11.0 RADIOLOGICAL EFFLUENT RELEASE DOSE CONSEQUENCES FROM NORMAL OPERATIONS

11.1 Introduction

Because the original SSAR submitted by the applicant did not contain a Chapter 11 gaseous and liquid radiological dose analysis, the NRC staff evaluated Environmental Report (ER) Chapter 5, Section 5.4 of the ESP application, Revision 1. Subsequently, the NRC staff informed the applicant, in a RAI dated February 16, 2007, that the SSAR did not comply with 10 CFR 52.17(a)(1) and 10 CFR 100.21(c)(1). By letter dated May 3, 2007, the applicant provided its response to the NRC staff's RAI. The applicant submitted Revision 2 of the ESP application, including SSAR Chapter 11, "Radioactive Waste Management." Chapter 11, Sections 11.2 and 11.3, contain the analysis for the gaseous and liquid radioactive effluents.

11.2 Regulatory Evaluation

The acceptance criteria for addressing radiological doses to members of the public from radiological effluents due to postulated normal plant operations are based on meeting the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100. The NRC staff considered the following regulatory requirements in reviewing the applicant's discussion and analysis of radiological doses to members of the public from radiological effluents due to postulated normal plant operations:

- 10 CFR 52.17(a), which requires that the application contain a description of the anticipated maximum levels of radiological and thermal effluents each proposed facility will produce.

- 10 CFR 100.21(c), which requires that site atmospheric dispersion characteristics be evaluated and dispersion parameters established such that (1) radiological effluent release limits associated with normal operation from the type of facility to be located at the site can be met for any individual located offsite; (2) radiological dose consequences of postulated accidents shall meet the criteria set forth in 10 CFR 50.34(a)(1) for the type of facility proposed to be located at the site.

The information assembled in compliance with the above regulatory requirements would be necessary, at the COL or CP stage, to assess whether the proposed facility will control, monitor, and maintain radioactive gaseous and liquid effluents from the proposed facility within the regulatory limits (including the referenced dose standards in 40 CFR Part 190) specified in 10 CFR Part 20 as well as maintain radiological effluents at as low as reasonably achievable (ALARA) levels, in accordance with the dose objective of Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents", to 10 CFR Part 50. Table 11.2-1 provides a quantitative summary of the above standards.

To the extent applicable under the above-cited regulatory requirements, the applicant applied the NRC-endorsed analytical methodologies and parameters found in RG 1.109, Revision 1, issued October 1977, and RG 1.111, Revision 1, issued July 1977. When independently

assessing the accuracy of the information presented by the applicant in SSAR Chapter 11, the NRC staff applied the same above-cited analytical methodologies and parameters.

Table 11.2-1 - NRC Staff's Summary of 10 CFR Part 50 Appendix I Dose Objectives and 40 CFR Part 190 Environmental Dose Standards

Regulation	Type of Effluent	Pathway	Organ	Dose Limit (mrem/yr per unit)
10 CFR Part 50, Appendix I *	Liquid	all	total body	3
		all	any organ	10
	Gaseous	all	total body	5
		all	skin	15
	Radioiodines & Particulates	all	any organ	15
	Gaseous	gamma air dose	n/a	10***
		beta air dose	n/a	20***
40 CFR Part 190 **	all	all	total body	25#
	all	all	thyroid	75#
	all	all	any other organs	25#

Notes:

* Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50,"Domestic Licensing of Production and Utilization Facilities," defines dose objectives for the maximally exposed individual (MEI).

** Dose limits are defined for any real member of the public. Under NRC requirements, this standard is implemented under 10 CFR Part 20.1301(e).

*** Air doses are expressed in mrad/year instead of mrem/year.

40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." dose limits are for the entire site and apply to all operating units.

11.3 Technical Evaluation

The applicant provided estimates of radiological impacts on members of the public from gaseous and liquid effluents that would be generated as a normal byproduct of nuclear power operations. This included a description of the exposure pathways by which radiation and radioactive effluents could be transmitted to members of the public within a 50-mile (80 Km) radius from the site. The estimates of the maximum doses to the public are based on the AP1000 reactor's normal operational effluent releases, as discussed in Westinghouse Electric Company, LLC, AP1000 Design Control Document, Revision 15, November 11, 2005. The applicant evaluated the impact of these doses by comparing them to applicable regulatory limits.

The applicant also provided a list of fission and activation products that may be released in liquid and gaseous effluents from the two proposed units. The applicant evaluated the impacts from effluent releases and direct radiation by considering the probable pathways to individuals, populations, and biota near the proposed new units. The applicant also calculated the highest dose from the major exposure pathways for a given specific receptor. In addition, the applicant estimated the dose to the maximally exposed individual (MEI) from both the liquid and gaseous effluent release pathways, and calculated a collective whole body dose for the population within 50 miles (80 km) of the Vogtle site. The NRC staff's analysis of the gaseous and liquid radioactive effluents is provided in the following sections 11.3.1 and 11.3.2.

11.3.1 Gaseous Effluents

The applicant provided an analysis describing the exposure pathways by which radiation and radioactive effluents could be transmitted from the new units to individuals living near the plant, and estimated the maximum doses to the public.

The applicant calculated the total body and individual organ dose to a hypothetical maximally-exposed member of the public from gaseous effluents using radiological exposure models based on RG 1.109, the GASPAR II computer program (NUREG/CR-4653, "GASPAR II - Technical Reference and User Guide," March 1987), and RG 1.111. Section 2.3.5 of the SSAR discusses the derivation of the atmospheric dispersion parameters, and presents specific values for the dispersion and deposition parameters used in the applicant's radiological dose assessment.

The applicant calculated the gaseous pathway doses to the MEI at the nearest site boundary, residence, garden, and meat animal. The applicant did not include the milk consumption pathway for the maximally-exposed individual because the current land use census found no milk producing animals within 5 miles of the facility. The applicant did, however, include milk consumption for the population dose calculation. The applicant estimated the site boundary dose for noble gas plume immersion, ground shine from deposited radioactive iodine and particulate radionuclides, and inhalation of radio-iodine, and particulate radionuclides (including tritium and carbon-14). The applicant also estimated the dose for the current MEI receptor based on plume and ground plane exposure, inhalation, and ingestion of cow meat and garden vegetables.

In Table 11.3-3 of the SSAR, the applicant provided an estimate of the radiological releases associated with gaseous effluents that may occur during normal operation of the plant. The

applicant obtained estimates of gaseous radioactive effluent releases from Table 11.3-3 of the NRC staff approved DCD for the AP1000.

These gaseous effluent releases are used to estimate doses at the site boundary and to the MEI. Tables 11.3-1, 11.3-2, and 11.3-4 of the SSAR include other calculation input data, including regional milk, meat and vegetable production rates, atmospheric dispersion and ground deposition factors, receptor locations, and the assumed consumption rates of food products by the MEI.

As shown in Tables 11.3-5 and 11.3-6 of the SSAR, the applicant calculated the gaseous pathway doses to the MEI for the site boundary, the nearest residence and garden and meat animal. The results show for the site boundary a gamma annual air dose of 0.0067 milliGray (mGy) or 0.67 millirad (mrad), a beta annual air dose of 0.028 mGy or 2.8 mrads; a total annual body dose of 0.0056 milliSieverts (mSv) or 0.56 millirem (mrem) and an annual skin dose of 0.022 mSv or 2.2 mrem. Table 11.3-6 of the SSAR also lists the maximum annual organ dose (thyroid) of 0.059 mSv or 5.9 mrem for the child.

Using the GASPAR II code and the applicant's input data, the NRC staff performed an independent evaluation of the applicant's gaseous effluent pathway doses, and the NRC staff calculations achieved results similar to that of the applicant. Therefore, the NRC staff finds that the applicant's calculated doses are correct and appropriate per the applicable dose criteria listed in SER Table 11.2-1.

The applicant also compared the MEI doses with the exposure criteria of 40 CFR Part 190, as would be required of the applicant at the COL stage, per 10 CFR 20.1301(e). The applicant's results are presented in Table 11.3-7 of the SSAR and included the sum of doses from the two proposed units and the two existing units. For the total site, the applicant's results were less than the maximum doses specified in 40 CFR Part 190.10(a) of 25 mrem/yr whole body, 75 mrem/yr thyroid, and 25 mrem/yr any other organ (Table 11.2-1):

- 2.4 mrem/yr (0.024 mSv) for the whole body,
- 12 mrem/yr (0.12 mSv) for the thyroid, and
- 8.9 mrem/yr (0.089 mSv) to bone.

As such, the NRC staff find that the applicant's results would comply with the requirements of 40 CFR Part 190 and 10 CFR Part 20.1301(e).

Based on the above, the NRC staff concludes that the applicant has provided a bounding assessment for gaseous effluents, demonstrating its capability to comply with the regulatory requirements in 10 CFR Part 20 and Appendix I to 10 CFR Part 50 given the atmospheric dispersion parameters set forth in Section 2.3.5 of the NRC staff's SER.

11.3.2 Liquid Effluents

If built, the postulated two new units at the Vogtle site would release liquid effluents into the Savannah River through a newly constructed discharge structure. The applicant calculated liquid pathway doses for several pathways, including eating fish caught in the Savannah River, drinking Savannah River water, shoreline exposure, and exposure from swimming and boating. The applicant excluded crop irrigation and livestock watering because the results of the most recent land use censuses described in the 2005 Radiological Environmental Operating Report for Vogtle Electric Generating Plant, Units 1 and 2, confirmed that the Savannah River is not used for these purposes within 100 miles downstream of the site.

In its response to the NRC staff's RAI dated May 3, 2007, the applicant provided a description of all required model assumptions and input parameters needed to run LADTAP II computer codes; justification for excluding potential exposure pathways; and its basis for using a dilution factor.

Using radiological exposure models based on RG 1.109 and the LADTAP II computer program (NUREG/CR-4013, "LADTAP II - Technical Reference and User Guide," April 1986), the applicant calculated the estimated doses to a hypothetical MEI of the public and to the population within 50 miles (80 Km) from the postulated liquid effluents discharged.

In Table 11.2-3 of the SSAR, the applicant listed the estimated radiological source terms associated with liquid effluents that may be released from normal operation of the plant. The applicant obtained these estimates of liquid radioactive effluent from the NRC staff-approved AP1000 DCD, Table 11.2-7. Tables 11.2-1 and 11.2-2 of the SSAR include other liquid pathway parameters used as input to the dose calculation, including effluent discharge flow rate, site-specific dilution factors, transit time to receptor and consumption factors rates for fish and water, and recreational usage data for the Savannah River. The analysis assumed direct releases into the Savannah River without dilution by the discharge flow of the plant. The liquid effluent release parameters shown in Tables 11.2-1, 11.2-2, and 11.2-3 were then used to calculate the annual liquid pathway doses to the MEI (SSAR Table 11.2-4). The applicant calculated a maximum annual dose to the total body of 0.00017 mSv (0.017 mrem) and a maximum annual dose to the liver of 0.00021 mSv (0.021 mrem). The applicant compared the MEI doses with the 10 CFR Part 50, Appendix I criteria in Table 11.2-5 of the SSAR. The NRC staff reviewed these calculated doses and found that the applicant's analysis would satisfy, at the COL stage, 10 CFR Part 50, Appendix I, Section II.A dose requirements for the MEI.

The applicant also analyzed whether the above-discussed data would comply with the exposure criteria of 40 CFR Part 190, as would be required to be demonstrated by the applicant at the COL stage, per 10 CFR 20.1301(e). The applicant's results are presented in SSAR Tables 11.2-6 and 11.2-7 for the MEI; the applicant's results are less than the maximum doses specified in 40 CFR Part 190.10(a) of 25 mrem/yr whole body, 75 mrem/yr thyroid, and 25 mrem/yr any other organ (Table 11.2-1). Therefore, the NRC staff determined that the applicant's analysis would meet the requirements of 40 CFR Part 190 and 10 CFR 20.1301(e).

The NRC staff performed an independent assessment and determined that the applicant's results represent conservative upper bound estimates for three reasons:

- First, the applicant assumed the drinking of Savannah River water when no such use has been shown to exist within 100 miles downstream of the site.

- Second, the applicant ignored the dilution from the plant discharge water.

- Third, the applicant used a low estimate of annual average river flow.

Table 11.3-1 below shows the comparison of important input values between the applicant's and the NRC staff's analyses. Table 11.3-2 compares the resulting dose estimates between the applicant's and the NRC staff's analyses. These tables show that the assumptions and parameters used by the applicant result in about an order of magnitude higher total body and maximum organ doses when compared to the NRC staff's independent assessment.

The NRC staff concludes that the applicant has provided a bounding assessment demonstrating its capability to comply in the future, at the COL stage, with the regulatory requirements in 10 CFR Part 20 and Appendix I, to 10 CFR Part 50.

Table 11.3-1 - Comparison of Input Parameters

Pathways and Parameters	Application	NRC Staff's Analysis
Drinking water pathway	Yes	No*
Fish ingestion pathway	Yes	Yes
Recreational use of river	Yes	Yes
Annual average river flow (ft3/sec)	9,229	10,362**
Plant discharge flow (ft3/sec)	0	10.7***

*The current land use census does not identify any withdrawal of Savannah River water for drinking or irrigation for 100 miles downstream of the site.

**Average of annual mean stream flow calculated from 50 years of data for Burtons Ferry, Environmental Report (ER) Table 2.3.1-9.

***Taken from ER Table 3.3-1 and assuming single unit discharge.

Table 11.3-2 - Comparison of Maximum Individual Doses (mrem/yr)

Organ/Body	Application	NRC Staff's Analysis
Skin	7.2 E-05	6.5 E-05
Bone	1.2 E-02	1.0 E-02
Liver	2.1 E-02	1.2 E-02
Total Body	1.7 E-02	1.0 E-03
Thyroid	1.5 E-02	1.0 E-03
Kidney	1.2 E-02	4.0 E-03
Lung	8.9 E-03	1.5 E-03
GI-Tract and Lower Large Intestine	8.6 E-03	3.9 E-04

11.4 Conclusion

As set forth above, the NRC staff has independently confirmed the adequacy of the applicant's dose consequence calculations from normal operations. The applicant provided adequate information to give reasonable assurances that it will control and maintain radioactive gaseous and liquid effluents from the proposed facility within the regulatory limits specified in 10 CFR Part 20, as well as maintain radiological effluents at ALARA levels, in accordance with Appendix I to 10 CFR Part 50. Based upon the foregoing, the NRC staff concludes that the postulated radiological doses to members of the public from radiological gaseous and liquid effluents resulting from the normal operation of one or more new nuclear power plants constructed on the proposed site would not pose an undue risk to the health and safety of the public. Therefore, the NRC staff concludes that, with respect to radiological effluent release dose consequences from normal operations, that the proposed site is acceptable for the applicant's chosen type of nuclear plant, and that the application meets the relevant requirements of 10 CFR 52.17 and 10 CFR Part 100.