, and thus typical values cannot be stated.

**Response to Question 11.02-17(4)(c):**

The 50-mile population dose is the result of multiple potential usage locations, many of which are far from the site. The dilution value of 365 is conservative for all recreational activities and fishing activities. This far-field dilution value represents the centerline dilution value of the plume. The value is considered to be conservative as 1) no credit is applied for dilution across the entire volume of the body of water and 2) the influx of fresh water from rivers downstream of the discharge location has not been included in the dilution calculation modeling. Additionally, the values of recreational activity usage (e.g., number of swimmers and those participating in shoreline activities) is conservative, as a significant number of the entire beach visitor and saltwater swimmer population is assumed.

**Response to Question 11.02-17(4)(d):**

The transit times for the listed activities, including shoreline, boating, swimming, commercial fishing (fish and invertebrate, if different), and sport fishing, are provided in Table 11.02-17-5.

U.S. EPR FSAR Tier 2, Table 11.2-9 will be updated to include transit times for these activities.

**Response to Question 11.02-17(5):**

U.S. EPR FSAR Tier 2, Table 11.2-8 lists the radionuclides that migrated to the environmental interface. The total volume released is assumed as the total of the two liquid waste storage tanks (each 70 $m^3$) and three concentrate tanks (each 34 $m^3$ or 242 $m^3$). The three concentrate storage tanks and two liquid radwaste storage tanks contain the majority of radioactive activity and thus are assumed to represent the entire inventory in the building. The discharge flow rate was assumed as the total volume of the five tanks over one year (i.e.; 8540$ft^3$/3.15E+07 second or 2.71E-04 $ft^3$/second).

A representative coastal site was assumed. The portion of the body of water assumed to dilute the release was a volume of 1,500 feet in length by 1,000 feet in width by 10 feet in depth (i.e., 1.5E+07 $ft^3$ or 4.25E+05 $m^3$). The building was assumed to be 1,200 feet from the shoreline. The mixing ratio ($M_p$ from equation A-3 of RG 1.109) was assumed to be one over the dilution factor (i.e., body of water dilution volume/total tank volume) or 5.7E-04.

Radionuclide travel rate in the ground water was assumed to be 0.083 feet/day for nuclides other than Cesium and Strontium. The estimated average rate of natural ground water movement at the costal site is less than one inch per day. This results in a decay time of 14,458 days (i.e., 1200 ft/0.083 ft/day) for nuclides other than Cesium or Strontium prior to entering the body of water. Radionuclide travel rate in the ground water was assumed to be 0.0012 feet/day for Cesium and Strontium (due to absorption and ion exchange). This results in a decay time of 1E6 days (i.e., 1200 ft/0.0012 ft/day) for Cesium and Strontium isotopes prior to entering the body of water.

Nuclides with short half lives relative to the decay time (due to ground transport) were not considered in the analysis.

Dose determination was based on consumption of aquatic food (i.e., fish and invertebrates) and external dose due to shoreline activities. The dose calculations were performed with the input parameters in Table 11.02-17-6.

The fission product radionuclides in Table 11.02-17-6 are based on 1 percent failed fuel fraction.

U.S. EPR FSAR Tier 2, Section 11.2.3.7 will be updated to include the additional input parameters and assumptions necessary to support the results provided in U.S. EPR FSAR Tier 2, Table 11.2-8.

**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**

| 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 |
| Teen | | 9.30E-03 | 3.73E-02 | 3.79E-02 | 4.05E-02 | 5.38E-02 | 3.66E-02 | 4.59E-01 |

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

| Pathway | Skin | Bone | Liver | Total Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|---|
| 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—Source References/Justification for LADTAP II Input Parameters used for Liquid Waste Cost-Benefit Analysis – Saltwater Site**

| Parameter | Value | Justification or Reference |
|---|---|---|
| 50-Mile Population | 8.1E+06 | Actual salt water site value |
| Shoreline Activity (person-hours per year) | 3.8E+07 | NOAA, National Ocean Survey |
| Boating (person-hours per year) | 4.4E+07 | Based on boating registrations; U.S. Coast Guard data |
| Swimming (person-hours per year) | 3.0E+07 | NOAA, National Ocean Survey |
| Commercial Fishing Harvest (kg per year) | 1.5E+08 | NOAA, National Marine Fisheries Service; Fisheries of the United States 2000; state Department of Natural Resources |
| Commercial Invertebrate Harvest (kg per year) | 2.6E+07 | (Same as above) |
| Sport Fishing Harvest (kg per year) | 1.3E+06 | NOAA, National Marine Fisheries Services; state Marine Resources Commission |
| Sport Invertebrate Harvest (kg per year) | 1.6E+06 | (Same as above) |
| Shore-Width Factor | 1.0 | Most conservative (i.e., maximizes the dose) shore width factor. This shore width factor is associated with a tidal basin. |
| Discharge Flow Rate | 39.3 cfs | This represents the discharge flow rate available to the body of water for diluting liquid effluent discharge prior to entering the receiving water body). The majority of this discharge during power operation is from cooling tower blowdown. To maintain flow dilution capability during shutdown conditions, discharge flow rate is maintained by flow from the cooling tower makeup line. |
| Impoundment Reconcentration Model | None | This model disregards any effects of an impoundment |

**Table 11.02-17-4—Source References/Justification for LADTAP II Input Parameters used for Liquid Waste Cost-Benefit Analysis – Saltwater Site**

| Parameter | Value | Justification or Reference |
|---|---|---|
| | | volume (such as radioactive decay) and assumes release of liquid effluents directly to the receiving water body |
| Site Type | Saltwater | Specific site chosen for population dose analysis is a saltwater site |
| Dilution factor | 365 | Represents a conservative time average far-field dilution credit for the actual salt water site. |

**Table 11.02-17-5—Transit Times for Activities Used for LADTAP II Input for Liquid Waste Cost-Benefit Analysis**

| | Transit time (hr) |
|---|---|
| Shoreline activity | 0 |
| Boating | 0 |
| Swimming | 0 |
| Commercial fishing (fish and invertebrate) | 240 |
| Sport fishing (fish and invertebrate) | 168 |

**Table 11.02-17-6—Additional Input Parameters and Justification for Postulated Releases Due to Liquid-Containing Tank Failures**

| Parameter | Value(s) | Reference |
|---|---|---|
| Nuclide activity values (Curie) for liquid waste storage tank (per tank) | Mn-54 0.07<br>Co-58 0.20<br>Co-60 0.02<br>Sr-89 0.18<br>Cs-137 30.2<br>H-3 280.0<br>Te-127m 0.12<br>Te-129m 0.40<br>Fe-55 0.05 | Activities which make up 99% of total activity and have a half-life greater than 30 days. Tritium tank activity based on the design basis concentration value of 4 µCi/g. |
| Nuclide activity values (Curies) for concentrate tank (per tank) | Mn-54 23.7<br>Co-58 50.4<br>Co-60 8.76<br>Sr-89 38.7<br>Cs-137 1.13E+04<br>H-3 136.0<br>Te-127m 35.0<br>Te-129m 68.7<br>Fe-55 19.3<br>Fe-59 2.68<br>Zn-65 7.39<br>Nb-95 8.27<br>Ce-144 6.51<br>Zr-95 6.22<br>Y-91 5.67 | Activities which make up 99% of total activity and have a half-life greater than 30 days. Tritium tank activity based on the design basis concentration value of 4 µCi/g. |
| Shoreline width factor | 1.0 for tidal basis | Table A-2 of RG 1.109 |
| Mixing ratio | 5.7E-04 | Assumption |
| Transit time | 24 hours for aquatic food; zero for all others | Assumptions and default values from RG 1.109 |
| Sediment exposure time | 1 hour | Assumption |
| Usage factors | AGE / FISH (KG/YR) / INVERT. (KG/YR) / SHORELINE (HR/YR)<br>ADULT 21 5 12<br>TEEN 16 3.8 67<br>CHILD 6.9 1.7 14 | Table E-5 of RG 1.109 |

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 11.2.3.7 and Tables 11.2-5, 11.2-6, and 11.2-9 will be updated as discussed in the response and the FSAR markups provided by March 31,2010.

**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(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 updated to include the references and assumptions for the GASPAR II input parameters used in calculating doses to the maximally exposed individual, plus the added parameter for the nearest residence.

**Response to Question 11.03-15 (b):**

Table 11.03-15-2 presents results for all age groups and all organs of RG 1.109. As shown in the table, the total body dose and the skin dose are the same for all age groups.

U.S. EPR FSAR Tier 2, Table 11.3-5 will be updated to include additional dose results for these four age groups and additional organs.

**Response to Question 11.03-15 (c):**

U.S. EPR FSAR Tier 2, Table 11.3-7 provides input parameters for the GASPAR code, and is reproduced in this response as Table 11.03-15-3 with the reference or justification for the parameters. This includes a correction to the value given for vegetable production. Tables 11.03-15-4 to 11.03-15-11 provide the breakdown by sector and distance of the population, agricultural production, and dispersion factors that were used as input into the GASPAR code. The site in the LADTAP analysis is also used in the GASPAR analysis.

The basis for the airborne source term in U.S. EPR FSAR Tier 2, Table 11.3-7 will be changed to U.S. EPR FSAR Tier 2, Table 11.3-3. U.S. EPR FSAR Tier 2, Section 11.3.4.1 will be revised to correct the table citation from Table 11.3-4 to Table 11.3-7.

U.S. EPR FSAR Tier 2, Table 11.3-7 will be updated to include the references and assumptions for the GASPAR II input parameter used in calculating population doses.

**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**

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 | 1.02E+00 | | | | | | | 9.75E+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 | |
| 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 | |

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

**Sheet 2 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 |
| 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 | 1.03E+00 | 4.76E-01 | 1.97E+00 | 4.82E-01 | 4.81E-01 | 2.48E+00 | 4.69E-01 | 9.76E+00 |
| TEEN | 1.03E+00 | 6.78E-01 | 2.97E+00 | 6.93E-01 | 6.91E-01 | 3.57E+00 | 6.70E-01 | 9.76E+00 |
| CHILD | 1.03E+00 | 1.48E+00 | 6.94E+00 | 1.52E+00 | 1.51E+00 | 7.06E+00 | 1.48E+00 | 9.76E+00 |
| INFANT | 1.03E+00 | 9.04E-01 | 3.87E+00 | 9.65E-01 | 9.44E-01 | 9.90E+00 | 9.06E-01 | 9.76E+00 |

**Table 11.03-15-3—Source References/Justification for GASPAR II Input Parameters used for Gaseous Waste Cost-Benefit Analysis – Saltwater Site**

| Parameter | Value | Reference or justification |
|---|---|---|
| 50-mile population | 8.1E+06 | Actual salt water site value |
| Cow milk | 2.3E+08 kg/yr | USDA National Agricultural Statistics Services 2002 Census of Agriculture. |
| Meat[1] | 3.6E+07 kg/y | USDA National Agricultural Statistics Services 2002 Census of Agriculture, "Slaughtered Cattle Average Live and Dressed Weights" www.cattlerange.com |
| Vegetable[2] | 5.62E+11 kg/yr | USDA National Agricultural Statistics Services 2002 Census of Agriculture. |
| Fraction of year that animals are on pasture | 0.583 | NOAA 2002 Local Climatological Data – Annual Summary with Comparative Data |
| Average humidity during growing season[3] | 8.4 $g/m^3$ | NUREG/CR-3332 |
| | | |
| Atmospheric dispersion factor | 5.0E-06 $s/m^3$ | Highest sector at 0.5 miles from actual site |

[1] Value represents total meat production (beef + poultry).

[2] The grain data was entered into GASPAR II as a single value for the total production within 50 miles because the GASPAR II code does not accept values with an order of magnitude of 1E+10 by sector and distance. The distribution overestimates the vegetable production nearest the site and underestimates production at the 40 and 50 mile distances. This computer generated grain production distribution results in higher calculated doses compared to actual production distribution because more vegetation is exposed to the higher effluent concentrations near the site.

[3] The average humidity over the growing season, 8.4 $g/m^3$, is used as an input in the GASPAR II code. Temperature is only used as an input to the GASPAR II code to calculate absolute humidity. This requires relative humidity to be entered into the GASPAR II code. Because absolute humidity was known, a value of 0 was entered into the GASPAR II code for temperature.

**Table 11.03-15-4—Site Population Data within 50 miles of the Site for Year 2080 (Projected)**

| Direction | Distance (miles) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **0-1** | **1-2** | **2-3** | **3-4** | **4-5** | **5-10** | **10-20** | **20-30** | **30-40** | **40-50** |
| N | 0 | | | | | | | 15248 | 198666 | 229286 |
| NNE | 0 | | | | | | 761 | 12217 | 46412 | 37244 |
| NE | 0 | | | | | 2 | 2285 | 16825 | 56137 | 65256 |
| ENE | 0 | | | | | 1357 | 3736 | 37475 | 24945 | 73387 |
| E | 0 | | | | | 78 | 529 | 1048 | 12247 | 180306 |
| ESE | 0 | | | | | 0 | 1588 | 1331 | 8460 | 30493 |
| SE | 0 | 0 | 877 | 0 | 583 | | 410 | 0 | 1885 | 13099 |
| SSE | 0 | 0 | 102 | 3019 | 10050 | 19851 | 3764 | 6273 | 3627 | 5347 |
| S | 0 | 208 | 760 | 586 | 4662 | 36849 | 161461 | 15423 | 17607 | 14300 |
| SSW | 0 | 133 | 642 | 443 | 632 | 46744 | 127297 | 7449 | 20209 | 12820 |
| SW | 0 | 1020 | 0 | 512 | 177 | 22605 | 66962 | 6987 | 6540 | 9159 |
| WSW | 0 | 2657 | 2176 | 202 | 1380 | 17573 | 59633 | 30712 | 47148 | 28877 |
| W | 93 | 1339 | 896 | 543 | 1107 | 5214 | 90987 | 61796 | 52610 | 203614 |
| WNW | 0 | 171 | 183 | 264 | 1569 | 8441 | 68358 | 368479 | 366222 | 1527435 |
| NW | 0 | 2154 | 3587 | 3215 | 989 | 7490 | 32522 | 45700 | 521566 | 2081727 |
| NNW | 0 | 0 | | | | 2226 | 63612 | 45177 | 165248 | 490640 |

Note: Numbers are not shown for sectors with no land area, and therefore no population.

**Table 11.03-15-5—Cow Milk Production (kg/yr) within 50 miles of the Site[1]**

| Sector | Distance (miles) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | Total |
| N | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 833,415 | 2,333,561 | 4,650,453 | 7,817,428 |
| NNE | 0 | 0 | 0 | 0 | 0 | 0 | 135,413 | 1,354,135 | 6,908,886 | 8,472,875 | 16,871,309 |
| NE | 0 | 0 | 0 | 0 | 0 | 62,506 | 925,090 | 1,918,358 | 15,842,533 | 20,368,971 | 39,117,458 |
| ENE | 0 | 0 | 0 | 0 | 0 | 312,530 | 2,450,239 | 3,333,658 | 15,842,533 | 5,377,944 | 27,316,904 |
| E | 0 | 0 | 0 | 0 | 0 | 312,530 | 2,500,244 | 4,167,073 | 5,833,902 | 7,500,731 | 20,314,479 |
| ESE | 0 | 0 | 0 | 0 | 0 | 62,506 | 2,250,219 | 2,083,536 | 4,083,731 | 7,125,694 | 15,605,687 |
| SE | 0 | 0 | 0 | 0 | 0 | 187,518 | 500,049 | 833,415 | 1,458,475 | 3,000,292 | 5,979,749 |
| SSE | 0 | 0 | 0 | 0 | 0 | 406,290 | 500,049 | 833,415 | 280,905 | 361,163 | 2,381,821 |
| S | 0 | 0 | 0 | 0 | 0 | 531,302 | 2,250,219 | 1,003,231 | 2,247,238 | 3,250,470 | 9,282,460 |
| SSW | 0 | 0 | 0 | 0 | 0 | 500,049 | 1,875,183 | 1,244,007 | 2,809,048 | 2,889,306 | 9,317,593 |
| SW | 0 | 0 | 0 | 0 | 0 | 531,302 | 2,125,207 | 802,585 | 2,809,048 | 3,611,633 | 9,879,775 |
| WSW | 0 | 0 | 0 | 0 | 0 | 437,543 | 2,500,244 | 2,083,536 | 2,387,691 | 3,611,633 | 11,020,646 |
| W | 0 | 0 | 0 | 0 | 0 | 500,049 | 2,250,219 | 3,750,365 | 4,667,121 | 2,889,306 | 14,057,061 |
| WNW | 0 | 0 | 0 | 0 | 0 | 625,061 | 2,125,207 | 4,167,073 | 2,528,143 | 3,069,888 | 12,515,372 |
| NW | 0 | 0 | 0 | 0 | 0 | 562,555 | 2,250,219 | 4,167,073 | 5,833,902 | 0 | 12,813,748 |
| NNW | 0 | 0 | 0 | 0 | 0 | 187,518 | 2,125,207 | 3,958,719 | 5,833,902 | 7,500,731 | 19,606,077 |
| Totals | 0 | 0 | 0 | 0 | 0 | 5,219,258 | 26,763,008 | 36,533,592 | 81,700,618 | 83,681,091 | 233,897,569 |

[1] GASPAR II requires milk production to be input in L/year. The above numbers were converted to L/year by dividing the density of milk by 1.03 kg/L.

**Table 11.03-15-6—Beef Production (kg/yr) within 50 miles of the Site**

| Sector | Distance (miles) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | Total |
| N | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13,430 | 37,603 | 74,937 | 125,970 |
| NNE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37,101 | 56,270 | 224,900 | 318,272 |
| NE | 0 | 0 | 0 | 0 | 0 | 91 | 1,354 | 52,560 | 86,569 | 431,670 | 572,245 |
| ENE | 0 | 0 | 0 | 0 | 0 | 457 | 3,586 | 49,468 | 86,569 | 431,670 | 571,751 |
| E | 0 | 0 | 0 | 0 | 0 | 457 | 3,659 | 61,835 | 125,767 | 161,700 | 353,419 |
| ESE | 0 | 0 | 0 | 0 | 0 | 91 | 3,293 | 30,918 | 88,037 | 136,800 | 259,138 |
| SE | 0 | 249 | 249 | 290 | 373 | 3,732 | 732 | 12,367 | 28,000 | 57,600 | 103,591 |
| SSE | 0 | 498 | 829 | 1,161 | 1,493 | 8,086 | 17,096 | 28,493 | 19,945 | 133,209 | 210,810 |
| S | 0 | 498 | 829 | 1,161 | 1,493 | 10,574 | 76,931 | 71,233 | 828,858 | 1,198,884 | 2,190,460 |
| SSW | 0 | 498 | 829 | 1,161 | 1,194 | 9,952 | 64,109 | 27,930 | 58,812 | 60,492 | 224,978 |
| SW | 0 | 498 | 539 | 755 | 597 | 10,574 | 72,657 | 18,019 | 58,812 | 75,616 | 238,066 |
| WSW | 0 | 498 | 622 | 1,161 | 896 | 8,708 | 85,479 | 71,233 | 113,668 | 171,935 | 454,199 |
| W | 0 | 498 | 663 | 1,161 | 1,493 | 9,952 | 76,931 | 62,863 | 78,230 | 205,150 | 436,940 |
| WNW | 0 | 498 | 829 | 1,161 | 1,493 | 12,440 | 42,295 | 142,465 | 115,370 | 140,092 | 456,641 |
| NW | 0 | 323 | 539 | 813 | 1,120 | 11,196 | 44,782 | 69,848 | 80,203 | 0 | 208,824 |
| NNW | 0 | 0 | 0 | 0 | 0 | 3,732 | 42,295 | 63,791 | 94,008 | 120,867 | 324,692 |
| Totals | 0 | 4,055 | 5,930 | 8,824 | 10,151 | 90,041 | 535,198 | 813,554 | 1,956,722 | 3,625,524 | 7,049,998 |

**Table 11.03-15-7—Poultry Production (kg/yr) within 50 miles of the Site**

| Sector | Distance (miles) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | Total |
| N | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NNE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43,920 | 66,612 | 74,062 | 184,594 |
| NE | 0 | 0 | 0 | 0 | 0 | 2,669 | 39,496 | 62,220 | 102,480 | 547,226 | 754,090 |
| ENE | 0 | 0 | 0 | 0 | 0 | 13,343 | 104,611 | 58,560 | 102,480 | 547,226 | 826,220 |
| E | 0 | 0 | 0 | 0 | 0 | 13,343 | 106,746 | 73,200 | 636,805 | 818,749 | 1,648,843 |
| ESE | 0 | 0 | 0 | 0 | 0 | 2,669 | 96,071 | 36,600 | 445,764 | 588,465 | 1,169,569 |
| SE | 0 | 0 | 0 | 0 | 0 | 0 | 21,349 | 14,640 | 120,446 | 247,775 | 404,210 |
| SSE | 0 | 0 | 0 | 0 | 0 | 0 | 41,296 | 68,826 | 185,492 | 238,489 | 534,103 |
| S | 0 | 0 | 0 | 0 | 0 | 0 | 185,831 | 662,471 | 1,483,934 | 2,146,405 | 4,478,641 |
| SSW | 0 | 0 | 0 | 0 | 0 | 0 | 154,859 | 821,464 | 1,854,918 | 1,907,916 | 4,739,156 |
| SW | 0 | 0 | 0 | 0 | 0 | 0 | 175,507 | 529,977 | 1,854,918 | 2,384,894 | 4,945,296 |
| WSW | 0 | 0 | 0 | 0 | 0 | 0 | 206,479 | 172,066 | 1,576,680 | 2,384,894 | 4,340,120 |
| W | 0 | 0 | 0 | 0 | 0 | 0 | 185,831 | 5 | 7 | 495,550 | 681,393 |
| WNW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 344,132 | 1,669,426 | 2,027,160 | 4,040,718 |
| NW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 14 | 0 | 20 |
| NNW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals | 0 | 0 | 0 | 0 | 0 | 32,024 | 1,318,076 | 2,888,087 | 10,099,976 | 14,408,811 | 28,746,974 |

**Table 11.03-15-8—Total Meat Production (beef and poultry) (kg/yr) within 50 miles of the Site**

| Sector | Distance (miles) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-4 | 4-5 | 5-10 | 10-20 | 20-30 | 30-40 | 40-50 | Total |
| N | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.343E+04 | 3.760E+04 | 7.494E+04 | 1.260E+05 |
| NNE | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 8.102E+04 | 1.229E+05 | 2.990E+05 | 5.029E+05 |
| NE | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.760E+03 | 4.085E+04 | 1.148E+05 | 1.890E+05 | 9.789E+05 | 1.326E+06 |
| ENE | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.380E+04 | 1.082E+05 | 1.080E+05 | 1.890E+05 | 9.789E+05 | 1.398E+06 |
| E | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 1.380E+04 | 1.104E+05 | 1.350E+05 | 7.626E+05 | 9.804E+05 | 2.002E+06 |
| ESE | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 2.760E+03 | 9.936E+04 | 6.752E+04 | 5.338E+05 | 7.253E+05 | 1.429E+06 |
| SE | 0.000E+00 | 2.490E+02 | 2.490E+02 | 2.900E+02 | 3.730E+02 | 3.732E+03 | 2.208E+04 | 2.701E+04 | 1.484E+05 | 3.054E+05 | 5.078E+05 |
| SSE | 0.000E+00 | 4.980E+02 | 8.290E+02 | 1.161E+03 | 1.493E+03 | 8.086E+03 | 5.839E+04 | 9.732E+04 | 2.054E+05 | 3.717E+05 | 7.449E+05 |
| S | 0.000E+00 | 4.980E+02 | 8.290E+02 | 1.161E+03 | 1.493E+03 | 1.057E+04 | 2.628E+05 | 7.337E+05 | 2.313E+06 | 3.345E+06 | 6.669E+06 |
| SSW | 0.000E+00 | 4.980E+02 | 8.290E+02 | 1.161E+03 | 1.194E+03 | 9.952E+03 | 2.190E+05 | 8.494E+05 | 1.914E+06 | 1.968E+06 | 4.964E+06 |
| SW | 0.000E+00 | 4.980E+02 | 5.390E+02 | 7.550E+02 | 5.970E+02 | 1.057E+04 | 2.482E+05 | 5.480E+05 | 1.914E+06 | 2.461E+06 | 5.183E+06 |
| WSW | 0.000E+00 | 4.980E+02 | 6.220E+02 | 1.161E+03 | 8.960E+02 | 8.708E+03 | 2.920E+05 | 2.433E+05 | 1.690E+06 | 2.557E+06 | 4.794E+06 |
| W | 0.000E+00 | 4.980E+02 | 6.630E+02 | 1.161E+03 | 1.493E+03 | 9.952E+03 | 2.628E+05 | 6.287E+04 | 7.824E+04 | 7.007E+05 | 1.118E+06 |
| WNW | 0.000E+00 | 4.980E+02 | 8.290E+02 | 1.161E+03 | 1.493E+03 | 1.244E+04 | 4.230E+04 | 4.866E+05 | 1.785E+06 | 2.167E+06 | 4.497E+06 |
| NW | 0.000E+00 | 3.230E+02 | 5.390E+02 | 8.130E+02 | 1.120E+03 | 1.120E+04 | 4.478E+04 | 6.985E+04 | 8.022E+04 | 0.000E+00 | 2.088E+05 |
| NNW | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 3.732E+03 | 4.230E+04 | 6.379E+04 | 9.401E+04 | 1.209E+05 | 3.247E+05 |
| Totals | 0.000E+00 | 4.058E+03 | 5.928E+03 | 8.824E+03 | 1.015E+04 | 1.221E+05 | 1.853E+06 | 3.702E+06 | 1.206E+07 | 1.803E+07 | 3.580E+07 |

**Table 11.03-15-9—Bounding Values by Sector for Undecayed, Undepleted and Gamma χ/Q Values (sec/m$^3$)**

| Sector | Downwind Distance (miles) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 7.5 | 15 | 25 | 35 | 45 |
| N | 1.892E-06 | 2.550E-07 | 1.051E-07 | 6.381E-08 | 4.469E-08 | 2.207E-08 | 1.004E-08 | 5.531E-09 | 3.870E-09 | 2.870E-09 |
| NNE | 3.168E-06 | 3.846E-07 | 1.538E-07 | 9.274E-08 | 6.496E-08 | 3.244E-08 | 1.519E-08 | 8.587E-09 | 5.938E-09 | 4.645E-09 |
| NE | 4.973E-06 | 5.982E-07 | 2.307E-07 | 1.357E-07 | 9.344E-08 | 4.537E-08 | 2.074E-08 | 1.217E-08 | 8.292E-09 | 6.225E-09 |
| ENE | 2.059E-06 | 2.559E-07 | 1.039E-07 | 6.244E-08 | 4.362E-08 | 2.183E-08 | 1.034E-08 | 6.278E-09 | 4.341E-09 | 3.294E-09 |
| E | 1.491E-06 | 2.136E-07 | 8.710E-08 | 5.299E-08 | 3.724E-08 | 1.869E-08 | 8.845E-09 | 5.180E-09 | 3.566E-09 | 2.695E-09 |
| ESE | 1.895E-06 | 2.639E-07 | 1.052E-07 | 6.238E-08 | 4.304E-08 | 2.087E-08 | 9.470E-09 | 5.388E-09 | 3.648E-09 | 2.726E-09 |
| SE | 2.353E-06 | 3.757E-07 | 1.436E-07 | 8.151E-08 | 5.430E-08 | 2.444E-08 | 1.003E-08 | 5.256E-09 | 3.406E-09 | 2.466E-09 |
| SSE | 1.336E-06 | 2.340E-07 | 9.320E-08 | 5.277E-08 | 3.501E-08 | 1.557E-08 | 6.250E-09 | 3.209E-09 | 2.054E-09 | 1.473E-09 |
| S | 1.826E-06 | 3.116E-07 | 1.163E-07 | 6.525E-08 | 4.284E-08 | 1.872E-08 | 7.426E-09 | 3.788E-09 | 2.423E-09 | 1.739E-09 |
| SSW | 1.604E-06 | 2.842E-07 | 1.073E-07 | 6.005E-08 | 3.950E-08 | 1.729E-08 | 6.858E-09 | 3.496E-09 | 2.234E-09 | 1.603E-09 |
| SW | 1.573E-06 | 2.658E-07 | 9.901E-08 | 5.516E-08 | 3.623E-08 | 1.585E-08 | 6.292E-09 | 3.210E-09 | 2.102E-09 | 1.535E-09 |
| WSW | 1.086E-06 | 2.111E-07 | 8.133E-08 | 4.575E-08 | 3.015E-08 | 1.320E-08 | 5.210E-09 | 2.616E-09 | 1.766E-09 | 1.277E-09 |
| W | 8.274E-07 | 1.681E-07 | 6.807E-08 | 3.913E-08 | 2.610E-08 | 1.161E-08 | 4.850E-09 | 2.427E-09 | 1.537E-09 | 1.095E-09 |
| WNW | 6.060E-07 | 1.125E-07 | 4.888E-08 | 2.940E-08 | 2.104E-08 | 1.003E-08 | 4.213E-09 | 2.419E-09 | 1.575E-09 | 1.235E-09 |
| NW | 7.037E-07 | 1.358E-07 | 5.738E-08 | 3.403E-08 | 2.322E-08 | 1.082E-08 | 4.558E-09 | 2.635E-09 | 1.760E-09 | 1.287E-09 |
| NNW | 1.523E-06 | 2.587E-07 | 1.037E-07 | 6.040E-08 | 4.090E-08 | 1.980E-08 | 9.140E-09 | 5.093E-09 | 3.273E-09 | 2.358E-09 |

**Table 11.03-15-10—Normal Effluent Annual Average, Depleted χ/Q Values (sec/m$^3$)**

| Sector | Downwind Distance (miles) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 7.5 | 15 | 25 | 35 | 45 |
| N | 1.732E-06 | 2.237E-07 | 9.128E-08 | 5.502E-08 | 3.827E-08 | 1.863E-08 | 8.239E-09 | 4.429E-09 | 3.076E-09 | 2.251E-09 |
| NNE | 2.900E-06 | 3.343E-07 | 1.315E-07 | 7.849E-08 | 5.452E-08 | 2.678E-08 | 1.218E-08 | 6.718E-09 | 4.577E-09 | 3.573E-09 |
| NE | 4.553E-06 | 5.187E-07 | 1.957E-07 | 1.134E-07 | 7.715E-08 | 3.659E-08 | 1.608E-08 | 9.286E-09 | 6.196E-09 | 4.574E-09 |
| ENE | 1.889E-06 | 2.227E-07 | 8.846E-08 | 5.295E-08 | 3.684E-08 | 1.815E-08 | 8.344E-09 | 5.027E-09 | 3.423E-09 | 2.565E-09 |
| E | 1.369E-06 | 1.868E-07 | 7.688E-08 | 4.642E-08 | 3.241E-08 | 1.606E-08 | 7.432E-09 | 4.299E-09 | 2.922E-09 | 2.187E-09 |
| ESE | 1.739E-06 | 2.342E-07 | 9.220E-08 | 5.411E-08 | 3.703E-08 | 1.765E-08 | 7.780E-09 | 4.348E-09 | 2.896E-09 | 2.136E-09 |
| SE | 2.163E-06 | 3.375E-07 | 1.269E-07 | 7.110E-08 | 4.680E-08 | 2.051E-08 | 8.041E-09 | 4.062E-09 | 2.556E-09 | 1.808E-09 |
| SSE | 1.231E-06 | 2.123E-07 | 8.352E-08 | 4.665E-08 | 3.058E-08 | 1.323E-08 | 5.068E-09 | 2.506E-09 | 1.558E-09 | 1.092E-09 |
| S | 1.689E-06 | 2.834E-07 | 1.039E-07 | 5.734E-08 | 3.710E-08 | 1.568E-08 | 5.856E-09 | 2.837E-09 | 1.740E-09 | 1.205E-09 |
| SSW | 1.496E-06 | 2.616E-07 | 9.708E-08 | 5.345E-08 | 3.466E-08 | 1.468E-08 | 5.487E-09 | 2.656E-09 | 1.628E-09 | 1.127E-09 |
| SW | 1.464E-06 | 2.434E-07 | 8.898E-08 | 4.876E-08 | 3.156E-08 | 1.336E-08 | 5.014E-09 | 2.440E-09 | 1.548E-09 | 1.098E-09 |
| WSW | 1.010E-06 | 1.953E-07 | 7.394E-08 | 4.092E-08 | 2.658E-08 | 1.125E-08 | 4.198E-09 | 2.007E-09 | 1.320E-09 | 9.215E-10 |
| W | 6.476E-07 | 1.585E-07 | 6.337E-08 | 3.597E-08 | 2.372E-08 | 1.027E-08 | 4.114E-09 | 1.979E-09 | 1.216E-09 | 8.447E-10 |
| WNW | 4.258E-07 | 1.054E-07 | 4.553E-08 | 2.714E-08 | 1.931E-08 | 9.046E-09 | 3.679E-09 | 2.079E-09 | 1.327E-09 | 9.476E-10 |
| NW | 5.722E-07 | 1.266E-07 | 5.305E-08 | 3.117E-08 | 2.108E-08 | 9.629E-09 | 3.918E-09 | 2.217E-09 | 1.410E-09 | 9.518E-10 |
| NNW | 1.406E-06 | 2.349E-07 | 9.306E-08 | 5.361E-08 | 3.594E-08 | 1.711E-08 | 7.709E-09 | 4.122E-09 | 2.563E-09 | 1.787E-09 |

**Table 11.03-15-11—Normal Effluent Annual Average, D/Q Values (sec/m$^3$)**

| Sector | Downwind Distance (miles) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | 1.5 | 2.5 | 3.5 | 4.5 | 7.5 | 15 | 25 | 35 | 45 |
| N | 1.327E-08 | 1.491E-09 | 4.727E-10 | 2.363E-10 | 1.415E-10 | 5.126E-11 | 1.657E-11 | 7.141E-12 | 4.065E-12 | 2.645E-12 |
| NNE | 2.085E-08 | 2.169E-09 | 6.685E-10 | 3.305E-10 | 1.972E-10 | 7.134E-11 | 2.336E-11 | 1.020E-11 | 5.883E-12 | 3.846E-12 |
| NE | 3.799E-08 | 3.887E-09 | 1.187E-09 | 5.842E-10 | 3.481E-10 | 1.257E-10 | 4.116E-11 | 1.796E-11 | 1.036E-11 | 6.794E-12 |
| ENE | 1.614E-08 | 1.785E-09 | 5.608E-10 | 2.803E-10 | 1.684E-10 | 6.158E-11 | 2.039E-11 | 9.098E-12 | 5.354E-12 | 3.558E-12 |
| E | 1.192E-08 | 1.292E-09 | 4.016E-10 | 1.992E-10 | 1.192E-10 | 4.314E-11 | 1.408E-11 | 6.187E-12 | 3.598E-12 | 2.379E-12 |
| ESE | 1.936E-08 | 1.982E-09 | 6.009E-10 | 2.942E-10 | 1.746E-10 | 6.243E-11 | 2.011E-11 | 8.637E-12 | 4.936E-12 | 3.232E-12 |
| SE | 2.727E-08 | 2.932E-09 | 8.910E-10 | 4.358E-10 | 2.585E-10 | 9.208E-11 | 2.916E-11 | 1.249E-11 | 7.309E-12 | 4.971E-12 |
| SSE | 1.478E-08 | 1.832E-09 | 5.795E-10 | 2.873E-10 | 1.717E-10 | 6.146E-11 | 1.917E-11 | 8.182E-12 | 4.764E-12 | 3.222E-12 |
| S | 2.851E-08 | 3.320E-09 | 1.033E-09 | 5.124E-10 | 3.066E-10 | 1.105E-10 | 3.553E-11 | 1.563E-11 | 9.244E-12 | 6.270E-12 |
| SSW | 2.217E-08 | 2.713E-09 | 8.590E-10 | 4.293E-10 | 2.580E-10 | 9.350E-11 | 3.010E-11 | 1.336E-11 | 7.981E-12 | 5.453E-12 |
| SW | 2.169E-08 | 2.665E-09 | 8.368E-10 | 4.156E-10 | 2.488E-10 | 8.955E-11 | 2.833E-11 | 1.229E-11 | 7.827E-12 | 6.976E-12 |
| WSW | 1.249E-08 | 1.814E-09 | 5.920E-10 | 2.987E-10 | 1.801E-10 | 6.518E-11 | 2.034E-11 | 8.724E-12 | 5.933E-12 | 5.879E-12 |
| W | 6.930E-09 | 1.105E-09 | 3.725E-10 | 1.908E-10 | 1.158E-10 | 4.230E-11 | 1.336E-11 | 6.023E-12 | 3.789E-12 | 2.736E-12 |
| WNW | 4.991E-09 | 7.622E-10 | 2.577E-10 | 1.324E-10 | 8.075E-11 | 2.957E-11 | 9.447E-12 | 4.464E-12 | 3.379E-12 | 3.924E-11 |
| NW | 7.858E-09 | 1.047E-09 | 3.420E-10 | 1.734E-10 | 1.049E-10 | 3.830E-11 | 1.239E-11 | 6.396E-12 | 2.311E-11 | 5.170E-11 |
| NNW | 1.913E-08 | 2.286E-09 | 7.238E-10 | 3.615E-10 | 2.170E-10 | 7.860E-11 | 2.525E-11 | 2.559E-11 | 3.305E-11 | 3.548E-11 |

**FSAR Impact:**

U.S. EPR FSAR Tier 2, Section 11.3.4.1, and Tables 11.3-4 and 11.3-7 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Tables 11.3-4, 11.3-5 and 11.3-7 will be updated as discussed in the response and the FSAR markups provided by March 31,2010.

# U.S. EPR Final Safety Analysis Report Markups

## 11.3.4 Gaseous 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 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. 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.

11.03-15(c)

The GASPAR II code (Reference 2) was used to determine the population doses for both cases. Input parameters are given in Table 11.3-74. 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 11.3-47.

11.03-15(c)

### 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

**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 11.03-15(a) → | GALE (Table 11.3-32–4, 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—Input Parameters for the GASPAR II Computer Code used in Gaseous Waste Cost-Benefit Analysis**

| Parameter | Value |
|---|---|
| Source Term 11.03-15(c) | GALE (Table 11.3-32-4, "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—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 |

Next File