

11.0 RADIOACTIVE WASTE MANAGEMENT

The radioactive waste management systems are designed to control, collect, handle, process, store, and dispose of liquid, gaseous, and solid wastes that may contain radioactive materials. The systems include the instrumentation used to monitor and control the release of radioactive effluents and wastes and are designed for normal operation (including refueling; purging; fuel handling and storage; radioactive material handling, processing, use, storage, and disposal; maintenance; routine operational surveillance; in-service inspection (ISI); and calibration), and anticipated operational occurrences (AOOs).

11.1 Source Terms

The radioactive source terms are used to identify the potential dose to members of the public and plant employees as a result of plant operation. This includes consideration of parameters used to determine the concentration of each isotope in the reactor coolant, fraction of fission product activity released to the reactor coolant, and concentrations of all non-fission product radioactive isotopes in the reactor coolant. Gaseous and liquid waste sources are considered in the evaluation of effluent releases.

Section 11.1 of the William States Lee III Nuclear Station (WLS) combined license (COL) Final Safety Analysis Report (FSAR), Revision 4, incorporates by reference, with no departures or supplements, Section 11.1, "Source Terms," of Revision 19 of the AP1000 Design Control Document (DCD). The Nuclear Regulatory Commission (NRC) staff reviewed the application and checked the referenced DCD to ensure that no issue relating to this section remained for review.¹ The NRC staff's review confirmed that there is no outstanding issue related to this section. The results of the NRC staff's technical evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793, "Final Safety Evaluation Report [FSER] Related to Certification of the AP1000 Standard Design," and its supplements.

11.2 Liquid Waste Management Systems

11.2.1 Introduction

The liquid waste management system (LWMS) is designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences.

11.2.2 Summary of Application

Section 11.2 of the WLS COL FSAR, Revision 4, incorporates by reference Section 11.2 of the AP1000 DCD, Revision 19.

¹ See Section 1.2.2 for a discussion of the staff's review related to verification of the scope of information to be included in a COL application that references a design certification (DC).

In addition, in WLS COL FSAR Section 11.2, the applicant provided the following:

AP1000 COL Information Items

- STD COL 11.2-1

The applicant provided additional information in Standard (STD) COL 11.2-1 to resolve COL Information Item 11.2-1 (COL Action Item 11.2-1). The additional information addresses the use of mobile or temporary equipment to process liquid effluents in WLS COL FSAR Section 11.2.1.2.5.2.

- STD COL 11.2-2

The applicant provided additional information in STD COL 11.2-2 regarding liquid radwaste cost-benefit analysis methodology.

- WLS COL 11.2-2

The applicant provided additional information in WLS COL 11.2-2 to resolve COL Information Item 11.2-2 (COL Action Item 11.2-2). The additional information addresses the dilution factors used for dose calculations and the cost-benefit analysis of population doses in WLS COL FSAR Sections 11.2.3.3 and 11.2.3.5.

- WLS COL 2.4-5 and WLS COL 15.7-1

WLS COL FSAR Section 11.2 does not identify WLS COL 2.4-5 and WLS COL 15.7-1 as COL information items applicable to Section 11.2. However, WLS COL 2.4-5 and WLS COL 15.7-1 provide information regarding a postulated liquid waste tank failure, which is evaluated by the NRC staff as part of liquid waste management. Therefore, WLS COL 2.4-5 and WLS COL 15.7-1 are evaluated in Section 11.2.4 of this safety evaluation report (SER). In WLS COL FSAR Section 2.4.13, the applicant performed the consequence analysis of a postulated liquid waste tank failure to address COL Information Items 2.4-5 and 15.7-1.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve COL Information Item 11.5-3 (COL Action Item 11.5-3). The additional information addresses compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," 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," Section II.A in WLS COL FSAR Section 11.2.3.5.

Supplemental Information

- STD SUP 11.2-1

The applicant added in WLS COL FSAR Section 11.2.3.6 supplemental (SUP) information to address the quality assurance (QA) program to be applied to the LWMS.

- WLS SUP 11.2-2

The applicant added supplemental information in WLS COL FSAR Section 11.2.3 to address the liquid effluent site interface parameter.

- WLS SUP 11.2-3

The applicant added supplemental information in WLS COL FSAR Section 11.2.1.2.4 regarding the exterior radwaste discharge piping.

11.2.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed in NUREG-1793 and its supplements.

In addition, the regulatory basis for acceptance of the supplementary information on the LWMS is established in:

- 10 CFR 20.1301(e)
- 10 CFR 20.1302, "Compliance with dose limits for individual members of the public"
- 10 CFR 20.1406, "Minimization of contamination"
- 10 CFR 50.34a, "Design objectives for equipment to control releases of radioactive material in effluents – nuclear power reactors"
- 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 60, "Control of releases of radioactive materials to the environment"
- 10 CFR Part 50, Appendix A, GDC 61, "Fuel storage and handling and radioactivity control"
- 10 CFR Part 50, Appendix I, Sections II.A and II.D
- 10 CFR 52.80(a)
- Title 40 of the *Code of Federal Regulations* (40 CFR) Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations"

Guidance for accepting the supplementary information on the LWMS is in:

- The codes and standards listed in Table 1 of Regulatory Guide (RG) 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Revision 2
- Regulatory Position C.1.1 of RG 1.143, Revision 2

- RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1
- RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors"
- RG 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," Revision 1
- RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning"

The acceptance criteria associated with the LWMS are given in Section 11.2 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)," and NUREG-0800, Section 2.4.13, Acceptance Criterion No. 5, including Branch Technical Position (BTP) 11-6.

11.2.4 Technical Evaluation

The NRC staff reviewed Section 11.2 of the WLS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.¹ The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the LWMS. The results of the NRC staff's evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

The staff's review of this application included the following COL information and supplementary items:

- STD COL 11.2-1, Processing of Liquid Waste by Mobile Equipment
- STD COL 11.2-2, Liquid Radwaste Cost-Benefit Analysis Methodology
- WLS COL 11.2-2, Cost-benefit Analysis of Population Doses
- WLS COL 2.4-5, Accidental Release of Liquid Effluents into Groundwater and Surface Water
- WLS COL 15.7-1, Consequences of Tank Failure
- WLS COL 11.5-3, Individual Dose Limits in 10 CFR Part 50, Appendix I
- STD SUP 11.2-1, Quality Assurance
- WLS SUP 11.2-2, Interface Requirements
- WLS SUP 11.2-3, Exterior Radwaste Discharge Piping

In addition to the above items, the staff reviewed the entire section against Section 11.2 of NUREG-0800 to determine if the information in WLS COL FSAR Section 11.2 met the regulatory requirements in the regulations stated above (SER Section 11.2.3) and the NUREG-0800 acceptance criteria. The relevant NUREG-0800 acceptance criteria are as follows:

- The LWMS should have the capability to meet the dose design objectives and include provisions to treat liquid radioactive wastes such that the following is true:
 - A. The calculated annual total quantity of all radioactive materials released from each reactor at the site to unrestricted areas will not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 0.03 millisievert (mSv) (3 millirem (mrem)) to the total body or 0.1 mSv (10 mrem) to any organ. RGs 1.109, 1.112, and 1.113 provide acceptable methods for performing this analysis.
 - B. In addition to A, the LWMS should include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return for a favorable cost-benefit ratio, can effect reductions in doses to the population reasonably expected to be within 80 kilometers (km) (50 miles (mi)) of the reactor. RG 1.110 provides an acceptable method for performing this analysis.
 - C. The concentrations of radioactive materials in liquid effluents released to unrestricted areas should not exceed the concentration limits in Table 2, Column 2 of Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage" to 10 CFR Part 20, "Standards for Protection Against Radiation."
- The LWMS should be designed to meet the anticipated processing requirements of the plant. Adequate capacity should be provided to process liquid wastes during periods when major processing equipment may be down for maintenance (single failures) and during periods of excessive waste generation. Systems that have adequate capacity to process the anticipated wastes and that are capable of operating within the design objectives during normal operation, including anticipated operational occurrences, are acceptable. To meet these processing demands, interconnections between subsystems, redundant equipment, mobile equipment, and reserve storage capacity will be considered.
- System designs should describe features that will minimize, to the extent practicable, contamination of the facility and environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste, in accordance with the guidelines of RG 1.143, for liquids and liquid wastes produced during normal operation and anticipated operational occurrences, and the requirements of 10 CFR 20.1406. These system design features should be provided in the FSAR or the COL application to the extent that they are not addressed in a referenced certified design or DC application.

- BTP 11-6, as it relates to the assessment of a potential release of radioactive liquids following the postulated failure of a tank and its components, located outside of containment, and impacts of the release of radioactive materials at the nearest potable water supply, located in an unrestricted area, for direct human consumption or indirectly through animals, crops, and food processing.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER for the reference COL application (Vogtle Electric Generating Plant((VEGP)) Units 3 and 4) were equally applicable to the WLS Units 1 and 2 COL application, the staff undertook the following reviews:

- The staff compared the VEGP COL FSAR, Revision 2, to the WLS COL FSAR. In performing this comparison, the staff considered changes made to the WLS COL FSAR (and other parts of the COL application, as applicable) resulting from requests for additional information (RAIs).
- The staff confirmed that all responses to RAIs identified in the corresponding standard content evaluation were endorsed.
- The staff verified that the site-specific differences were not relevant.

The staff has completed its review and found the evaluation performed for the standard content to be directly applicable to the WLS COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting. Section 1.2.3 of this SER provides an explanation of why the standard content material from the SER for the reference COL application (VEGP) contains evaluation material from the SER for the Bellefonte Nuclear Plant (BLN), Units 3 and 4 COL application.

The following portion of this technical evaluation section is reproduced from Section 11.2.4 of the VEGP SER:

AP1000 COL Information Items

The following portion of this technical evaluation section is reproduced from Section 11.2.4 of the BLN SER:

- *STD COL 11.2-1*

The applicant provided additional information in STD COL 11.2-1 to resolve COL Information Item 11.2-1. COL Information Item 11.2-1 states:

The Combined License applicant will discuss how any mobile or temporary equipment used for storing or processing liquid radwaste conforms to Regulatory Guide 1.143. For example, this

includes discussion of equipment containing radioactive liquid radwaste in the non-seismic Radwaste Building.

The commitment was also captured in COL Action Item 11.2-1 in Appendix F of the NRC staff's FSER for the AP1000 DCD (NUREG-1793), which states:

The COL applicant will provide information on how any mobile or temporary equipment used for storing or processing liquid radwaste conforms to RG 1.143.

The applicant provided information in BLN COL FSAR Section 11.2.1.2.5.2 that addresses how any mobile or temporary equipment that will be used for storing or processing liquid radwaste conforms to RG 1.143. For example, this includes discussion of equipment containing radioactive liquid radwaste in the non-seismic Radwaste Building. The staff issued Request for Additional Information (RAI) 11.2-5 to clarify some of the language used in the COL concerning the extent of compliance with RG 1.143 for the temporary and mobile equipment. The applicant responded to this RAI by proposing a revision to the BLN COL FSAR text to clearly state that the applicable requirements in RG 1.143 pertain to mobile and temporary equipment.

The NRC staff reviewed the resolution of COL Information Item 11.2-1 related to the use of mobile or temporary equipment included under Section 11.2 of the BLN COL FSAR and found that the applicant's commitments for installing and operating mobile systems meets the acceptance criteria in Section 11.2 of NUREG-0800 and RG 1.143. The NRC staff verified that Revision 1 of the BLN COL FSAR (STD COL 11.2-1) adequately incorporates the above. As a result, RAI 11.2-5 is closed.

- **STD COL 11.2-2**

The discussion of VEGP COL 11.2-2 addresses the site-specific cost-benefit analysis performed to address the requirements of 10 CFR Part 50, Appendix I, regarding population doses due to liquid effluents. The applicant provided additional information in STD COL 11.2-2 to resolve COL Information Item 11.2-2 with regard to the cost-benefit analysis methodology.

The NRC staff reviewed the resolution of COL Information Item 11.2-2 related to the cost-benefit analysis methodology described in VEGP FSAR Section 11.2.3.5.1 and concluded that the methodology used for the analysis was consistent with the guidance of RG 1.110 and was, therefore, acceptable.

- **WLS COL 11.2-2**

The applicant provided additional information in WLS COL 11.2-2 to resolve COL Information Item 11.2-2, which states:

The analysis performed to determine offsite dose due to liquid effluents is based upon the AP1000 generic site parameters included in Chapter 1 and

Tables 11.2-5 and 11.2-6. The Combined License [COL] applicant will provide a site specific cost-benefit analysis to address the requirements of 10 CFR 50, Appendix I, regarding population doses due to liquid effluents.

The commitment was also captured as COL Action Item 11.2-2 in Appendix F of NUREG-1793, which states:

The applicant will provide a site-specific cost-benefit analysis to demonstrate compliance with 10 CFR Part 50, Appendix I, regarding population doses due to liquid effluents.

The NRC staff reviewed the resolution of COL Information Item 11.2-2 related to the cost benefit analysis included under Section 11.2.3.5.2 of the WLS COL FSAR and issued RAI 11.2-1. This RAI stated that the applicant needed to provide a detailed and plant-specific cost-benefit analysis. The applicant provided this analysis in a response to the RAI.

The results of the applicant's analysis showed that the lowest-cost option for liquid radwaste treatment system augments is a 20 gallons per minute (gpm) cartridge filter at \$11,140 per year which yields a threshold value of 11.14 person-rem total body or thyroid dose from liquid effluents. For AP1000 sites with population dose estimates less than 11.14 person-rem total body or thyroid dose from liquid effluents, no further cost-benefit analysis is needed to demonstrate compliance with 10 CFR Part 50, Appendix I, Section II.D. The total body (0.296 person-rem) and thyroid (0.393 person-rem) population doses provided by the applicant in WLS COL FSAR Table 11.2-204 are a small fraction of the threshold dose of 11.14 person-rem. Thus, the applicant concluded that the LWMS meets the as low as reasonably achievable (ALARA) requirements and requires no augments.

The NRC staff performed an independent assessment using the population doses calculated by the staff (see following section) and the guidance in RG 1.110 and came to the same conclusion. As a result, RAI 11.2-11 is closed and COL Information Item 11.2-2 is resolved.

- WLS COL 2.4-5 and WLS COL 15.7-1

The applicant provided additional information in WLS COL 2.4-5 and WLS COL 15.7-1 to resolve COL Information Items 2.4-5 and 15.7-1.

COL Information Item 2.4-5 states:

Combined License applicants referencing the AP1000 certified design will address site-specific information on the ability of the ground and surface water to disperse, dilute, or concentrate accidental releases of liquid effluents. Effects of these releases on existing and known future use of surface water resources will also be addressed.

The commitment was also captured as COL Action Item 2.4.1-1 in Appendix F of NUREG-1793, which states:

The COL applicant will provide site specific information on the ability of the ground and surface water to disperse, dilute, or concentrate accidental releases of liquid effluents. The COL applicant will also address the effects of such releases on existing and known future use of surface water resources.

COL Information Item 15.7-1 states:

Combined License applicants referencing the AP1000 certified design will perform an analysis of the consequences of potential release of radioactivity to the environment due to a liquid tank failure as outlined in subsection 15.7.3.

The commitment was also captured as COL Action Item 15.3.8-1 in Appendix F of NUREG-1793, which states:

The COL applicant will perform a site-specific analysis of the consequences of a potential release of radioactivity to the environment as a result of a liquid tank failure.

Section 2.4.13 of the applicant's FSAR addresses accidental release of liquid effluents into ground and surface water. The applicant postulated a release of the contents of the effluent hold-up tank (or hold-up tank). BTP 11-6 provides guidance in assessing potential release of radioactive liquids at the nearest potable water supply located in an unrestricted area. BTP 11-6 further states the evaluation of the release should consider the use of water for direct human consumption or indirectly through animals (livestock watering), crops (agricultural irrigation), and food processing (water as an ingredient).

Evaluations performed by the applicant determined that the hold-up tanks have the greatest potential radionuclide inventory of all waste effluent system tanks. Spent resin storage tanks were considered by the applicant, but were excluded because most of the activity is bound to the spent resins and have minimal free water in them. Tanks inside the containment building were not considered because the containment building is a seismic Category I structure. Other tanks were considered such as the monitor tanks, the hold-up tanks, and the chemical waste tank. The hold-up tanks were found to have the highest potential radioactivity concentration and highest volume. Based on groundwater flow directions shown on WLS COL FSAR Figure 2.4.12-204, Sheet 8, Unit 2 was analyzed because its tanks are nearer the points of exposure, which are Hold-Up Pond A and the Broad River. The contents spilled from the tank were assumed to enter the groundwater instantaneously. The source term developed by the applicant is as follows:

- Tritium source term concentration is 1.0 microcuries per gram taken from AP1000 DCD Table 11.1-8
- Corrosion product source terms Cr-51, Mn-54, Mn-56, Fe-55, Fe-59, Co-58, and Co-60 taken from AP1000 DCD Table 11.1-2
- Other isotope source terms taken from AP1000 DCD Table 11.1-2, multiplied by 0.12/0.25 to adjust the radionuclide concentrations to the required 0.12 percent failed fuel fraction outlined in BTP 11-6.

The applicable regulatory acceptance criteria for a liquid waste tank failure is that the postulated failure would not result in radionuclide concentrations in excess of 10 CFR Part 20, Appendix B, Table 2, Column 2 values (effluent concentration limit ((ECL)) values) at the nearest source of potable water, where the ECL radionuclide concentrations correspond to a calculated dose of 50 mrem per year from the drinking water pathway. The applicant provided an analysis for compliance with 10 CFR Part 20, in Section 2.4.13. Compliance was demonstrated by calculating concentration/ECL ratios for all the radionuclides expected to enter the Broad River. The nearest potable surface water supply was in the Broad River. All the ratios for the location were determined to be less than one. In addition, the applicant demonstrated compliance with the requirement that the sum of the individual ratios of nuclide concentration to its ECL must be less than unity. The result of this calculation was that the sum of the ratios was 0.1 for the Broad River. The calculation is conservative in that no credit is taken for dilution of radionuclides in the Broad River caused by water flow and that the radionuclides are assumed to remain in the Broad River near groundwater discharge point for a period of one year.

The applicant's initial application did not include an analysis of pathways of exposure other than drinking water. The staff determined that the analysis should also have discussed other applicable pathways, such as fish and crop irrigation. These pathways of exposure may concentrate radionuclide levels, leading to potentially higher dose contributions. In response to RAI 2.4.13-2, the applicant evaluated potential doses from the fish and irrigated foods pathways for the liquid tank failure analysis. Using RESRAD-OFFSITE dose methodology, the applicant calculated hypothetical doses to members of the public of 0.071 mrem/year from fish consumption and 0.244 mrem/year from irrigated crops consumption. The staff reviewed the applicant's analysis and performed an independent evaluation of the fish and irrigated crop pathways. These evaluations are presented below.

The staff applied the dose calculational methodology of RG 1.109, using the applicant's conservatively evaluated maximum concentration of radionuclides in the Broad River assuming no additional dilution in the river. Using this methodology, the staff calculated hypothetical doses of 0.14 mrem/year for fish consumption and 0.043 mrem/year for irrigated crops ingestion. These doses are sufficiently consistent with those calculated by the applicant to constitute independent confirmation, with differences attributable to modeling assumptions.

As the above analyses for fish and irrigated crop ingestion show, doses resulting from the failure of a waste hold-up tank would be a small fraction of the established regulatory limit. The sum of the fish consumption and irrigated vegetable pathways with the drinking water pathway yields a hypothetical maximum individual dose of approximately 5 mrem assuming a full year exposure time. This total is a small fraction of the 50 mrem/year dose criterion for the liquid tank failure analysis.

Based on the above evaluations and the applicant's analysis in the WLS COL FSAR, the staff finds potential doses to members of the public resulting from an accidental release of liquid effluents meets Acceptance Criterion No. 5 in NUREG-0800 and the referenced BTP 11-6; therefore, the staff considers RAI 2.4.13-2 closed and COL Information Items 2.4-5 and 15.7-1 resolved.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve the COL responsibilities as set forth in Section 11.5.7 of the AP1000 DCD, which states:

The Combined License applicant is responsible for addressing the 10 CFR Part 50, Appendix I, Sections II.A and II.D guidelines for maximally exposed offsite individual doses and population doses via liquid and gaseous effluents.

The commitment was also captured as COL Action Item 11.5-3 in Appendix F of NUREG-1793, which states:

The COL applicant is responsible for addressing the guidelines of Appendix I to 10 CFR Part 50, as they relate to maximally exposed offsite individual doses and population doses attributable to liquid and gaseous effluents.

In WLS COL FSAR Sections 11.2.3.5, the applicant discussed the methods used to assure that individual and estimated population doses are maintained ALARA in accordance with 10 CFR Part 50, Appendix I (this information is also applicable to WLS COL FSAR Sections 11.3.3.4 and 11.4).

The NRC staff reviewed the applicant's response to WLS COL 11.5-3 related to compliance with 10 CFR Part 50, Appendix I, Sections II.A and II.D and issued RAI 11.2-3 and RAI 11.2-4. RAI 11.2-3 requested that the applicant provide the details of the individual and population dose analysis. RAI 11.2-4 questioned the applicant's assumption concerning the elimination of the irrigation exposure pathway.

In response to the above listed RAIs, the applicant provided a description of the required model assumptions and input parameters needed to run LADTAP II computer codes and justification for excluding the irrigation exposure pathway to calculate doses.

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 maximally exposed individual (MEI) of the public and to the population within 80 km (50 mi) from the postulated liquid effluents discharged.

WLS COL FSAR Tables 11.2-201 and 11.2-202 include liquid pathway parameters used as input to the dose calculation, including discharge flow rate, site-specific dilution factors, transit-times to receptors, consumption factors for fish and water, and recreational usage data for the Broad River. The analysis assumed a completely mixed impoundment model to calculate dilution of the radioactive effluent by the Broad River. Given the proximity of the discharge structure to the Ninety-Nine Islands Hydroelectric Dam, which impounds the "run-of-the-river" Ninety-Nine Islands Reservoir, the diffusion characteristics of the discharge piping and the river flow velocity, the staff viewed the mixing model as a discharge into the river fully mixing with the river flow. The downstream exposure pathways would then effectively see a dilution of 189.4 (ratio of flow rate through the dam divided by liquid effluent discharge flow rate). The result for both individual and population doses were the same as in the applicant's analysis. WLS COL FSAR Tables 11.2-203 and 11.2-204 list the liquid pathway doses to the MEI and surrounding population, respectively.

The applicant calculated a maximum individual annual dose (per unit) to the adult total body of $6.09\text{E-}04$ mSv (0.0609 mrem) and a maximum annual individual dose (per unit) to the child liver of $7.75\text{E-}04$ mSv (0.0775 mrem). The applicant compared the MEI doses with the 10 CFR Part 50, Appendix I, Section II.A criteria and showed the doses to be well below the limits of 3 mrem to the total body and 10 mrem to any organ.

The calculated annual population doses listed in WLS COL FSAR Table 11.2-204 are $2.96\text{E-}03$ person-Sv (0.296 person-rem) to the total body (per unit), and $3.93\text{E-}03$ person-Sv (0.393 person-rem) to the thyroid (per unit). The applicant uses the population doses in the cost-benefit analysis previously describe in this SER.

In response to RAI 11.2-3, the applicant explained the derivation of values used for population water use, sport fish harvest, commercial fish harvest, and recreational time spent on the river. The staff reviewed the derivation of these values and found them to be reasonable upper bound estimates. Consequently, the staff used the applicant's values in its independent dose estimation.

In response to RAI 11.2-4, the applicant stated that consumption of most of an individual's annual intake of vegetables from a vegetable garden irrigated with public water was not regarded as either a pathway that fell within a reasonable deviation from the average for the population, or a pathway unique to the WLS site that was likely to contribute a dose increment equal to or greater than 10 percent of the total from all pathways considered in RG 1.109. Therefore, individual use of public water for garden irrigation was not considered in the determination of doses to the public from routine release of liquid reactor effluents from WLS Units 1 and 2. The applicant then provided a conservative dose analysis that concluded that the calculated individual dose associated with the irrigated, individual garden pathway contributes just 2 percent of the total body dose due to all liquid effluent pathways. The population dose did not include crop irrigation since it was not found to occur in the vicinity of the WLS site. Since the calculated dose does not have the potential to contribute 10 percent or more to individual or population doses, the applicant did not consider this pathway to be significant. The staff evaluated this response and concurred that this pathway is not significant. Therefore, the doses to the MEI and population associated with consuming vegetables watered by public drinking water are not included in the dose analyses.

The NRC staff performed an independent assessment using the LADTAP II computer code and compared results to the applicant's and the Appendix I criteria. The modeling assumptions used by the staff for the MEI and population dose calculations, as shown in Table 11.2-1 of this SER, were consistent with the applicant's. Modeling parameter values, as shown in Table 11.2-2 of this SER, were also consistent with the applicant's. The results of the staff's calculations were consistent with those of the applicant.

SER Table 11.2-3 compares the resulting dose estimates between the applicant's analysis and the 10 CFR Part 50, Appendix I criteria. This table shows that all doses are below the Appendix I criteria. The staff concludes that the applicant has provided a bounding assessment demonstrating its capability to comply with the regulatory requirements in 10 CFR Part 20 and 10 CFR Part 50, Appendix I, and therefore the staff considers COL Information Item 11.5-3 resolved.

Based on the above evaluation, RAIs 11.2-3 and 11.2-4 are closed.

The following portion of this technical evaluation section is reproduced from Section 11.2.4 of the VEGP SER:

Supplemental Information

The following portion of this technical evaluation section is reproduced from Section 11.2.4 of the BLN SER:

- STD SUP 11.2-1

The applicant provided supplemental information in BLN COL FSAR Section 11.2.3.6, "Quality Assurance," addressing the quality assurance program to be applied to the liquid waste system and stated that the program complies with the guidance presented in RG 1.143.

The NRC staff reviewed this supplemental quality assurance information included in BLN COL FSAR Section 11.2.3.6 and finds that this supplemental statement commits the applicant to the regulatory positions in RG 1.143 related to quality assurance and is acceptable.

- WLS SUP 11.2-2

The applicant stated that the only liquid effluent site interface parameter outside the Westinghouse scope is the release point to the Broad River. The staff finds this statement correct because the release point to the environment of liquid radioactive effluent is site-specific and to the Broad River.

- WLS SUP 11.2-3

The applicant provided supplemental information in WLS SUP 11.2-3 related to the exterior radwaste discharge piping. The information stated that the exterior radwaste discharge piping is enclosed within a guard pipe and monitored for leakage, and that liquid radwaste effluent will be discharged to the Broad River with plant discharge.

This item is related to 10 CFR 20.1406 and is addressed in SER Section 12.3.

Demonstrating Compliance with 10 CFR 20.1301(e)

Pursuant to 10 CFR 20.1301(e), the NRC-licensed facilities must comply with the Environmental Protection Agency's (EPA) generally applicable environmental radiation standards of 40 CFR Part 190 for facilities that are part of the fuel cycle. The EPA annual dose limits are 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid, and 0.25 mSv (25 mrem) to any other organ. Meeting the requirements of 10 CFR 20.1301(e) requires the consideration of all potential sources of external radiation and radioactivity, including liquid and gaseous effluents and external radiation exposures from buildings, storage tanks, radioactive waste storage areas, and N-16 skyshine from boiling-water reactor (BWR) turbine buildings. The EPA standards apply to the entire site or facility, whether it has single or multiple units.

The staff's review of the WLS COL FSAR revealed that the applicant did not provide any information demonstrating compliance with 10 CFR 20.1301(e). Because of this, the staff issued RAI 11.2-2 requesting that the applicant demonstrate compliance with the EPA standard.

The applicant provided the demonstration by summing the annual individual liquid and gaseous effluent doses for WLS Units 1 and 2. In response to RAI 11.2-2, the applicant listed the results in WLS COL FSAR Table 11.2-206. SER Table 11.2-4 lists these dose summations and compares them to the dose requirements in 40 CFR Part 190. The expected doses are below the EPA limits, therefore the requirement of 10 CFR 20.1301(e) is met. The staff verified that Table 11.2-206 has been incorporated in the WLS COL FSAR, thus RAI 11.2-2 is closed.

Demonstrating Compliance with 10 CFR 20.1302

Pursuant to 10 CFR 20.1302, the annual average concentration of radioactive material released in liquid effluents at the boundary of the unrestricted area must not exceed the values specified in Table 2 of Appendix B to 10 CFR Part 20. The applicant demonstrated compliance with this requirement by referencing the AP1000 DCD. Section 11.2.3.4 of the AP1000 DCD shows that even at the Technical Specification limit for percent failed fuel defects, the nominal blowdown flow provides sufficient dilution to ensure that the expected effluent release concentrations will be less than those specified in Table 2 of Appendix B to 10 CFR Part 20.

In NUREG-1793, the staff evaluated and accepted the conclusions of Section 11.2.3.4 of the AP1000 DCD. Based on this acceptance, the staff concludes that the applicant complies with 10 CFR 20.1302.

Demonstrating Compliance with 10 CFR 20.1406

Pursuant to 10 CFR 20.1406, the applicant must provide a description of how facility design and procedures for operation will 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 applicant demonstrated compliance with this requirement by incorporating by reference the design descriptions provided in the AP1000 DCD and providing the description of operating programs in WLS COL FSAR Section 12.3 and 12.5. The staff's evaluation and conclusion pertaining to compliance with 10 CFR 20.1406 are included in SER Section 12.3.

11.2.5 Post Combined License Activities

There are no post-COL activities related to this section.

11.2.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information relating to the LWMS, and that there is no outstanding information expected to be addressed in the WLS COL FSAR related to this section. The results of the NRC staff's technical evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff evaluated the additional COL information (STD COL 11.2-1, STD COL 11.2-2, WLS COL 11.2-2, WLS COL 11.5-3, and STD SUP 11.2-1, WLS COL 2.4-5, WLS COL 15.7-1, WLS SUP 11.2-2, WLS SUP 11.2-3) in the application against the relevant NRC regulations, acceptance criteria defined in NUREG-0800, Section 11.2, and other NRC regulatory guides. The applicant has satisfactorily addressed all RAIs related to Section 11.2.

The staff verified that the applicant had provided sufficient information and that the review and calculations support the conclusions that follow. The staff concludes that the LWMS (as a permanently installed system or in combination with mobile systems) includes the equipment necessary to control releases of radioactive materials in liquid effluents in accordance with GDC 60 and 61 of Appendix A to 10 CFR Part 50 and the requirements of 10 CFR 50.34a. Therefore the staff concludes that the design of the LWMS is acceptable and meets the requirements of 10 CFR 20.1301(e), 10 CFR 20.1302, 10 CFR 20.1406, 10 CFR 50.34a, GDC 60 and 61, and Appendix I to 10 CFR Part 50.

11.3 Gaseous Waste Management System

11.3.1 Introduction

The gaseous waste management system (GWMS) is designed to control, collect, process, handle, store, and dispose of gaseous radioactive waste generated as the result of normal operation, including anticipated operational occurrences.

11.3.2 Summary of Application

Section 11.3 of the WLS COL FSAR, Revision 4, incorporates by reference Section 11.3 of the AP1000 DCD, Revision 19.

In addition, in WLS COL FSAR Section 11.3, the applicant provided the following:

AP1000 COL Information Items

- STD COL 11.3-1

The applicant provided additional information in STD COL 11.3-1 to resolve COL Information Item 11.3-1 (COL Action Item 11.3-1) regarding gaseous radwaste cost-benefit analysis methodology.

- WLS COL 11.3-1

The applicant provided additional information in WLS COL 11.3-1 to resolve COL Information Item 11.3-1 (COL Action Item 11.3-1). The additional information addresses the estimated doses to the public from the gaseous waste system and the associated cost-benefit analysis in WLS COL FSAR Section 11.3.3.4.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve COL Information Item 11.5-3 (COL Action Item 11.5-3). The additional information addresses compliance with

10 CFR Part 50, Appendix I, Sections II.B and II.C related to operation of the gaseous waste system in WLS COL FSAR Section 11.3.3.4.

Supplemental Information

- STD SUP 11.3-1

The applicant added supplemental information in WLS COL FSAR Section 11.3.3.6 to address the QA program to be applied to the GWMS.

- STD SUP 11.3-2

The applicant added supplemental information in WLS COL FSAR Section 11.3.3 to address the gaseous effluent site interface parameter.

11.3.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed in NUREG-1793 and its supplements.

In addition, the regulatory basis for acceptance of the supplementary information on the GWMS is established in:

- 10 CFR 20.1301(e)
- 10 CFR 20.1302
- 10 CFR 20.1406
- 10 CFR 50.34a
- 10 CFR Part 50, Appendix A, GDC 3, "Fire protection"
- 10 CFR Part 50, Appendix A, GDC 60, "Control of releases of radioactive materials to the environment"
- 10 CFR Part 50, Appendix A, GDC 61, "Fuel storage and handling and radioactivity control"
- 10 CFR Part 50, Appendix I, Sections II.B, II.C and II.D
- 10 CFR 52.80(a)

Guidance for meeting these requirements is in:

- Regulatory Position C.2 of RG 1.143, Revision 2

- RG 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1
- RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors"
- RG 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1
- RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning"

The acceptance criteria associated with the GWMS are given in Section 11.3 of NUREG-0800, including BTP 11-5.

11.3.4 Technical Evaluation

The NRC staff reviewed Section 11.3 of the WLS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.¹ The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the GWMS. The results of the NRC staff's evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

The staff's review of this application included the following COL information and supplementary items:

- STD COL 11.3-1, Gaseous Radwaste Cost-Benefit Analysis Methodology
- WLS COL 11.3-1, Cost-Benefit Analysis of Population Doses
- WLS COL 11.5-3, 10 CFR Part 50, Appendix I, Sections II.B and II.C
- STD SUP 11.3-1, Supplemental Information on Quality Assurance
- STD SUP 11.3-2, Supplemental Information on Gaseous Effluent Site Interface Parameters

In addition to the above items, the staff reviewed the entire section against Section 11.3 of NUREG-0800 to determine if the information in WLS COL FSAR Section 11.3 met the regulatory requirements in the regulations stated above (SER Section 11.3.3) and NUREG-0800 acceptance criteria. The relevant NUREG-0800 acceptance criteria are as follows:

- The GWMS should have the capability to meet the dose design objectives and should include provisions to treat gaseous radioactive wastes, such that the following is true:

- A. The calculated annual total quantity of all radioactive materials released from each reactor to the atmosphere will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 0.05 mSv (5 mrem) to the total body or 0.15 mSv (15 mrem) to the skin. RGs 1.109 and 1.111 provide acceptable methods for performing this analysis.
 - B. The calculated annual total quantity of radioactive materials released from each reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 0.01 centigray (cGy) (10 millirads (mrad)) for gamma radiation or 0.02 cGy (20 mrad) for beta radiation. RGs 1.109 and 1.111 provide acceptable methods for performing this analysis.
 - C. The calculated annual total quantity of radioiodines, carbon-14, tritium, and all radioactive materials in particulate form released from each reactor at the site in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such releases for any individual in an unrestricted area from all pathways of exposure in excess of 0.15 mSv (15 mrem) to any organ. RGs 1.109 and 1.111 provide acceptable methods for performing this analysis.
 - D. In addition to 1.A, 1.B, and 1.C, above, the GWMS should include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, for a favorable cost-benefit ratio, can effect reductions in dose to the population reasonably expected to be within 80 km (50 mi) of the reactor. RG 1.110 provides an acceptable method for performing this analysis.
 - E. The concentrations of radioactive materials in gaseous effluents released to an unrestricted area should not exceed the limits specified in Table 2, Column 1 of Appendix B to 10 CFR Part 20.
 - F. The regulatory position in RG 1.143 is met, as it relates to the definition of the boundary of the GWMS, beginning at the interface from plant systems to the point of controlled discharges to the environment as defined in the Offsite Dose Calculation Manual (ODCM), or at the point of storage in holdup tanks or decay beds for gaseous wastes produced during normal operation and anticipated operational occurrences.
- System designs should describe features that will minimize, to the extent practicable, contamination of the facility and environment; facilitate eventual decommissioning; and minimize, to the extent practicable, the generation of radioactive waste in accordance with RG 1.143, for gaseous wastes produced during normal operation and anticipated operational occurrences, and the requirements of 10 CFR 20.1406 or the DC application, update in the SAR, or the COL application to the extent not addressed in a referenced certified design.
 - BTP 11-5, as it relates to potential releases of radioactive materials (noble gases) as a result of postulated leakage or failure of a waste gas storage tank or off-gas charcoal delay bed.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER for the reference COL application (VEGP Units 3 and 4) were equally applicable to the WLS Units 1 and 2 COL application, the staff undertook the following reviews:

- The staff compared the VEGP COL FSAR, Revision 2, to the WLS COL FSAR. In performing this comparison, the staff considered changes made to the WLS COL FSAR (and other parts of the COL application, as applicable) resulting from RAIs.
- The staff confirmed that all responses to RAIs identified in the corresponding standard content evaluation were endorsed.
- The staff verified that the site-specific differences were not relevant.

The staff has completed its review and found the evaluation performed for the standard content to be directly applicable to the WLS COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting. Section 1.2.3 of this SER provides an explanation of why the standard content material from the SER for the reference COL application (VEGP) contains evaluation material from the SER for the BLN Units 3 and 4 COL application.

AP1000 COL Information Items

The following portion of this technical evaluation section is reproduced from Section 11.2.4 of the VEGP SER:

- *STD COL 11.3-1*

The discussion of VEGP COL 11.3-1 addresses the site-specific cost-benefit analysis performed to address the requirements of 10 CFR Part 50, Appendix I, regarding population doses due to gaseous effluents. The applicant provided additional information in STD COL 11.3-1 to resolve COL Information Item 11.3-1 with regard to the cost-benefit analysis methodology.

The NRC staff reviewed the resolution of COL Information Item 11.3-1 related to the cost-benefit analysis methodology described in VEGP FSAR Section 11.3.3.4 and concluded that the methodology used for the analysis was consistent with the guidance of RG 1.110 and was, therefore, acceptable.

- WLS COL 11.3-1

The applicant provided additional information in WLS COL 11.3-1 to resolve COL Information Item 11.3-1, which states:

The analysis performed to determine offsite dose due to gaseous effluents is based upon the AP1000 generic site parameters included in Chapter 1 and Tables 11.3-1, 11.3-2 and 11.3-4. The Combined License applicant will provide

a site specific cost-benefit analysis to demonstrate compliance with 10 CFR 50, Appendix I, regarding population doses due to gaseous effluents.

The commitment was also captured as COL Action Item 11.5-3 in Appendix F of NUREG-1793, which states:

The COL applicant will provide a site-specific cost-benefit analysis to demonstrate compliance with 10 CFR 50, Appendix I, regarding population doses due to gaseous effluents.

The NRC staff reviewed the resolution of COL Information Item 11.3-1 related to the cost-benefit analysis included under Sections 11.3.3.4.2 and 11.3.5.1 of the WLS COL FSAR and issued RAI 11.3-1 because the NEI Template 07-11, "Generic FSAR Template Guidance for Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," cited by Duke Energy Carolinas, LLC had been withdrawn by NEI from further consideration. This RAI asked the applicant to provide a detailed and plant-specific cost-benefit analysis.

In response to RAI 11.3-1, the applicant performed a site-specific analysis to determine whether the offsite dose due to gaseous effluents is bounded by the AP1000 site parameters included in Chapter 1 and Tables 11.3-1, 11.3-2 and 11.3-4 of the DCD. The applicant discussed the site-specific cost-benefit analysis in WLS COL FSAR Section 11.3.3.4 to address the requirements of 10 CFR Part 50, Appendix I, Section II.D, regarding population doses due to gaseous effluents. The dose and dose rate to man was calculated using the GASPARD II computer code, which is based on the methodology presented in RG 1.109.

The applicant's analysis showed that the lowest-cost option for gaseous radwaste treatment system augments is the steam generator flash tank vents to the main condenser at \$6,320 per year. The population doses, 4.79 person-rem total body per reactor and 9.52 person-rem thyroid per reactor, are given in the WLS COL FSAR Table 11.3-204. Assuming 100 percent efficiency of this augment, the resulting cost per person-rem is determined by dividing the cost of the augment by the population dose, or \$1,319 per person-rem total body ($\$6,320/4.79$ person-rem) and \$664 per person-rem thyroid ($\$6320/9.52$ person-rem). While the costs per person-rem reduction exceed the \$1,000 per person-rem criterion considering the total body dose, the costs considering the thyroid dose are below the \$1,000 per person-rem criterion, and therefore, warranted further evaluation.

The applicant's further analysis of the population thyroid dose examined a number of potential gaseous radwaste treatment system augments based on their estimated 9.52 person-rem/year thyroid dose (and, therefore, those augments with a "Total Annual Cost" of less than \$9,520). In order of decreasing total annual cost (TAC), the applicant evaluated:

- Pressurized-water reactor (PWR) air ejector charcoal/high efficiency particulate air (HEPA) filtration unit with a TAC of \$9,140, which would have to remove at least 9.14 of the 9.52 person-rem (thyroid) to be cost-beneficial. The applicant stated that based on the system design, no iodine is released through the condenser air removal (off-gas) system design; therefore, this augment does not affect the iodine discharged by the plant which accounts for 4.79 person-rem in the thyroid population dose. Since it would be impossible to achieve the necessary dose reduction, this augment is not cost-beneficial.

- 3 ton charcoal absorber with a TAC of \$8,770, which would have to remove at least 8.77 of the 9.52 person-rem (thyroid) to be cost-beneficial. It is assumed that this augment would be appended to the gaseous radwaste system where it would increase the delay time of noble gases exiting the existing activated carbon delay beds. The applicant stated that no iodine is released through the gaseous radwaste system; therefore, this augment does not affect the iodine discharged by the plant, which accounts for 4.79 person-rem in the thyroid population dose. Since it would be impossible to achieve the necessary dose reduction, this augment is not cost-beneficial.
- Main condenser vacuum pump charcoal/HEPA filtration systems with a TAC of \$7,690, which would have to remove at least 7.69 of the 9.52 person-rem (thyroid) to be cost-beneficial. The applicant stated that based on the system design, no iodine is released through the condenser air removal system; therefore, this augment does not affect the iodine discharged by the plant which accounts for 4.79 person-rem in the thyroid population dose. Since it would be impossible to achieve the necessary dose reduction, this augment is not cost-beneficial.
- 1000 cubic feet per minute (cfm) charcoal/HEPA filtration systems with a TAC of \$7,580, which would have to remove at least 7.58 of the 9.52 person-rem (thyroid) to be cost-beneficial. The applicant stated that even assuming that this rather small capacity augment could be placed in the ventilation system at some point that would eliminate all iodine and particulate releases, it would not be effective in reducing the noble gas releases, the carbon-14 release, or the airborne tritium release, all of which account for 4.46 person-rem in the thyroid population dose. Since it would be impossible to achieve the necessary dose reduction, this augment is not cost-beneficial.
- 600 ft³ gas decay tank with a TAC of \$7,460, which would have to remove at least 7.46 of the 9.52 person-rem (thyroid) to be cost-beneficial. This augment would be part of a conventional high pressure waste gas holding system. The applicant stated that based on the system design, no iodine is released through this system; therefore, this augment does not affect the iodine discharged by the plant, which accounts for 4.79 person-rem in the thyroid population dose. Since it would be impossible to achieve the necessary dose reduction, this augment is not cost-beneficial.
- Steam generator flash tank vent to main condenser with a TAC of \$6,320, which would have to remove at least 6.32 of the 9.52 person-rem (thyroid) to be cost-beneficial. Addition of this augment presumes that the design already includes a steam generator flash tank; the augment being evaluated is the installation of vent piping and instrumentation from the tank to the main condenser. However, the system design does not include a steam generator flash tank; therefore, the TAC of \$6,320 is underestimated. Additionally, the AP1000 design includes steam generator blowdown heat exchangers that provide cooling of the blowdown fluid and prevent flashing prior to the blowdown flow entering the main condenser. Therefore, this augment would not provide any additional dose reduction, and this augment is not cost-beneficial.

Based on the above evaluation, the applicant concluded that none of the radwaste augments are cost-beneficial in reducing the annual thyroid dose from gaseous effluents for WLS.

The staff reviewed this evaluation and concurred with its results. Thus, the staff concluded that the GWSS meets ALARA requirements and requires no augmentations. Therefore, the staff considers COL Information Item 11.3-1 resolved. This closes RAI 11.3-1.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve COL Information Item 11.5-3, which states:

The Combined License applicant is responsible for addressing the 10 CFR 50, Appendix I guidelines for maximally exposed offsite individual doses and population doses via liquid and gaseous effluents.

The commitment was also captured in COL Action Item 11.5-3 in Appendix F of NUREG-1793, which states:

The COL applicant is responsible for addressing the guidelines of Appendix I to 10 CFR Part 50, as they relate to maximally exposed offsite individual doses and population doses attributable to liquid and gaseous effluents.

The NRC staff reviewed the resolution of COL Information Item 11.5-3 related to the compliance with Appendix I to 10 CFR Part 50 as presented in Section 11.3.3.4 of the WLS COL FSAR and issued RAI 11.3-2 requesting the applicant provide the details of the individual and population dose analyses.

In response to RAI 11.3-2, the applicant provided an evaluation of the impacts from gaseous effluent releases by considering the probable pathways to individuals and populations near the proposed new units. The applicant estimated the total-body and organ dose to the MEI from the gaseous effluent release pathways, and also calculated a collective total body and organ dose for the population within 80 km (50 mi) of the WLS site. The estimates of the maximum doses to the public are based on the AP1000 reactor's normal operational effluent releases, as discussed in the AP1000 DCD. The applicant evaluated the impact of these doses by comparing them to applicable regulatory limits.

If built, the postulated two new units at the WLS site would release gaseous effluents into the atmosphere. The applicant calculated doses for several airborne pathways, including direct exposure to a radioactive plume, direct exposure to radioactivity deposited on the ground, inhalation of airborne radioactivity and ingestion of contaminated agricultural products including, vegetables, milk, and meat. The applicant assumed that the MEI consumes both cow and goat's milk, while the population consumes only cow's milk.

In response to RAI 11.3-2, the applicant provided a description of all required model assumptions and input parameters needed to run the GASPAR II computer code. Using radiological exposure models based on RG 1.109, Revision 1 and the GASPAR II computer program (NUREG/CR-4653, "GASPAR II - Technical Reference and User Guide," March 1987), the applicant calculated the estimated doses to a hypothetical MEI of the public and to the population within 80 km (50 mi) from the postulated gaseous effluents discharged.

WLS COL FSAR Tables 2.3.5-287, 2.3.5-290, 2.3.5-291, and 2.3-292 include all the atmospheric dispersion and deposition factors used by the applicant to calculate individual and population doses. FSAR Table 11.3-201 includes gaseous pathway parameters used as input to the dose calculation, including population data, and site-specific agricultural usage information. The applicant provided justifications for these parameter values in the response to RAI 11.3-2. FSAR Tables 11.3-202 and 11.3-204 list the gaseous pathway doses to the MEI and surrounding population, respectively.

The applicant calculated the gaseous pathway doses to the MEI. The results show for the worst-case location outside the exclusion boundary a gamma annual air dose of 0.00613 milliGray (mGy) or 0.613 mrad, a beta annual air dose of 0.0293 mGy or 2.93 mrad; a total annual body dose of 0.0132 mSv or 1.32 mrem and an annual skin dose of 0.0206 mSv or 2.06 mrem. Table 11.3-205 of the WLS COL FSAR was added; it lists the maximum annual organ dose (thyroid) of 0.0139 mSv or 13.9 mrem for the infant.

The calculated annual population doses listed in WLS COL FSAR Table 11.3-204 are 0.0479 person-Sv (4.79 person-rem) to the total body, and 0.0952 person-Sv (9.52 person-rem) to the thyroid. The applicant used the population doses in the cost-benefit analysis described in the WLS COL FSAR and evaluated in this SER.

The NRC staff performed an independent assessment using the GASPARD II computer code and compared its results to the applicant's and the Appendix I criteria. The modeling assumptions used and parameter values used were consistent with the applicant's.

In response to RAI 11.3-2, the applicant explained the derivation of values used for agricultural and usage parameters including the total production of vegetables, milk, and meat in the 8 km area around the site. The staff evaluated and verified the derivation of these values and found them to be reasonable upper bound estimates. Consequently, the staff used the applicant's agricultural and usage values listed in WLS COL FSAR Table 11.3-201 for the dose estimation.

The staff evaluated and agreed with the approach taken by the applicant to calculate maximum annual individual doses from gaseous effluents. Using this same approach, the staff verified the individual doses in the WLS COL FSAR by independently running the GASPARD II computer code with the applicant's parameter values. Table 11.3-2 in this SER compares the resulting dose estimates from the applicant's analyses with the 10 CFR Part 50, Appendix I criteria. All doses are below the Appendix I, Section II.B and II.C criteria

The staff evaluated and agreed with the approach taken by the applicant to calculate population doses from gaseous effluents. Using this same approach, the staff evaluated the population doses in the WLS COL FSAR by independently running the GASPARD II computer code with the applicant's parameter values. The applicant then used these doses in a cost-benefit analysis for augments to the GWMS. Table 11.3-3 in this SER summarizes the results of the applicant's and staff's analysis of population doses. This closes RAI 11.3-2.

The staff concluded that the information provided by the applicant for WLS COL 11.5-3 is acceptable. The NRC staff found that the applicant provided a bounding assessment demonstrating its capability to comply with the individual dose criteria in 10 CFR Part 20 and 10

CFR Part 50, Appendix I. In addition, the staff found the applicant's calculation of the population dose to be appropriate for use in assessing the cost-benefit requirements in Appendix I. Therefore, the staff considers COL Information Item 11.5-3 resolved. The following portion of this technical evaluation section is reproduced from Section 11.3.4 of the VEGP SER:

Supplemental Information

The following portion of this technical evaluation section is reproduced from Section 11.3.4 of the BLN SER:

- *STD SUP 11.3-1*

The applicant provided supplemental information in BLN COL FSAR Section 11.3.3.6, "Quality Assurance," addressing the quality assurance program to be applied to the gaseous waste system and stated that the program complies with the guidance presented in RG 1.143.

The NRC staff reviewed this supplemental quality assurance information included in BLN COL FSAR Section 11.3.3.6 and finds that this supplemental statement commits the applicant to the regulatory positions in RG 1.143 related to quality assurance and is acceptable.

The following portion of this technical evaluation section is reproduced from Section 11.3.4 of the VEGP SER:

- *STD SUP 11.3-2*

The applicant provided additional information in VEGP COL FSAR Section 11.3.3 to address gaseous effluent site interface parameters. The applicant stated that there are no gaseous effluent site interface parameters outside the Westinghouse scope. The staff finds this statement true because all gaseous effluent release points are through the main gas vent and the turbine building exhaust and are part of the certified design.

Postulated Radioactive Release Due to a Waste Gas Leak or Failure

NUREG-0800, Section 11.3, acceptance criteria and BTP 11-5 require the staff to evaluate the results of a postulated radioactive release resulting from a leakage or failure of a waste gas storage tank or offgas charcoal delay bed. The waste gas system is part of the radioactive GWMS and information on the system is considered as part of the design information required by 10 CFR 50.34a.

The AP1000 DCD and NUREG-1793 addressed the results of this analysis. In response to RAI SRP11.3-CHPB-02 covering AP1000 DCD, Revision 17, Westinghouse detailed the results of this analysis for inclusion in the next revision of the DCD. The staff found this analysis acceptable and that it encompassed the site-specific parameters for the VEGP site. Once the staff confirms the inclusion of the failure analysis in a future revision of the

*AP1000 DCD and the incorporation by reference of that DCD revision by the VEGP applicant, the staff will consider this item closed for the VEGP COL FSAR. This is considered **Confirmatory Item 11.3-1**.*

Resolution of Standard Content Confirmatory Item 11.3-1

Confirmatory Item 11.3-1 is a commitment by the applicant to incorporate changes, by reference, proposed by Westinghouse to Section 11.3.3.4 of the AP1000 DCD to include the results of the postulated radioactive release resulting from a leakage or failure of a waste gas storage tank or offgas charcoal delay bed. The staff verified that the applicant has incorporated the AP1000 DCD Revision 18 that includes the above changes. As a result, Confirmatory Item 11.3-1 is now closed.

Demonstrating Compliance with 10 CFR 20.1301(e)

The staff discusses compliance with 10 CFR 20.1301(e) in Section 11.2.4 of this SER.

Demonstrating Compliance with 10 CFR 20.1302

The annual average concentration of radioactive material released in gaseous effluents at the boundary of the unrestricted area must not exceed the values specified in Table 2 of Appendix B to 10 CFR Part 20. The applicant demonstrated compliance with this requirement by referencing the AP1000 DCD. Section 11.3.3.5 of the DCD shows that even at the Technical Specification limit for percent failed fuel defects, the site provides sufficient atmospheric dilution to ensure that the expected effluent release concentrations will be less than those specified in Table 2 of Appendix B to 10 CFR Part 20.

In NUREG-1793, the staff evaluated and accepted the conclusions of Section 11.3.3.5 of the DCD. Based on this acceptance, the staff concludes that the applicant complies with 10 CFR 20.1302.

Demonstrating Compliance with 10 CFR 20.1406

The staff discusses compliance with 10 CFR 20.1406 in Section 11.2.4 of this SER.

11.3.5 Post Combined License Activities

There are no post-COL activities related to this section.

11.3.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information relating to the GWMS, and there is no outstanding information expected to be addressed in the WLS COL FSAR

related to this section. The results of the NRC staff's technical evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff evaluated the additional COL information (STD COL 11.3-1, WLS COL 11.3-1, WLS COL 11.5-3, STD SUP 11.3-1 and STD SUP 11.3-2) in the application against the relevant NRC regulations, acceptance criteria defined in NUREG-0800, Section 11.3, and other NRC regulatory guides. The applicant has satisfactorily addressed all RAIs related to Section 11.3.

In other areas of the evaluation of the GWMS, the staff verified that the applicant had provided sufficient information and that the review and calculations support the conclusion that the GWMS includes the equipment necessary to control releases of radioactive materials in gaseous effluents in accordance with GDC 3, GDC 60, and GDC 61 of Appendix A to 10 CFR Part 50 and the requirements of 10 CFR 50.34a. The staff finds that the applicant meets the requirements in GDC 3 by conforming to the guidance in BTP 11-5. The staff finds that the applicant meets the requirements in GDC 60 and 61 by demonstrating conformance to 10 CFR Part 50, Appendix I. The staff also concludes that the design of the GWMS meets the requirements of 10 CFR 20.1301(e), 10 CFR 20.1302, 10 CFR 20.1406, 10 CFR 50.34a, GDC 3, 60 and 61, and Appendix I to 10 CFR Part 50.

11.4 Solid Waste Management

11.4.1 Introduction

The solid waste management system (SWMS) is designed to collect and accumulate spent ion exchange resins and deep-bed filtration media, spent filter cartridges, dry active wastes, and mixed wastes generated from normal plant operation, including anticipated operational occurrences. Processing and packaging of wastes are by mobile systems and the packaged waste is stored in the auxiliary and radwaste buildings until it is shipped offsite to a licensed disposal facility.

11.4.2 Summary of Application

Section 11.4 of the WLS COL FSAR, Revision 4, incorporates by reference Section 11.4 of the AP1000 DCD, Revision 19.

In addition, in WLS COL FSAR Section 11.4, the applicant provided the following:

AP1000 COL Information Items

- STD COL 11.4-1

The applicant provided additional information in STD COL 11.4-1 to address COL Information Item 11.4-1 (COL Action Item 11.4-1). The additional information provides a Process Control Program (PCP) for both wet and dry solid wastes.

Supplemental Information

- STD SUP 11.4-1

The applicant added supplemental information in WLS COL FSAR Section 11.4.5 to address how the solid radwaste system complies with the guidance in RG 1.143. STD SUP 11.4-1 also addresses the processes to be followed to ship waste that complies with 10 CFR 61.55 “Waste classification,” and 10 CFR 61.56, “Waste characteristics” in WLS COL FSAR Section 11.4.6.1.

License Condition

- Part 10, License Condition 3, Operational Program Implementation

WLS COL FSAR Section 13.4, Table 13.4-201, “Operational Programs Required by NRC Regulations,” identifies one entry under Item 9, the PCP, as a program required to be implemented by a milestone. In accordance with License Condition 3, this program is to be implemented prior to initial fuel load.

- Part 10, License Condition 6, Operational Program Readiness

The applicant proposed a license condition to provide a schedule to support NRC inspection of operational programs including the PCPPCP.

11.4.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed in NUREG-1793 and its supplements.

In addition, the regulatory basis for acceptance of the supplemental information on the SWMS is established in the requirements and guidelines of several codes and standards. These include:

- 10 CFR Part 20, “Standards for Protection Against Radiation”
- 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities”
- 10 CFR 52.79, “Contents of applications; technical information in final safety analysis report”
- 10 CFR Part 71, “Packaging and Transportation of Radioactive Material”
- 49 CFR Part 173, “Shippers—General requirements for shipments and packagings”
- State regulations and disposal site waste form requirements for burial at a low level waste disposal site that is licensed in accordance with 10 CFR Part 61 or equivalent State regulations
- Table 1 and Regulatory Positions C.3.2 and C.3.3 of RG 1.143, Revision 2

The acceptance criteria associated with the SWMS are given in NUREG-0800, Section 11.4, including BTP 11-3.

11.4.4 Technical Evaluation

The NRC staff reviewed Section 11.4 of the WLS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.¹ The NRC staff's review confirmed that the information the application and incorporated by reference addresses the required information relating to the SWMS. The results of the NRC staff's evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

The staff's review of this application included the following COL information item and supplemental information:

- STD COL 11.4-1, Solid Waste Management System Process Control Program (PCP)
- STD SUP 11.4-1, Quality Assurance

In addition to the above items, the staff reviewed the entire section against NUREG-0800, Section 11.4, to determine if the information in WLS COL FSAR Section 11.4 met the regulatory requirements in the regulations stated above (SER Section 11.4.3) and NUREG-0800 acceptance criteria. The relevant NUREG-0800 acceptance criteria are as follows:

- All effluent releases (gaseous and liquid) associated with the operation (normal and anticipated operational occurrences) of the SWMS will comply with 10 CFR Part 20 and RG 1.143, as they relate to the definition of the boundary of the SWMS beginning at the interface from plant systems, including multiunit stations, to the points of controlled liquid and gaseous effluent discharges to the environment or designated onsite storage locations, as defined in the PCP and ODCM.
- Operational Programs. For COL reviews, the description of the operational program and proposed implementation milestone for the PCP aspect of the Process and Effluent Monitoring and Sampling Program are reviewed in accordance with 10 CFR 20.1301, 10 CFR 20.1302, 10 CFR 50.34a, 10 CFR 50.36a, and 10 CFR Part 50, Appendix I, Sections II and IV. Its implementation is required by a license condition.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER for the reference COL application (VEGP Units 3 and 4) were equally applicable to the WLS Units 1 and 2 COL application, the staff undertook the following reviews:

- The staff compared the VEGP COL FSAR, Revision 2, to the WLS COL FSAR. In performing this comparison, the staff considered changes made to the WLS COL FSAR (and other parts of the COL application, as applicable) resulting from RAIs.

- The staff confirmed that all responses to RAIs identified in the corresponding standard content evaluation were endorsed.
- The staff verified that the site-specific differences were not relevant.

The staff has completed its review and found the evaluation performed for the standard content to be directly applicable to the WLS COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting. Section 1.2.3 of this SER provides an explanation of why the standard content material from the SER for the reference COL application (VEGP) contains evaluation material from the SER for the BLN Units 3 and 4 COL application.

Although the staff concluded that the evaluation performed for the standard content is directly applicable to the WLS COL application, there is a difference in how the WLS applicant addressed STD COL 11.4-1 and how the VEGP applicant addressed this review item. This difference is evaluated by the staff below, following the standard content material for STD COL 11.4-1.

The following portion of this technical evaluation section is reproduced from Section 11.4.4 of the VEGP SER:

AP1000 COL Information Items

The following portion of this technical evaluation section is reproduced from Section 11.4.4 of the BLN SER:

- *STD COL 11.4-1*

The applicant provided additional information in STD COL 11.4-1 to resolve COL Information Item 11.4-1. COL Information Item 11.4-1 states:

The Combined License applicant will develop a process control program in compliance with 10 CFR Sections 61.55 and 61.56 for wet solid wastes and 10 CFR Part 71 and DOT [Department of Transportation] regulations for both wet and dry solid wastes. Process control programs will also be provided by vendors providing mobile or portable processing or storage systems. It will be the plant operator's responsibility to assure that the vendors have appropriate process control programs for the scope of work being contracted at any particular time. The process control program will identify the operating procedures for storing or processing wet solid wastes. The mobile systems process control program will include a discussion of conformance to Regulatory Guide 1.143, Generic Letter GL-80-009, and Generic Letter GL-81-039 and, information of equipment containing wet solid wastes in the non-seismic Radwaste Building. In the event additional onsite storage facilities are a part of Combined License plans, this program will include a discussion of conformance to Generic Letter GL-81-038.

The commitment was also captured as COL Action Item 11.4-1 in Appendix F of the NRC staff's FSER for the AP1000 DCD (NUREG-1793), which states:

The COL applicant will develop a process control program for both wet and dry solid wastes.

In BLN COL FSAR Section 11.4.6, the applicant addressed this COL information item. The applicant adopted NEI [Nuclear Energy Institute] 07-10, "FSAR Template Guidance for Process Control Program (PCP) Description." The PCP describes the administrative and operational controls used for the solidification of liquid or wet solid waste and the dewatering of wet solid waste. It provides the necessary controls such that the final disposal waste product meets applicable federal regulations (10 CFR Parts 20, 50, 61, 71 and 49 CFR Part 173), state regulations, and disposal site waste form requirements for burial at a low level waste disposal site licensed in accordance with 10 CFR Part 61. Waste processing equipment and services may be provided by the plant or by third-party vendors. In a letter dated January 8, 2009, (ML082910077), the NRC accepted NEI 07-10, Revision 3. Specifically, the NRC staff indicated that for COL applications NEI 07-10, Revision 3, provides an acceptable template for assuring that the administrative and operational controls for waste processing, processing parameters, and surveillance requirements within the scope of the PCP will meet the requirements of 10 CFR 52.79. In a letter dated April 23, 2009 (ML091170073), the applicant proposed to revise BLN FSAR Section 11.4 to incorporate the approved NEI 07-10 Revision 3. Since the BLN COL FSAR Section 11.4 has not adopted the approved version of the NEI Template, this is **Confirmatory Item 11.4-1**. Each process used meets the applicable requirements of the PCP. BLN COL FSAR Table 13.4-201 provides milestones for PCP implementation and is acceptable.

In STD COL 11.4-1, the applicant states that "no additional onsite radwaste storage is required beyond that described in the DCD." The applicant should explain why this statement is included or should remove it. In section 11.4 of NUREG-1793, the staff stated that if a need for onsite storage of low-level waste has been identified beyond that provided in AP1000 Standard Design because of unavailability of offsite storage, the applicant should submit the details of any proposed onsite storage facility to the NRC. The applicant needs to provide any arrangements for offsite storage for low-level waste or to submit plans for onsite storage. This is identified as **Open Item 11.4-1**.

The following portion of this technical evaluation section is reproduced from Section 11.4.4 of the VEGP SER:

Resolution of Standard Content Confirmatory Item 11.4-1

To address Confirmatory Item 11.4-1 in the BLN SER with open items, the applicant updated VEGP FSAR Section 11.4.6 to indicate adoption of the NRC-approved version of NEI 07-10A. VEGP adoption of this template effectively resolves Confirmatory Item 11.4-1.

Resolution of Standard Content Open Item 11.4-1

To address Open Item 11.4-1 in the BLN SER with open items, the applicant updated VEGP FSAR Section 11.4 with information supporting the statement that no additional onsite radwaste storage was required beyond that described in the DCD. This additional information is in VEGP COL 11.4-1 and VEGP SUP 11.4-1 and is evaluated below.

Evaluation of Site-specific Information for STD COL 11.4-1

Regarding the Resolution of Standard Content Open Item 11.4-1, the staff does not consider the open item relevant to the WLS COL application because the applicant has available offsite disposal of all types of low-level radioactive waste through its membership in the Atlantic Compact. Therefore, an update of the WLS COL FSAR is not necessary to resolve this item.

The following portion of this technical evaluation section is reproduced from Section 11.4.4 of the VEGP SER:

Supplemental Information

The following portion of this technical evaluation section is reproduced from Section 11.4.4 of the BLN SER:

- *STD SUP 11.4-1*

The applicant provided supplemental information in Section 11.4.5 of the BLNBLN COL FSAR to describe the QA program applicable to design, construction, installation and testing provisions of the solid radwaste system. This QA program is established by procedures and complies with the guidance presented in RG 1.143.

In BLN FSAR Section 11.4.6, the applicant also added a description of procedures relating to waste shipments, waste stream processing, verifying waste as non-radioactive, periodic system maintenance, personnel training, and document revision, clearing with third party vendors. The staff reviewed the descriptions and found them to be comprehensive and acceptable.

The NRC staff reviewed the supplemental information provided in STD SUP 11.4-1 related to the QA program for the solid radwaste system included under Section 11.4.4 of the BLN COL FSAR and finds that this supplemental statement commits the applicant to the regulatory positions in RG 1.143 related to quality assurance.

License Conditions

- *Part 10, License Condition 3, Operational Program Implementation*

VEGP COL FSAR Section 11.4.6 describes the process control program. VEGP COL FSAR Table 13.4-201 provides the milestone (prior to initial fuel load) for implementation of the process control program and is acceptable as described in the staff's SER related to NEI 07-10.

- *Part 10, License Condition 6, Operational Program Readiness*

The applicant proposed a license condition to provide a schedule to support NRC inspection of operational programs including the process control program. The proposed license condition is consistent with the policy established in SECY-05-0197 and is acceptable.

Compliance with 10 CFR Part 50 Appendix I Design Criteria

The design of the SWMS described in the AP1000 DCD has no release points directly to the environment. Compliance with Appendix I ALARA criteria is strictly based on the releases from the LWMS and GWMS and not the SWMS.

11.4.5 Post Combined License Activities

For the reasons discussed in the technical evaluation section above, the staff finds the following two license conditions proposed by the applicant acceptable:

- License Condition (11-1) - Prior to initial fuel load, the licensee shall implement an operational program for process and effluent monitoring and sampling. The program shall include the subprogram and documents for a Process Control Program.
- License Condition (11-2) - The licensee shall develop a schedule that supports planning for and conduct of NRC inspections of the operational programs listed in WLS COL FSAR Table 13.4-201, "Operational Programs Required by NRC Regulations." This schedule must be available to the NRC staff no later than 12 months after issuance of the COL. The schedule shall be updated every 6 months until 12 months before scheduled fuel load, and every month thereafter until the operational programs listed in WLS COL FSAR Table 13.4-201 have been fully implemented.

11.4.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information relating to the SWMS, and there is no outstanding information expected to be addressed in the WLS COL FSAR related to this section. The results of the NRC staff's technical evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff evaluated the additional COL information (STD COL 11.4-1 and STD SUP 11.4-1) in the application against the relevant NRC regulations, acceptance criteria in NUREG-0800, Section 11.4, and other NRC regulatory guides. .

Based on the evaluation above, the staff determined that the applicant's means for handling radioactive solid waste during normal operations, including AOOs are consistent with GDC 60. In accordance with 10 CFR 52.79(a)(3), the staff also determined that the applicant has provided sufficient information regarding the kinds and quantities of radioactive materials expected to be produced in the operation of the facility and the means for controlling and limiting radioactive effluents and exposures within the limits set forth in 10 CFR Part 20. The staff verified that the applicant has provided sufficient information and that the review supports the conclusion that the design and operation of the SWMS is acceptable and meets the requirements of GDC 61 of Appendix A of 10 CFR Part 50; 10 CFR 50.34a, 10 CFR 20.1301(e), 10 CFR 20.1406, and Appendix I to 10 CFR Part 50, and 10 CFR Parts 61 and 71.

11.5 Radiation Monitoring

11.5.1 Introduction

The radiation monitoring systems are used to monitor liquid and gaseous process streams and effluents from the LWMS, GWMS, and SWMS. The radiation monitoring systems include subsystems used to collect process and effluent samples during normal operation and AOO's, and under post-accident conditions.

11.5.2 Summary of Application

Section 11.5 of the WLS COL FSAR, Revision 4, incorporates by reference Section 11.5 of the AP1000 DCD, Revision 19.

In addition, in WLS COL FSAR Section 11.5, the applicant provided the following:

AP1000 COL Information Items

- STD COL 11.5-1

The applicant provided additional information in STD COL 11.5-1 to resolve COL Information Item 11.5-1 (COL Action Item 11.5-1). The information addresses the ODCM.

- STD COL 11.5-2

The applicant provided additional information in STD COL 11.5-2 to resolve COL Information Item 11.5-2 (COL Action Item 11.5-2). The information provides programmatic aspects of the effluent monitoring and sampling program.

- WLS COL 11.5-2

The applicant provided additional information in WLS COL 11.5-2 to add language to WLS COL FSAR Section 11.5.3 addressing extension of the existing Duke Energy program for QA of radioactive effluent and environmental monitoring to apply to WLS Units 1 and 2.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve COL Information Item 11.5-3 (COL Action Item 11.5-3). The information relates to the 10 CFR Part 50, Appendix I guidelines.

License Conditions

- Part 10, License Condition 3, Operational Program Implementation, Item G.3

WLS COL FSAR Section 13.4, Table 13.4-201, "Operational Programs Required by NRC Regulations," identifies three entries under Item 9, "Process and Effluent Monitoring and Sampling Program," as follows: (1) Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls;; (2) Offsite Dose Calculation Manual (ODCM); and (3) Radiological Environmental Monitoring program, as programs identified in FSAR Section 11.5 required to be implemented by a milestone. In accordance with License Condition 3, Item G.3, these programs are to be implemented prior to initial fuel load.

- Part 10, License Condition 6, Operational Program Readiness

The applicant proposed a license condition to provide a schedule to support the NRC's inspection of operational programs including the Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls; the ODCM; and the Radiological Environmental Monitoring program.

11.5.3 Regulatory Basis

The regulatory basis of the information incorporated by reference is addressed in NUREG-1793 and its supplements.

In addition, the regulatory basis for acceptance of the supplementary information on radiation monitoring addressed in COL Information Items 11.5-1, 11.5-2, and 11.5-3 is established in the requirements and guidelines of:

- 10 CFR Part 50, Appendix A, GDC 64, "Monitoring radioactivity releases"
- 10 CFR Part 20, "Standards for Protection Against Radiation Material"
- 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"
- 10 CFR Part 52,, "Licenses, Certifications, and Approvals for Nuclear Power Plants"
- 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste"
- 10 CFR Part 71, "Packaging and Transportation of Radioactive Material"
- American National Standards Institute/Health Physics Society (ANSI/HPS) N13.1, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities"

- ANSI N42.18, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents"
- RG 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," Revision 2
- RGRG 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment," Revision 2

The applicable acceptance criteria associated with the radiation monitoring system are given in NUREG-0800, Section 11.5.

11.5.4 Technical Evaluation

The NRC staff reviewed Section 11.5 of the WLS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic¹. The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the radiation monitoring system. The results of the NRC staff's evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the following information in the WLS COL FSAR:

AP1000 COL Information Items

- STD COL 11.5-1, ODCM
- STD COL 11.5-2, Programmatic Aspects of the Effluent Monitoring and Sampling Program
- WLS COL 11.5-2 adds language to WLS COL FSAR Section 11.5.3 addressing extension of the existing Duke Energy program for QAQA of radioactive effluent and environmental monitoring to apply to WLS Units 1 and 2.
- WLS COL 11.5-3, 10 CFR Part 50, Appendix I Guidelines

In addition to the above items, the staff reviewed the entire section against NUREG-0800, Section 11.5, to determine if the information in WLS COL FSAR Section 11.5 met the regulatory requirements in the regulations stated above (SER Section 11.5.3) and NUREG-0800 acceptance criteria. The relevant NUREG-0800 acceptance criteria are as follows:

- Provisions should be made to ensure representative sampling from radioactive process streams and tank contents. Recirculation pumps for liquid waste tanks (collection or sample test tanks) should be capable of recirculating at a rate of not less than two tank volumes in 8 hours. For gaseous and liquid process stream samples, provisions should be made for purging sampling lines and for reducing the plate-out of radioactive

materials in sample lines. Provisions for gaseous sampling from ducts and stacks should be consistent with ANSI/HPS N13.1-1999.

- For COL reviews, the description of the operational program and proposed implementation milestone for the radiological effluent technical specification/standard radiological effluent control, ODCM and Radiological Environmental Monitoring Program aspects of the Process and Effluent Monitoring and Sampling Program are reviewed in accordance with 10 CFR 20.1301, 10 CFR 20.1302, 10 CFR 50.34a, 10 CFR 50.36a, and 10 CFR Part 50, Appendix I, Sections II and IV. Its implementation is required by a license condition.

Section 1.2.3 of this SER provides a discussion of the strategy used by the NRC to perform one technical review for each standard issue outside the scope of the DC and use this review in evaluating subsequent COL applications. To ensure that the staff's findings on standard content that were documented in the SER for the reference COL application (VEGP Units 3 and 4) were equally applicable to the WLS Units 1 and 2 COL application, the staff undertook the following reviews:

- The staff compared the VEGP COL FSAR, Revision 2, to the WLS COL FSAR. In performing this comparison, the staff considered changes made to the WLS COL FSAR (and other parts of the COL application, as applicable) resulting from RAIs.
- The staff confirmed that all responses to RAIs identified in the corresponding standard content evaluation were endorsed.
- The staff verified that the site-specific differences were not relevant.

The staff has completed its review and found the evaluation performed for the standard content to be directly applicable to the WLS COL application. This standard content material is identified in this SER by use of italicized, double-indented formatting. Section 1.2.3 of this SER provides an explanation of why the standard content material from the SER for the reference COL application (VEGP) contains evaluation material from the SER for the BLN Units 3 and 4 COL application.

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the VEGP SER:

AP1000 COL Information Items

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the BLN SER:

- *STD COL 11.5-1*

The applicant provided additional information in STD COL 11.5-1 to resolve COL Information Item 11.5-1. COL Information Item 11.5-1 states:

The Combined License applicant will develop an offsite dose calculation manual that contains the methodology and parameters

used for calculation of offsite doses resulting from gaseous and liquid effluents. The Combined License applicant will address operational setpoints for the radiation monitors and address programs for monitoring and controlling the release of radioactive material to the environment, which eliminates the potential for unmonitored and uncontrolled release. The offsite dose calculation manual will include planned discharge flow rates.

This commitment was also captured as COL Action Item 11.5-1 in Appendix F of the NRC staff's FSER for the AP1000 DCD (NUREG-1793), which states:

The COL applicant will develop an offsite dose calculation manual that contains the methodology and parameters used to calculate offsite doses resulting from gaseous and liquid effluents.

*In BLN COL FSAR Section 11.5.7, the applicant adopts NEI 07-09, "FSAR Template Guidance for Offsite Dose Calculation Manual (ODCM) Program Description." The ODCM program description contains: (1) the methodology and parameters used for calculating doses resulting from liquid and gaseous effluents; (2) operational setpoints, including planned discharge rates, for radiation monitors and monitoring programs; and (3) the limitations on operation of the radwaste systems, including functional capability of monitoring instruments, concentrations of effluents, sampling, analysis, 10 CFR Part 50, Appendix I dose and dose commitments and reporting. In a letter dated January 27, 2009 (ML083530745), the NRC accepted NEI 07-09, Revision 4. Specifically, the NRC indicated that for COL applications, NEI 07-09, Revision 4 provides an acceptable template assuring that the ODCM program meets applicable NRC regulations and guidance. In a letter dated April 23, 2009 (ML091170073), the applicant proposed to revise BLN COL FSAR Section 11.5 to incorporate the approved NEI 07-09, Revision 4. Since the BLN COL FSAR Section 11.5 has not adopted the approved version of the NEI Template, this is **Confirmatory Item 11.5-1**. BLN COL FSAR Table 13.4-201 provides milestones for ODCM implementation. This section also addresses Plant Interface Item 11.4, "requirements for offsite sampling and monitoring of effluent concentrations." The staff finds the applicant's consideration of Plant Interface Item 11.4 to be acceptable based on a review of the ODCM program (NEI 07-09). The NRC staff reviewed the resolution of STD COL 11.5-1 related to the ODCM included under Section 11.5.7 of the BLN COL FSAR and considers it adequately addressed in NEI 07-09.*

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the VEGP SER:

Resolution of Standard Content Confirmatory Item 11.5-1

To address Confirmatory Item 11.5-1, the applicant updated the VEGP FSAR Section 11.5.7 to indicate adoption of the NRC-approved version of NEI 07-09A. VEGP adoption of this template effectively resolves Confirmatory Item 11.5-1.

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the BLN SER:

- STD COL 11.5-2

The applicant provided additional information in STD COL 11.5-2 to resolve COL Information Item 11.5-2 (COL Action Item 11.5-2). COL Information Item 11.5-2 states:

The Combined License applicant is responsible for the site-specific and program aspects of the process and effluent monitoring and sampling in accordance with ANSI N13.1 and RGs 1.21 and 4.15.

The commitment was also captured as COL Action Item 11.5-2 in Appendix F of the NRC staff's FSER for the AP1000 DCD (NUREG-1793), which states:

The COL applicant is responsible for ensuring that the process and effluent monitoring and sampling program at its site conforms to the guidelines of ANSI N13.1-1969, RG 1.21, and RG 4.15.

In BLN COL FSAR Sections 11.5.1.2, 11.5.2.4, 11.5.4, 11.5.4.1, 11.5.4.2 and 11.5.6.5, the applicant described the programmatic aspects of the effluent monitoring and sampling program. In addition, the applicant provided in BLN COL 11.5-2 specific language regarding the applicant's extension of the existing TVA program for quality assurance of radiological effluent and environmental monitoring which is based on RG 4.15, Revision 1, instead of the most current Revision 2. To maintain consistency, the applicant proposes to apply the same program to BLN Units 3 and 4.

The NRC staff reviewed the resolution of BLN COL 11.5-2 related to the effluent monitoring and sampling program included under Sections 11.5.1.2, 11.5.2.4, 11.5.3, 11.5.4, 11.5.4.1, 11.5.4.2 and 11.5.6.5 of the BLN COL FSAR and considers it adequately addressed in NEI 07-09.

- WLS COL 11.5-2

In WLS COL 11.5-2, the applicant extended the existing Duke Energy QA program, including RG 4.15, Revision 1R1, for effluent and environmental monitoring to Units 1 and 2. By using the current program, which is based on RG 4.15, Revision 1 instead of Revision 2, the applicant will also avoid confusion and the potential for error because the program for the existing and planned units will share the same equipment and personnel. Therefore, the staff finds the use of RG 4.15, Revision 1 acceptable and considers COL Information Item 11.5-2 resolved.

- WLS COL 11.5-3

The applicant provided additional information in WLS COL 11.5-3 to resolve COL Information Item 11.5-3, which states:

The Combined License applicant is responsible for addressing the 10 CFR 50, Appendix I guidelines for maximally exposed offsite individual doses and population doses via liquid and gaseous effluents.

The commitment was also captured as COL Action Item 11.5-3 in Appendix F of NUREG-1793, which states:

The COL applicant is responsible for addressing the guidelines of Appendix I to 10 CFR Part 50, as they relate to maximally exposed offsite individual doses and population doses attributable to liquid and gaseous effluents.

The applicant addressed this COL item by adding information to WLS COL FSAR Sections 11.2.3.5 and 11.3.3.4 for liquid and gaseous effluents, respectively.

The NRC staff reviewed the resolution of WLS COL 11.5-3 related to compliance with 10 CFR Part 50, Appendix I, as discussed in SER Sections 11.2.4 and 11.3.4, and considers it adequately addressed.

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the VEGP SER:

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the BLN SER:

Section 11.5.4.2, Representative Sampling

In this section, the applicant describes how it will take representative samples for analysis. Based on the staff's review, the staff issued RAIs 11.5-1 and 11.5-2. RAI 11.5-1 requested clarification about the use of ANSI/HPS N13.1-1999. RAI 11.5-2 requested more information concerning how the applicant ensures representative liquid effluent and environmental sampling.

In response to RAI 11.5-1, the applicant revised its commitment to use the 1999 standard. Because the applicant made no changes to the certified design, it removed the commitment to use ANSI/HPS N13.1-1999, and committed to ANSI N13.1-1969 to be consistent with the AP1000 certified design. ANSI withdrew the 1969 standard and replaced it with ANSI/HPS N13.1-1999 because the approach taken in the 1969 standard did not provide assurance that the sample in the effluent vent would be representative. The 1999 standard differs significantly from the earlier version in that it is now performance based. NUREG-0800 Section 11.5 (2007) uses the 1999 standard as acceptance criteria. The staff is pursuing this issue through the DC because it deals with the design of the sampling systems for radioactive gas streams.

The applicant provided a response to RAI 11.5-2 and the staff finds the response acceptable. The response provided a more detailed description of how the applicant will assure that liquid samples will be representative. The applicant committed to follow the recommendations in ANSI N42.18 and RG 1.21. In addition, the applicant provided more operational descriptions for composite

sampling. The NRC staff verified that Revision 1 of the BLN COL FSAR adequately addressed the above. As a result, RAI 11.5-2 is closed.

The following portion of this technical evaluation section is reproduced from Section 11.5.4 of the VEGP SER:

License Condition

- *Part 10, License Condition 3, Operational Program Implementation, Item G.3*

VEGP COL FSAR Section 11.5.3 describes effluent monitoring and sampling and Section 11.5.7 describes the offsite dose calculation manual. License Condition 3, Item G.3 requires the licensee to implement the "Process and Effluent Monitoring and Sampling" program prior to initial fuel load. VEGP COL FSAR Section 13.4, Table 13.4-201, "Operational Programs Required by NRC Regulations," identifies three entries under Item 9, "Process and Effluent Monitoring and Sampling Program," as follows: (1) Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls, (2) Offsite Dose Calculation Manual; and (3) Radiological Environmental Monitoring program, as programs identified in FSAR Section 11.5 required to be implemented by a milestone. The ODCM includes the Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls and the Radiological Environmental Monitoring program. In accordance with License Condition 3, Item G.3, these programs are to be implemented prior to initial fuel load. VEGP COL FSAR Table 13.4-201 provides the milestones (prior to initial fuel load) for implementation of these elements of the Process and Effluent Monitoring and Sampling Program and is acceptable as described in the staff's SER related to NEI 07-09.

- *Part 10, License Condition 6, Operational Program Readiness*

The applicant proposed a license condition to provide a schedule to support NRC inspection of operational programs including the ODCM, effluent technical specifications, and the radiological environmental monitoring program. The proposed license condition is consistent with the policy established in SECY-05-0197 and is acceptable.

11.5.5 Post Combined License Activities

For the reasons discussed in the technical evaluation section above, the staff finds the following two license conditions proposed by the applicant acceptable:

- License Condition (11-3) - Prior to initial fuel load, the licensee shall implement an operational program for process and effluent monitoring and sampling. The program shall include the following subprograms and documents:

- a. Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls
 - b. Offsite Dose Calculation Manual
 - c. Radiological Environmental Monitoring Program
- License Condition (11-4) - No later than 12 months after issuance of the COL, the licensee shall submit to the Director of NRO a schedule that supports planning for and conduct of NRC inspections of the operational program for process and effluent monitoring and sampling (including Radiological Effluent Technical Specifications/Standard Radiological Effluent Controls, Offsite Dose Calculation Manual, and Radiological Environmental Monitoring Program). The schedule shall be updated every 6 months until 12 months before scheduled fuel loading, and every month thereafter until the above operational program has been fully implemented.

11.5.6 Conclusion

The NRC staff reviewed the application and checked the referenced DCD. The NRC staff's review confirmed that the applicant addressed the required information relating to the radiation monitoring system, and there is no outstanding information expected to be addressed in the WLS COL FSAR related to this section. The results of the NRC staff's technical evaluation of the information incorporated by reference in the WLS COL application are documented in NUREG-1793 and its supplements.

In addition, the staff evaluated the additional COL information (STD COL 11.5-1, STD COL 11.5-2, WLS COL 11.5-2, and WLS COL 11.5-3) in the application against the relevant NRC regulations, acceptance criteria defined in NUREG-0800, Section 11.5, and other NRC regulatory guides. The staff concludes that the applicant has satisfactorily addressed all RAIs related to Section 11.5.

The staff verified that the applicant has provided sufficient information and that the review supports the conclusion that the process and effluent radiological monitoring and sampling systems are sufficient to comply with applicable portions of GDC 64 of Appendix A of 10 CFR Part 50; applicable requirements of 10 CFR Parts 20, 50 and 52; ANSI/HPS N13.1, ANSI N42.18, RGs 1.21 and 4.15, and applicable acceptance criteria in NUREG-0800, Section 11.5.

Table 11.2-1. Comparison of Important Modeling Assumptions

| Pathways and Parameters | Application | NRC Staff's Analysis |
|--|------------------------------|-----------------------------|
| Drinking water pathway for MEI and population | Yes | Yes |
| Fish ingestion pathway for MEI and population | Yes | Yes |
| Recreational use of river for MEI and population | Yes | Yes |
| Irrigation pathway for the MEI | No | No |
| Surface Water Dilution Model | Completely mixed impoundment | Fully mixed with river flow |

Table 11.2-2. Modeling Parameter Values*

| Parameter | Value | Basis |
|--|---|-----------------------------|
| Annual radionuclide release (Ci/yr) | Multiple values | AP1000 DCD Table 11.2-7 |
| Effluent discharge rate (cfs) | 13.4 | WLS COL FSAR Table 11.2-202 |
| Annual average river flow for the MEI doses (cfs) | 2,538 | WLS COL FSAR Table 11.2-201 |
| Dilution factors | 1 | WLS COL FSAR Table 11.2-202 |
| Transit time (hr) | 14.2 hr for drinking water 0 for other | WLS COL FSAR Table 11.2-202 |
| Reconcentration model** | Complete mixing | WLS COL FSAR Table 11.2-201 |
| Population drinking river water | Union 24,725 | WLS COL FSAR Table 11.2-202 |
| Sport fishing harvest (kg/yr) | 6,804 | WLS COL FSAR Table 11.2-202 |
| Swimming/Boating/Shoreline usage (person-hours per year) | 6,620,364 | WLS COL FSAR Table 11.2-202 |

* The staffs used LADTAP II default values for parameters not listed in the table

** The staffs assumed full mixing with the river rather than an impoundment model

Table 11.2-3. Comparison of Maximum Individual Doses (mrem/yr)

| Organ/Body | Application* | 10 CFR Part 50, Appendix I, Section II.A |
|------------|--------------|--|
| Liver | 7.75E-02 | 10 |
| Total Body | 6.09E-03 | 3 |
| Thyroid | 5.32E-02 | 10 |

* Taken from WLS COL FSAR Table 11.2-203

Table 11.2-4. Comparison of Maximum Individual Doses to 40 CFR Part 190 (mrem/yr)

| Organ/Body | Application* | 40 CFR Part 190 |
|--------------------------|--------------|-----------------|
| Total Body | 2.76 | 25 |
| Thyroid | 27.9 | 75 |
| Other Organ (Child Bone) | 8.67 | 25 |

* Taken from WLS COL FSAR Table 11.3-206

Table 11.3-1. Population Doses Breakdown by Source

| Source | Total Body (person-rem) | % of Total | Thyroid (person-rem) | % of Total |
|--------------|-------------------------|------------|----------------------|------------|
| Noble Gases | 1.43E+00 | 30% | 1.43E+00 | 15% |
| Iodine | 9.94E-03 | 0% | 4.79E+00 | 50% |
| Particulates | 3.18E-01 | 7% | 2.76E-01 | 3% |
| C-14 | 2.30E+00 | 48% | 2.30E+00 | 24% |
| H-3 | 7.28E-01 | 15% | 7.28E-01 | 8% |
| Total | 4.79E+00 | 100% | 9.52E+00 | 100% |

Table 11.3-2. Comparison of Maximum Annual Individual Doses

| Description | Application | 10 CFR Part 50, Appendix I, Sections II.B and II.C |
|--------------------------------------|-------------|--|
| <u>Noble Gases</u> | | |
| • Gamma Dose (mrad) | 0.613* | 10 |
| • Beta Dose (mrad) | 2.93* | 20 |
| • Total Body (mrem) | 0.370* | 5 |
| • Skin (mrem) | 2.06* | 15 |
| <u>Radioiodines and Particulates</u> | | |
| • Maximum Organ (mrem) | 13.9** | 15 |

* Taken from WLS COL FSAR Table 11.3-205

** Dose for the infant thyroid

Table 11.3-3. Comparison of Population Doses (person-rem/yr)

| Organ/Body | Application* | NRC Staff's Analysis |
|------------|--------------|----------------------|
| Total Body | 4.79 | 4.78 |
| Thyroid | 9.52 | 9.52 |

* Taken from WLS COL FSAR Table 11.3-204