# 11. RADIOACTIVE WASTE MANAGEMENT

## 11.1 Source Terms

### 11.1.1 Regulatory Criteria

No specific regulatory criteria are directly applicable to this section. The U.S. Nuclear Regulatory Commission (NRC) staff used the source terms provided by the applicant in Section 11.1, "Source Terms," of the design control document (DCD), Tier 2, Revision 7, to evaluate the liquid and gaseous waste management systems (GWMSs) described in DCD, Tier 2, Revision 7, Section 11.2 "Liquid Waste Management System," and Section 11.3, "Gaseous Waste Management System." Sections 11.2 and 11.3 of this report detail the staff's evaluation of DCD, Tier 2, Revision 7, Sections 11.2 and 11.3, respectively.

The following acceptance criteria apply to Sections 11.2 and 11.3 of this report:

- Title 10, of the *Code of Federal Regulations* (CFR), Part 20, "Standards for Protection Against Radiation," as it relates to dose limits for members of the public and effluent concentration limits in unrestricted areas

- 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," as it relates to the numerical guidelines for design objectives and limiting conditions for operation to meet the criterion to keep exposures "as low as is reasonably achievable" (ALARA) in Appendix I

- 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 60, "Control of Releases of Radioactive Materials to the Environment," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, as it relates to radioactive waste management system (RWMS) designs to control releases of gaseous and liquid radioactive effluents and to handle solid radioactive wastes produced during normal operation

The staff also used the source terms provided by the applicant in DCD, Tier 2, Revision 7, Section 11.1 in evaluating plant radioactive sources described in DCD, Tier 2, Revision 7, Sections 12.2 and 12.3. Sections 12.3 and 12.4 of this report describe the staff's evaluation of DCD, Tier 2, Revision 7, Sections 12.2 and 12.3, respectively.

The regulatory positions and guidance in the following NRC regulatory guides (RGs) and industry standards apply to this section:

- RG 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," Revision 1, as it relates to the method of calculating releases of radioactive materials in effluents from nuclear power plants;

- American National Standards Institute/American Nuclear Society (ANSI/ANS) Standard 18.1-1999, "Radioactive Source Term for Normal Operation of Light-Water Reactors;"

- NUREG-0016, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors" (BWR-GALE code), Revision 1.

The staff performed a comparison of the SRP (Section 11.1, 1981 version) used during the review of the DCD with the 2007 version of the SRP. The 2007 version includes additional guidance on the use of methods to develop primary coolant and steam radioactive source terms other than that described in the SRP. The expanded guidance was considered in the staff's review of the DCD, given the 2007 version of the SRP. Discussions and dispositions of these items are provided in this and other supporting sections of this report. Therefore, the staff concludes that the version of the SRP used, in combination with the additional review performed by the staff, is adequate for this review.

### 11.1.2 Summary of Technical Information

The Economic Simplified Boiling-Water Reactor (ESBWR) RWMS controls the handling and treatment of liquid, gaseous, and solid radioactive wastes. The system comprises the liquid waste management system (LWMS), the GWMS, and the solid waste management system (SWMS). DCD, Tier 2, Revision 7, Section 11.1 describes the sources of radioactivity (source terms) processed by the RWMS.

DCD, Tier 2, Revision 7, Section 11.1 defines the radioactive source terms in reactor coolant and steam as the design bases and normal operation source terms for the gaseous, liquid, and solid RWMS. Radioactive fission products are generated within the fuel assemblies and can leak to the reactor coolant system during normal plant operation, including anticipated operational occurrences (AOOs). As operational plant events, AOOs include unplanned releases of radioactive materials associated with equipment failures, operator errors, and administrative errors, with radiological consequences that are not considered accident conditions. The applicant described two types of source terms for the reactor primary coolant and steam. The first addresses the design basis, and the second describes the anticipated average concentrations in reactor coolant and steam over the life of a boiling-water reactor (BWR). These source terms serve as a basis for the RWMS design and shielding analysis and for the purpose of assessing doses to members of the public. DCD, Tier 2, Revision 7, Tables 11.1-1 through 11.1-7b give the source terms and supporting assumptions.

#### 11.1.2.1 Design-Basis Source Term

The design-basis source term is used for the plant equipment design and radiation shielding requirements.

The first category of design-basis source terms is the noble gas source term, which assumes a fuel defect level that produces 3700 megabecquerels (MBq) per second (s) (0.1 curie (Ci) per second) of noble gases after 30-minute decay. The applicant chose the noble gas source term rate after 30-minute decay as a measure of the fuel defect leakage rate based on BWR operating experience with off-gas systems (OGSs) (General Electric licensing topical reports NEDO-10871 and NEDO-21159, as referenced in DCD, Tier 2, Revision 7, Section 11.1).

The second category of design-basis source terms is the radioiodine source term, which is associated with leakage from failed fuel. The presence of radioiodines is based on a leak rate of 26 MBq per second (700 microcuries ($\mu$Ci) per second) from the fuel. The applicant assumed the ratio of the concentration of radioiodines in coolant to that of reactor steam to be 0.02, using ANSI/ANS 18.1-1999 as the basis.

The third design-basis source term category is the fission products source term, which includes all radionuclides other than noble gases and radioiodines. The fission products included in the source term are based on ANSI/ANS 18.1-1999 and include transuranics. The applicant assumed the ratio of the concentration of fission products in reactor coolant to that of reactor steam to be 0.001, using ANSI/ANS 18.1-1999 as the basis.

The last category of design-basis source terms includes coolant activation products, non-coolant activation products, and argon. Coolant activation products include nitrogen-16 (N-16) and tritium. The concentrations of N-16 and tritium are based on ANSI/ANS 18.1-1999 tabulations. The presence of N-16 results from the neutron activation of naturally occurring oxygen-16. The presence of tritium in coolant primarily results from the activation of naturally occurring deuterium in water and, to a lesser extent, appears as a fission product in fuel. The applicant assumed the reactor coolant, process water, and steam to have a common tritium concentration, as tritium is not reduced by coolant cleanup systems or liquid waste treatment systems. The source term for argon-41 (Ar-41), an activation product of naturally occurring Ar-40, is based on NUREG-0016, but adjusted to a power level of 4500 megawatts thermal. The level of Ar-41 in coolant primarily depends on air in-leakage into the primary coolant system. Neutron activation of circulating impurities and corrosion of irradiated system materials are the cause of non-coolant activation products in the coolant. The concentration of non-coolant activation products is based on ANSI/ANS 18.1-1999 tabulations. The applicant assumed the ratio of the concentration of non-coolant activation products in reactor coolant to that of reactor steam to be 0.001, using ANSI/ANS 18.1-1999 as the basis.

#### 11.1.2.2 *Normal Operation Source Term*

The normal operation source term is used to calculate the quantity of radioactive materials released annually in liquid and gaseous effluents during normal plant operation, including AOOs, to demonstrate compliance with the effluent concentration limits in Table 2 of Appendix B to 10 CFR Part 20, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage,”; the dose limits set forth in 10 CFR 20.1302, “Compliance with Dose Limits for Individual Members of the Public;” and the ALARA design objectives of Appendix I to 10 CFR Part 50.

The normal operation source term is the expected average concentration of the principal radionuclides in the reactor coolant and steam over the life of a BWR. The applicant assumed a realistic design-basis fuel defect level of 740 MBq per second (0.02 Ci per second) of noble gases released after 30-minute decay. For radioiodines, the estimated release rate is 3.7 MBq per second (100 $\mu$Ci per second). The applicant determined these values using the model in ANSI/ANS 18.1-1999 and NUREG-0016.

### 11.1.3 Staff Evaluation

DCD, Tier 2, Revision 7 did not use the methods and parameters described in NUREG-0016. Rather, the radioactive source terms defined in the DCD derive from ANSI/ANS 18.1-1999. Calculating the source term using ANSI/ANS 18.1-1999 is an alternative method listed in RG 1.112. RG 1.112 defines expected long-term radionuclide concentrations in the coolant and steam of BWRs. RG 1.112 provides a uniform approach for determining concentrations of principal radionuclides for a reference BWR plant and provides a method for adjusting radionuclide concentrations to a specific plant design. The data defining the reference plant reflect industry experience at operating BWR plants. The adjustment of radionuclide concentrations from the reference plant to a specific plant design requires information for various plant system parameters. The major parameters include plant thermal power, mass of water in the reactor vessel, cleanup demineralizer flow rate, steam flow rate, and ratio of condensate demineralizer to steam flow rate. Other parameters address factors characterizing the types of systems used to purify reactor coolant and cleanup efficiencies of such systems by class of radionuclides.

The source terms provide the bases for estimating typical concentrations of the principal radionuclides for operating BWR plants. The applicant used the source terms, in part, in DCD, Tier 2, Sections 11.2, 11.3, and 12.2.2 to calculate the quantity of radioactive materials released annually in liquid and gaseous effluents during normal plant operation, including AOOs, and to demonstrate compliance with the effluent concentration limits in Table 2 of Appendix B to 10 CFR Part 20, dose limits to members of the public in 10 CFR 20.1302, and the ALARA design objectives of Appendix I to 10 CFR Part 50.

While reviewing prior versions of the DCD Tier 2, the staff asked the applicant to provide additional information, as request for additional information (RAI). The staff issued a number of RAIs, not listed here for the sake of brevity, during the review of the application. These RAIs involved requests for the applicant to provide clarifications for technical completeness, provide details supporting design bases and design descriptions in demonstrating compliance with regulatory requirements, revise technical and regulatory references, and provide information for the staff to conduct independent evaluations of results presented in the application. These RAIs were satisfactorily resolved by the applicant and closed by the staff in DCD, Tier 2, Revision 7. The following paragraphs discuss the staff's evaluations of the applicant's responses to these RAIs on important technical and regulatory topics.

In RAI 11.1-1a, the staff asked the applicant to provide information on the parameters used to calculate concentrations of radioactive materials in primary and secondary coolant to ensure that they were consistent with NUREG-0016. The applicant responded that this information is addressed in DCD, Tier 2, Section 12.2.2 and in the responses provided to RAIs in DCD, Tier 2, Chapter 12. The staff found in DCD, Tier 2, Section 12.2.2 and in the responses provided to RAIs in DCD, Tier 2, Chapter 12 that the applicant used ANSI/ANS 18.1-1999 to calculate concentrations of radioactive materials in the primary coolant and steam as an acceptable alternative to that of RG 1.112 and NUREG-0016. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.1-1b, the staff asked the applicant to provide information on all normal and potential sources of radioactive effluents delineated in Section 11.1, Subsection I, of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (hereinafter referred to as the SRP). The applicant provided a list of the sources for both BWR

liquid and gaseous wastes, which are addressed in DCD, Tier 2, Section 12.2. The applicant's normal and potential sources of radioactive effluents are consistent with those listed in SRP Section 11.1 as sources of liquid and gaseous waste. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAIs 11.1-2 and 11.1-3, the staff asked the applicant to provide average operational source terms for fission, activation, and corrosion products in reactor water and steam and to provide all calculation parameters used to determine the average source terms. The applicant provided in DCD, Tier 2, Revision 5, Tables 11.1-1 through 11.1-7b the average operational source terms. The staff performed an independent confirmatory calculation of the average operational source terms using the methodology provided in ANS/ANSI 18.1-1999 and found that the applicant's values are acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.1-4, the staff asked the applicant to clarify the values provided for noble gases and zinc-65 (Zn-65) in the coolant source term. The applicant provided the adjustment factor used in its calculation for Zn-65 and described how the design-basis noble gas leakage rate was used to determine the noble gas concentrations. The staff performed an independent confirmatory calculation of the Zn-65 and noble gas concentration using the methodology provided in ANSI/ANS 18.1-1999 and in the applicant's information, and it found that the applicant's values are acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

### 11.1.4 Conclusions

The staff reviewed the reactor coolant and steam source terms for the ESBWR design. Based on the information discussed above, the staff concludes that the applicant calculated the ESBWR coolant and steam source terms in accordance with the guidance of RG 1.112. Therefore, the staff further concludes that the source terms provided in DCD, Tier 2, Revision 7, Section 11.1 are acceptable for evaluating the LWMS and GWMS described in DCD, Tier 2, Revision 7, Sections 11.2 and 11.3 respectively.

## 11.2 Liquid Waste Management System

### 11.2.1 Regulatory Criteria

The staff reviewed DCD, Tier 2, Revision 7, Section 11.2 in accordance with the guidance and acceptance criteria described in SRP Section 11.2, "Liquid Waste Management System." The following acceptance criteria are applicable:

- 10 CFR 20.1302, as it relates to limits on doses to persons and liquid effluent concentrations in unrestricted areas (these criteria apply to releases resulting from the LWMS during normal plant operations and AOOs)

- 10 CFR 20.1406, "Minimization of Contamination," as it relates to facility design and operational procedures for minimizing facility contamination and the generation of radioactive waste

- 10 CFR 50.34a, "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents—Nuclear Power Reactors," as it relates to the inclusion of sufficient

design information to demonstrate the design objectives for equipment necessary to control releases of radioactive effluents to the environment

- Sections II.A and II.D of Appendix I to 10 CFR Part 50, as they relate to the numerical guidelines for dose design objectives to meet the ALARA criterion and cost-benefit analysis

- GDC 60, "Control of Releases of Radioactive Materials to the Environment," as it relates to the design of LWMS to control releases of liquid radioactive effluents

- GDC 61, "Fuel Storage and Handling and Radioactivity Control," as it relates to the design of LWMS to ensure adequate safety under normal operations and postulated accident conditions

The following RGs contain the regulatory positions and guidance for meeting the relevant requirements of the regulations identified above:

- 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," issued October 1977, as it relates to demonstrating compliance with the numerical guidelines for dose design objectives and the ALARA criterion of Appendix I to 10 CFR Part 50

- RG 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors (for comment),", as it relates to performing a cost-benefit analysis for reducing the cumulative dose to the population by using available technology

- RG 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," Revision 2, issued November 2001, as it relates to the seismic design and quality group classification of components used in the LWMS and the structures housing this system, as well as the provisions used to control leakages

- RG 4.21, "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning"

- SRP Section 11.2, Branch Technical Position (BTP) 11-6, "Postulated Radioactive Releases Due to Liquid-Containing Tank Failures," Revision 3

The staff performed a comparison of the SRP (Section 11.2, 1981 version) used during the review of the DCD with the 2007 version of the SRP. The 2007 version includes additional acceptance criteria and guidance addressing the requirements of 10 CFR 20.1406, when compared to the prior version of the SRP. However, the requirements of 20.1406 were considered in the staff's review of the DCD, given the 2007 version of the SRP. Discussions and dispositions of these items are provided in this and other supporting sections of this report. Therefore, the staff concludes that the version of the SRP used, in combination with the additional review performed by the staff, is adequate for this review.

### 11.2.2 Summary of Technical Information

DCD, Tier 2, Revision 7, Section 11.2 describes the design of the LWMS and its functions in controlling, collecting, processing, storing, and disposing of liquid radioactive waste generated as a result of normal operation, including AOOs. The LWMS is a non-safety-related system and serves no safety functions except for the isolation of radioactive releases during planned discharges. Failure of the LWMS does not compromise safety-related systems or components and does not prevent the safe shutdown of the plant. DCD, Tier 2, Revision 7, Section 3.2 describes the seismic and quality group classification and corresponding codes and standards that apply to the design of the LWMS components and piping and the structures housing the system. The LWMS is designed to the seismic criteria of RG 1.143, Class RW-IIa. All waste collection and processing tanks have level-indication gauges and provisions for high-level alarms in the main control room. Local indications and controls are available on displays located in the radwaste building control room. DCD, Tier 2, Revision 7, Figure 11.2-1 provides an overview of the LWMS process diagram depicting all subsystems, while Figures 11.2-1a, 11.2-1b, 11.2-3, and 11.2-4 present specific design details for each subsystem. DCD, Tier 2, Revision 7, Figure 11.2-2 provides an LWMS process stream information directory and simplified flow diagram. DCD, Tier 2, Revision 7, Sections 9.3, 9.2 and 10.4 describe the equipment and floor drain drainage systems and origins and discharges of nonradioactive effluents. DCD, Tier 2, Revision 7, Figures 1.2-21 to 1.2-25 present the general arrangement~~s~~ of the radwaste building in which the LWMS is located. The LWMS does not normally process nonradioactive secondary system effluent and has no interconnections with the potable and sanitary water systems, as described in DCD, Revision 3, Section 9.2.4.

The LWMS and its components are housed in the radwaste building and located in radiologically controlled access areas. DCD, Tier 2, Revision 7, Figure 11.2-1 provides a process diagram showing the LWMS tanks, processing equipment, pumps, valves, ion exchangers, filters, and other components of the subsystems. All LWMS tank overflows are routed to building sumps and drains, which are pumped to their respective drain tanks. Subsystem tanks and components are vented to the radwaste building ventilation system, as described in DCD, Tier 2, Revision 7, Section 9.4. Cubicles, where tanks are located, are lined with steel liners to avoid releases of radioactive materials in the environment. Concrete walls are coated with sealants for additional protection and minimization of radioactive waste, e.g., in the form of contaminated concrete. The LWMS treatment system components are arranged in shielded enclosures to minimize exposure of plant personnel during operation, inspection, and maintenance. There are provisions for periodic inspection of major components to ensure the capability and integrity of the subsystems.

The LWMS is comprised of four types of subsystems, as permanently installed equipment and connected to other installed equipment. The LWMS subsystems are:

- equipment (low conductivity) drain subsystem
- floor (high conductivity) drain subsystem
- chemical drain subsystem
- detergent drain subsystem

The LWMS is divided into several subsystems so that liquid wastes from various sources can be segregated and processed separately. The subsystems maintain the segregation to support the most appropriate treatment of the waste by the LWMS. Cross-connections between subsystems provide additional flexibility in processing wastes by alternate methods and provide redundancy

if one subsystem becomes inoperable. The LWMS normally operates on a batch basis. The system provides for sampling at process points, as discussed in Section 11.5.2 of this report. Administrative controls and detection and alarm signaling of abnormal conditions protect against accidental discharges into the environment.

The treatment subsystems are designed to process wastes from equipment drains, floor drains, chemical wastes, and detergent wastes. The treatment subsystems rely on mixed bed demineralizers, charcoal beds and cartridge filters, reverse osmosis, and organic and neutralization treatments. The subsystems use plant service utilities for their operations, such as compressed air, water, electricity, ventilation, and radiation monitoring. DCD, Tier 2, Revision 7, Tables 11.2-1 through 11.2-4 list the descriptions and design parameters for these systems, which are depicted in DCD, Tier 2, Revision 7, Figures 11.2-1 to 11.2-4. DCD, Tier 2, Revision 7, Table 11.2-3 lists the decontamination factors (DFs) by types of process streams and types of processing methods. DCD, Revision 7, Section 9.3.3, provides additional design details. Descriptions of the associated process and effluent radiological monitoring and sampling systems appear in DCD, Revision 7, Sections 11.5.3 and 11.5.5. DCD, Tier 2, Revision 7, Section 12.2.2.3 presents estimates of liquid effluent radionuclide concentrations and average annual releases, and DCD, Revision 7, Section 12.2.2.4, describes associated doses to the maximally exposed individual located in unrestricted areas.

The LWMS processes four major categories of radioactive wastes, including the following:

(1) equipment drains from various plant sources;

(2) floor drains from various sumps in the reactor, turbine, and radwaste buildings;

(3) chemical drains from the laboratory and other relatively small-volume sources; and

(4) detergent drains from laundry and personnel decontamination and decontamination waste water from the reactor and turbine buildings.

The equipment drain subsystem processes liquid wastes (high purity) from the RWC and shutdown cooling system (SCS), fuel auxiliary pools cooling system, condensate demineralizer, and equipment drains in the reactor, fuel, turbine, and radwaste buildings. This subsystem can also receive liquid waste from the floor drains subsystem. The permanently installed equipment includes three collection tanks, each with a capacity of about 140,000 liters (37,000 gallons), and two sample tanks with the same capacity. The associated treatment subsystem consists of pre- and main filters, reverse osmosis units, pretreatment and polishing resin ion exchangers, and a resin trap. The subsystem's processing capacity is rated at about 330 liters per minute (88 gallons per minute). The subsystem's design includes process sampling points to assess its performance and compliance with regulatory requirements for the disposition or recycling of treated liquid waste.

The floor drain subsystem processes liquid wastes (low purity) from the reactor drywell and from floor drains in the reactor, fuel, turbine, and radwaste buildings. This subsystem can also receive liquid waste from the equipment drain, chemical drain, or detergent drain subsystems. The equipment includes two collection tanks, each with a capacity of about 130,000 liters (34,000 gallons), and two sample tanks with the same capacity. The associated treatment subsystem consists of pre- and main filters, a reverse osmosis unit, pretreatment and polishing resin ion exchangers, and a resin trap. The subsystem's processing capacity is rated at about

250 liters per minute (66 gallons per minute). The subsystem's design includes process sampling points to assess its performance and compliance with regulatory requirements for the disposition or recycling of treated liquid waste.

The chemical drain subsystem processes liquid wastes from the turbine and radwaste buildings, and from the detergent drain collection tank, if needed. The permanently installed equipment includes one collection tank with a capacity of about 4,000 liters (1,060 gallons) and no sample tanks. Chemicals are added to the tank for pH control or other chemical adjustments, as needed. The subsystem's design includes process sampling points to assess its performance and compliance with regulatory requirements for the disposition or recycling of treated liquid wastes.

The detergent drain subsystem processes liquid wastes from the hot-laundry and hot-shower facilities, and decontamination drains from the reactor, turbine, and radwaste buildings. This subsystem can also receive liquid waste from the chemical drains subsystem. The permanently installed equipment includes two collection tanks, each with a capacity of about 15,000 liters (4,000 gallons) and two sample tanks with the same capacity. The associated treatment subsystem consists of an organic pretreatment unit, which includes the pre- and main cartridge and charcoal filters, with a rated processing capacity of about 33 liters per minute (9 gallons per minute). The subsystem's design includes process sampling points to assess its performance and compliance with regulatory requirements for the disposition or recycling of treated liquid wastes.

When liquid wastes are processed, treated wastes returned to the LWMS for eventual discharge to the environment~~s~~ or are returned to the condensate storage tank (CST) for recycling, as described in DCD, Tier 2, Revision 7, Section 9.2.6. Liquid wastes that cannot be discharged are returned to their specific collection tanks for reprocessing or reuse in plant systems. Any liquid wastes that cannot be treated onsite are placed in tanks or containers and shipped offsite for processing and disposal. Process discharge paths are normally aligned to one of the subsystem sample tanks. Before discharge~~s~~, liquid wastes are sampled for radiological analysis and compliance with state and local requirements for non-radioactive contaminants, based on procedures for combined license (COL) holders. DCD, Tier 2, Revision 7, Sections 9.3.2 and 11.5.5 describe the features of the LWMS process sampling system. DCD, Tier 2, Revision 7, Table 9.3-1 identifies process and effluent streams that are to be evaluated for the presence of radioactivity.

All LWMS discharges are made through a single liquid waste discharge line to the discharge canal using procedures developed by COL holders. The release of processed liquid wastes from any sample tank to the environment~~s~~ is permitted only when the analysis of the tank's contents indicates that such a release meets the requirements of Appendix B to 10 CFR Part 20 for liquid effluent concentrations and Appendix I to 10 CFR Part 50 for doses to members of the public. During discharges, liquid wastes are mixed with and diluted by other water in the discharge canal, at a flow rate of about 20,000 liters per minute (5,300 gallons per minute), as described in DCD, Revision 7, Table 12.2-20a. The discharge flow rate from the LWMS is controlled to ensure that radionuclide concentration levels in unrestricted areas comply with effluent concentration limits Table 2, Column 2, of Appendix B to 10 CFR Part 20.

Based on DCD, Tier 2, Revision 7, Table 11.2-4, the combined normal generation rate of liquid wastes serviced by the four subsystems is estimated to be about 98,000 liters per day (25,600 gallons per day). The estimated maximum flow rate is about 240,000 liters per day (63,400

gallons per day), based on listed sources of liquid wastes. The estimated time needed to process the maximum anticipated flow rate varies from nearly 7 hours for the floor drain subsystem to about 0.2 hours for the chemical drain subsystem. The combined storage capacity and processing rates are expected to provide an adequate margin for handling surges in the generation of liquid wastes serviced by these subsystems.

The liquid radwaste discharge radiation monitor tracks all discharges from the LWMS before in-plant dilution and subsequent release to the discharge canal. The monitor is located on the common discharge line downstream of the LWMS sample tanks - see DCD, Tier 2, Revision 7, Figure 11.5-1. The radiation monitor provides a signal to terminate liquid waste releases before discharge concentrations exceed predetermined set points, based on effluent limits in Table 2, Column 2, of Appendix B to 10 CFR Part 20. DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-3, 11.5-4, 11.5-5, 11.5-7, and 11.5-9 describe the sampling requirements and operational characteristics of the liquid radwaste discharge radiation monitor The radiation monitoring system used to control and monitor releases of radioactive materials in liquid effluents to unrestricted areas conforms to the requirements of GDC 60.

In DCD, Tier 2, Revision 7, Section 11.2.6 identifies two COL information items for COL applicants. The COL items address the implementation of Inspection and Enforcement (IE) Bulletin (BL) 80-10, "Contamination of Non-Radioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment," dated May 6, 1980, on the protection of nonradioactive systems, and operational procedures for the minimization of contamination under the requirements of 10 CFR 20.1406. The COL items are:

- COL Information Item 11.2-1-A - The COL applicant is responsible for identifying LWMS subsystems interface and connections that are considered nonradioactive but that could later become radioactive through improper interfaces with radioactive systems. In identifying such connections, the applicant applies the guidance and information in IE BL 80-10.

- COL Information Item 11.2-2-A - The COL applicant is responsible for demonstrating compliance with 10 CFR 20.1406 as this section relates to the design and operational procedures of treatment subsystems to minimize contamination, facilitate eventual decommissioning, and minimize the generation of radioactive waste.

### 11.2.3 Staff Evaluation

The staff reviewed the LWMS in accordance with the guidance in SRP Section 11.2. Staff acceptance of the LWMS is based on the design meeting the requirements of 10 CFR 50.34a and GDC 60 and 61. Under the requirements of 10 CFR 50.34a, the applicant must provide sufficient design information to demonstrate that it has met the design objectives for equipment necessary to control releases of radioactive effluents to the environment. GDC 60 requires that the LWMS is designed to control releases of liquid radioactive effluents, and GDC 61 stipulates that the LWMS is designed to ensure adequate safety under normal operations and postulated accident conditions.

In response to staff inquiries, the applicant stated in DCD, Tier 2, Revision 7, Section 11.2 that the LWMS complies with the guidance in RG 1.143, Revision 2. Specifically, the guidance addresses the design and construction methods, materials specifications, welding, and inspection and testing standards for the LWMS pumps and piping. The COL holder is

responsible for testing all liquid waste processing subsystems installed in the plant, as described in DCD, Tier 2, Chapter 14. Chapter 14 of this report addresses the adequacy of the preoperational testing programs.

The LWMS tanks (floor and equipment drain tanks, sample tanks, detergent drain tanks, and chemical drain tanks) are located in the radwaste building. The LWMS is designed to the seismic criteria of RG 1.143, as Class RW-IIa. The associated subsystems and components, such as ion exchangers, filters, pumps, applicable valves, and waste processing equipment, are also located in the radwaste building. All LWMS tank overflows are routed to watertight rooms or cubicles within the radwaste building and drained to local sumps, which are pumped to their appropriate waste collection tanks. All tanks are vented through filtration systems and monitored for radioactivity before being discharged to the environment through the radwaste building stack. The staff finds the above design aspects of the LWMS acceptable with respect to meeting the design guidance specified in RG 1.143.

Regarding the presence of outdoor tanks, the applicant confirmed that, other than the CST, there are no LWMS tanks located in yard areas outside of buildings (see DCD, Tier 2, Revision 7, Section 9.2.6). The CST is the only outdoor tank that is expected to contain low levels of radioactivity. The CST is located in a catch basin that is designed to hold the entire volume of the tank. Tank overflow also discharges in the same basin. The design of the catch basin includes a sump, with provisions to pump water to the LWMS for treatment or to the site surface water drainage system if radioactivity levels are in compliance with the requirements of Appendix B to 10 CFR Part 20 for liquid effluent concentrations and Appendix I to 10 CFR Part 50 for doses to members of the public. The staff finds the above design aspects of the CST acceptable with respect to meeting the design guidance in RGs 1.143 and 4.21.

No other tank interfaces are necessary with the LWMS. The LWMS has no interconnections with the potable and sanitary water systems, and it does not normally process non-radioactive secondary system effluent. The applicant confirmed that all releases of radioactive effluents from the LWMS will be tracked by a continuous liquid effluent radiation monitor on the LWMS discharge line. The relevant requirements of GDC 60 and 61 are met by using the regulatory positions contained in RG 1.143, as it relates to the seismic design and quality group classification of components used in the LWMS, structures housing the systems, provisions used to control leakage, and definition of the discharge path beginning with interfaces with plant primary systems and terminating at the point of controlled discharge to the environment.

The LWMS is designed to handle most process and effluent streams and other anticipated events. However, for events occurring at low frequencies, or producing effluents not compatible with currently used processing equipment, additional or specialized temporary processing equipment may be brought into the radwaste building treatment system bay. Connections to various portions of LWMS subsystems facilitate the use of additional skid-mounted processing equipment. These connections allow for the use of skid-mounted equipment applied in series with or parallel to installed equipment as an alternative to returning treated liquid wastes to the LWMS, or the use of skid-mounted equipment as a pumping point into tanks for shipment, treatment, and disposal by third-party waste processors. The design includes the use of mobile shield walls to reduce ambient radiation levels and minimize exposure to workers during operation and maintenance. The COL holder is responsible for confirming that the use of any additional processing equipment complies with the DCD design bases and meets the NRC regulations on the discharge of liquid effluents, dose limits for members of the public, and radiation protection for workers during the operation and maintenance of such equipment.

The use of skid-mounted systems is expected to result in more efficient liquid waste processing by matching optimum treatment methods to waste streams, based on their chemical and radiological properties. The selection of specific treatment methods and ion exchange and adsorbent media depends on current and future developments of ion exchange and filtration technologies and known characteristics of liquid radwaste streams to be treated by waste processing subsystems. DCD, Tier 2, Revision 7, Table 11.2-3 lists the DFs by types of generic process streams and types of processing methods. The DFs were found to be consistent with the NRC guidance, as described in NUREG-0016, Revision 1. A COL applicant referencing the ESBWR certified design should confirm that the performance characteristics or types of adsorbent media it plans to use for all liquid waste processing subsystems will rely on the use of ion exchange or filtration media that will meet or exceed the DFs listed in DCD, Tier 2, Revision 7, Table 11.2-3 for the purpose of complying with liquid radioactive effluent concentration limits and doses to members of the public, as evaluated in DCD, Tier 2, Revision 7, Section 12.2.2. In applying the guidelines of RG 1.143, the staff will review the proposed use of any additional processing equipment for treating liquid radwaste on a plant-specific basis for particular COL applications. A COL applicant should discuss how such processing equipment intended for the treatment of liquid radwaste would be integrated with the design of permanently installed equipment and confirm that it meets the guidelines of RG 1.143 and the design objectives of Sections II.A and II.D of Appendix I to 10 CFR Part 50. The staff's evaluation of whether the design of the LWMS is acceptable and meets the requirements of 10 CFR 20.1301, "Dose Limits for Individual Members of the Public," and 10 CFR 20.1302 and the design objectives of Appendix I to 10 CFR Part 50 is considered part of its review of DCD, Tier 2, Revision 7, Section 12.2.2 and is addressed in Section 12.2 of this report.

The staff reviewed the system construction standards; system process flow outlines and descriptions; sources of liquid input volumes; collection points of liquid waste; flow paths of liquids through subsystems, including potential bypasses; provisions for monitoring radioactivity levels in effluent releases; and point of release of liquid effluents to the environment. The LWMS design includes provisions for sampling at specific process points and protecting against accidental discharges by the detection and alarm signaling of abnormal conditions, as managed under administrative controls by the COL holder. The system incorporates design and operational flexibility by providing redundancy in processing wastes through cross-connections to route effluents among subsystems and sufficient storage capacity using multiple collection drain and sample tanks. There are provisions for periodic inspection of major components to ensure the capability and integrity of LWMS subsystems. The COL holder is responsible for testing any additional skid-mounted liquid waste processing systems installed in the plant. The staff finds the design acceptable with respect to meeting the criteria of 10 CFR 50.34a, GDC 60 and 61, and the guidance in RG. 1.143, given the quality assurance (QA) program described in Chapter 17. Specifically, the QA requirements address the design, fabrication, procurement, and installation of permanently installed liquid waste processing systems or of such permanently installed systems combined with the use of skid-mounted processing equipment.

The staff's evaluation of the assessment of a potential release of radioactive liquids following the postulated failure of a tank and its components, located outside of containment, is part of the review of DCD, Tier 2, Revision 7, Section 15.3.16. The assessment considers the potential impacts of the release of radioactive materials on the nearest potable water supply located in an unrestricted area, unless the design includes specific engineering provisions to contain the expected amount of liquid radioactive waste and avoid a release of radioactivity into the

environment. Chapter 15 of this report addresses this issue and presents the results of the staff's analysis.

DCD, Tier 2, Revision 7, Section 12.6 addresses compliance with 10 CFR 20.1406 and RG 4.21, as they relate to facility design and operational procedures for permanently installed subsystems in minimizing the contamination of the facility and generation of radioactive waste. In addition, the DCD commits the COL applicant to follow the guidance of IE BL 80-10 to avoid the cross-contamination of nonradioactive systems, and avoid unmonitored, uncontrolled radioactive releases to the environment. These aspects are addressed under COL Information Items 11.2-1-A and 11.2-2-A. The COL applicant is responsible for identifying LWMS subsystems interface and connections that are considered nonradioactive but that could later become radioactive through improper interfaces with radioactive systems. In identifying such connections, the applicant applies the guidance and information in IE BL 80-10. The applicant does not list specific design features, while the detailed operational features of each subsystem are left to the COL applicant to define in specifications developed for the procurement of each subsystem through qualified vendors. DCD, Tier 2, Revision 7, Section 12.6 outlines design concepts and features that are expected to reduce contamination levels using the guidance in RG 4.21. The staff's evaluation is presented in Section 12.7 of this report.

A COL applicant referencing the ESBWR certified design should either include the operational set points of the liquid radwaste discharge radiation monitor in its plant-specific offsite dose calculation manual (ODCM), or include a description of the methodology for establishing the set points in the description of the Operational Program for the ODCM. In addition, the COL applicant should describe standard radiological effluent controls (SRECs) in monitoring and controlling releases of radioactive materials to the environment; thereby, eliminating the potential for unmonitored and uncontrolled release. The staff will review this information for each COL application. Section 11.5 of this report addresses this as COL Information Item 11.5-2-A.

Under the requirements of Sections II.A and II.D of Appendix I to 10 CFR Part 50, a COL applicant referencing the ESBWR certified design is responsible for addressing the requirements of the design objectives in Appendix I to 10 CFR Part 50 in controlling doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements define dose criteria for liquid effluents and stipulate the conduct of a cost-benefit analysis in justifying installed processing and treatment systems as permanently installed equipment and in combination with any additional skid-mounted subsystems, using the guidance in RG 1.110. Section 12.2 of this report addresses these aspects as COL Information Item 12.2-3-A for liquid effluents.

In reviewing prior revisions of DCD Tier 2, the staff could not confirm that some aspects of the ESBWR LWMS design were consistent with NRC regulatory requirements and guidance. The staff issued a number of RAIs, not listed here for the sake of brevity, during the review of the application. These RAIs involved requests for the applicant to provide clarifications for technical completeness, provide details supporting design bases and design descriptions in demonstrating compliance with regulatory requirements, revise and update system drawings for consistency with system descriptions, revise technical and regulatory references, and provide information for the staff to conduct independent evaluations of results presented in the application. These RAIs were satisfactorily resolved by the applicant and closed by the staff in DCD, Tier 2, Revision 6. The following paragraphs discuss the staff's evaluations of the applicant's responses to the staff's RAIs on important technical and regulatory topics.

In RAI 11.2-4, the staff asked the applicant to revise DCD, Tier 2, Revision 2, Table 11.2-1 to reflect the guidance in RG 1.143, Revision 2, for atmospheric tanks. In its response, the applicant provided a revised table which was included in DCD, Tier 2, Revision 3. The staff found that the applicant retained a footnote that added the use of fiberglass reinforced tanks constructed in accordance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) Section X. The use of fiberglass tanks is not consistent with the guidance in RG 1.143. BPVC Section X does not have any specific guidance on the use of fiberglass tanks in radiation zones or on the retention of radioactive liquids. According to 10 CFR 50.34(h)(3), the applicant should justify deviations from the established review criteria, as stated in the applicable SRP section. Therefore, the staff asked the applicant either to provide documentation to demonstrate that the use of fiberglass reinforced tanks for retention of liquids containing radioactive waste is acceptable and will not pose a risk to the health and safety of the public or plant workers, or to remove the provision to use fiberglass reinforced plastic tanks. In a letter dated July 19, 2007, the applicant agreed to delete Footnote 3 in DCD, Tier 2, Revision 3, Table 11.2-1 about using fiberglass tanks. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.2-5, the staff asked the applicant to revise Table 11.2-1 to reflect the guidance in RG 1.143, Revision 2, for tanks rated in the pressure range of 0–15 pounds (lbs) per square inch. In its response, the applicant agreed to revise the table to comply with RG 1.143. The staff reviewed the revised table attached to the applicant's response letter and included in DCD, Tier 2, Revision 3. The staff found that the applicant retained a footnote that adds the use of fiberglass reinforced tanks constructed in accordance with the requirements of ASME Code BPVC Section X. Based on the same reasons discussed in the above evaluation for the RAI 11.2-4 response, the staff found the response to RAI 11.2-5 unacceptable. In response to a supplemental RAI, the applicant agreed, in a letter dated August 31, 2007, to delete the provision (Footnote 3 to Table 11.2-1) allowing the use of fiberglass tanks to contain liquid radioactive waste. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.2-11, the staff asked for additional details on Figure 11.2-1, "Liquid Waste Management System Process Diagram." For example, the diagram did not show sufficient detail to allow identification of all sources of liquid input volumes; the points of collection of liquid waste; the flow paths of liquids through the system, including potential bypasses; and the specific point of release of liquid effluents to the environment. The level of detail should be sufficient to allow the staff to conduct its review in accordance with the Review Criterion III.1 in SRP Section 11.2, (Revision 2, July 1981). In its response, the applicant stated that Tier 2 would be revised to include a new Figure 11.2-2, "Liquid Waste Management System Process Stream Information Directory." Additionally, the applicant added a description of Figure 11.2-1b in the text of DCD, Tier 2, Revision 3, Section 11.2. The staff reviewed the revised figures in DCD, Tier 2, Revision 3 and still could not find the specific point(s) of release of liquid effluents to the environment (e.g., interfacing with the circulating water system). In a letter dated July 19, 2007, the applicant agreed to revise DCD, Tier 2, Revision 3, Figures 11.2-1b and 11.2-3 to identify the release point(s). Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.2-13, the staff asked the applicant to describe how the classifications and design criteria apply to the LWMS (including piping, tanks, and structures used to contain leakage) and how the criteria satisfy the requirements of GDC 61 with respect to designing radioactive waste

systems to ensure adequate safety under accident conditions. In its response, the applicant stated that the LWMS was designed to Quality Group D and modified by RG 1.143, Revision 2, Section 7 and Table 1. Referring to the response to RAI 11.2-9 and 11.2-10, the applicant addressed the compliance of the LWMS with RG 1.143 guidance. The staff reviewed the response to RAI 11.2-13. It previously had reviewed the responses to RAI 11.2-6 through 11.2-10, related to the compliance of the LWMS with RG 1.143, Revision 2. Based on SRP Section 11.2, the compliance with RG 1.143 forms the bases for satisfying GDC 61. A COL applicant referencing the ESBWR certified design should describe the QA program for design, fabrication, procurement, construction of structures, and installation of permanent LWMS systems and components in the plant in accordance with its overall QA program. However, DCD, Tier 2, Revision 3, Section 11.2.6 did not commit the COL applicant to conform with the QA guidance specified in RG 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," issued June 1974; 1.33, "Quality Assurance Program Requirements (Operation)," issued February 1978; and 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)-Effluent Streams and the Environment," issued July 2007. In RAI 11.2-13 S01, the staff asked the applicant to update the DCD to address this aspect. In a global response to RAI 11.2-13 S01 and 11.5-44, the applicant proposed changes to all sections of Chapter 11 related to this topic and stated that the applicable QA requirements are described in DCD, Tier 2, Revision 4 ~~5~~, Table 17.0-1. In a letter dated July 23, 2007, the applicant committed to placing a reference to QA requirements of DCD, Tier 2, Revision 4, Chapter 17 for the design, fabrication, procurement, and installation of the liquid radioactive waste system in accordance with the COL holder's overall QA program. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.2.3-1, 11.2.3-2, and 11.2.2-4, the staff asked the applicant to clarify the basis of the decontarmination factors (DFs) listed in DCD, Tier 2, Revision 1, Table 11.2-3 and their applications in deriving the estimated radioactive liquid effluent radioactive source term identified in DCD, Tier 2, Revision 3, Section 12.2.2.3. DCD, Tier 2, Revision 3, Table 11.2-3 presented updated DFs assigned by types of liquid wastes and groupings of radionuclides. The revised DFs are consistent with those presented in NUREG-0016 for general purpose ion-exchange and adsorbent media and filtration systems. Accordingly, the staff found the response to RAI 11.2.3-1 acceptable. However, the staff's review of DCD, Tier 2, Revision 3 noted that Section 11.2.6 did not commit the COL applicant to the performance of installed mobile processing equipment with that described in DCD, Tier 2, Revision 3, Tables 11.2-2c and 11.2-3. For example, a COL applicant referencing the ESBWR certified design should either describe the performance requirements of ion-exchange and adsorbent media and filtration, or identify the types of ion-exchange and adsorbent media and filtration systems it plans to use depending on the expected characteristics of liquid process and effluent streams. In RAI 11.2.3-1 S01, the staff asked the applicant to update the DCD to address this aspect. In a response to this supplemental RAI, the applicant noted that DCD, Tier 2, Section 11.2.2 and Table 11.2-3 would be revised to state that the processing equipment and adsorbent media used to treat liquid radioactive wastes will meet or exceed the DFs given in DCD Table 11.2-3 for the purpose of complying with liquid effluent concentration limits and doses to members of the public. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD Tier 2. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.2-16, the staff asked the applicant to revise DCD, Tier 2, Revision 3, Section 11.2.2 and DCD, Tier 1, Revision 3, Section 2.10.1 to indicate that the then proposed mobile liquid radioactive waste processing system was a conceptual design and that DCD Tier 2 included a COL information item committing the COL applicant to provide complete descriptions and specifications of the mobile LWMS and its subsystems so as to meet the performance specifications described in DCD, Tier 2, Revision 3, Table 11.2-3, and radiological liquid effluent source terms and doses to members of the public presented in DCD, Tier 2, Revision 3, Section 12.2.2. The staff's evaluation of the LWMS and the use of mobile waste processing systems concluded that the design of the LWMS is conceptual and, therefore, not in the scope of design certification (DC), given the requirements of 10 CFR 52.47(a)(24) and 52.47(a)(25). Alternatively, the applicant may provide final descriptions and specifications of the mobile LWMS and its subsystems in the DCD rather than conceptual design information, with the inspection, test, analysis, and acceptance criteria (ITAAC) included as appropriate. In the context of DCD Tier 1 requirements, design descriptions and interface requirements are intended to serve as binding requirements for the purpose of confirming that the plant will be built given the design descriptions and ITAACs described in Tier 1. In the context of COL information items, a COL applicant referencing the ESBWR certified design is responsible for ensuring that the plant is built in accordance with the design features described in DCD, Tier 2, Section 11.2 and other relevant and supporting DCD sections, and tested using the initial test program described in DCD, Tier 2, Section 14.2.

In a letter dated March 17, 2008, the applicant committed to replacing the initially proposed conceptual design of the mobile liquid waste processing subsystems with full design descriptions, including flow diagrams for each of the four subsystems. The design of each subsystem is described in DCD, Tier 2, Revision 7, Section 11.2.2 and shown in DCD, Tier 2, Revision 7, Figures 11.2-1 to 11.2-4. Similarly, DCD, Tier 2, Section 11.2.3, contains the safety evaluation; DCD, Tier 2, Section 11.2.4 describes the testing and inspection requirements; DCD, Tier 2, Section 11.2.5, describes the types of instrumentation used; and DCD, Tier 2, Section 11.2.6, identifies COL information to be addressed by COL applicants. Based on the applicant’s response, this RAI was resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 7.

In addressing 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC, the applicant has included specific ITAACs for the LWMS. The ITAACs are described in DCD, Tier 1, Revision 7, Section 2.10.1 and Tables 2.10.1-1 and 2.10.1-2. Two ITAACs address the descriptions and functional arrangements of the LWMS and assess the integrity of the LWMS when subjected to hydrostatic testing pressures expected during operation. An ITAAC is assigned to confirm that the initial loading of subsystem demineralizers and vessels includes the appropriate types of filtration and adsorption media in meeting or exceeding the DFs listed in Table 11.2-3 of DCD, Tier 2, Revision 7. An ITAAC addresses the loading of filtration and adsorption media in process subsystems. A further commitment assigns an ITAAC for the installation of steel liners in cubicles housing LWMS tanks and vessels to ensure that, in the event of a tank rupture, the effluent concentration limits of Table 2 (Column 2) of Appendix B to 10 CFR Part 20 will not be exceeded in unrestricted areas. Another ITAAC focuses on a test to confirm that the liquid radioactive waste discharge radiation monitor provides automatic closure of the discharge isolation valve on receipt of a high radiation signal exceeding a set-point value. If the inspections, tests, and analyses are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the Atomic Energy Act, as amended (AEA) and NRC regulations.

In RAI 11.0-1, the staff's review indicated that some listed references were not cited in the text, e.g., Ref. 11.2-8 and the reference list included improper regulatory citations, e.g., Ref. 11.2-2. In RAI 11.1-1, the staff asked the applicant to make the appropriate corrections. In a response dated November 13, 2008, the applicant agreed to make the appropriate corrections and provided proposed changes to be included in Revision 6 of the DCD. The staff found the proposed changes acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6

### 11.2.4 Conclusions

Based on the information discussed above, the staff concluded that the LWMS (as a permanently installed subsystem and in combination with the use of skid-mounted processing equipment) includes the equipment necessary to manage and treat process streams and control releases of radioactive materials in liquid effluents in accordance with 10 CFR 20.1301, 10 CFR 20.1302, and 10 CFR 20.1406; Appendix I to 10 CFR Part 50; the requirements of GDC 60 and 61; and the requirements of 10 CFR 50.34a. This conclusion is based on the following requirements that:

- The ESBWR design meets the dose requirements of 10 CFR 20.1302 by ensuring that the annual average concentration of radioactive materials in liquid effluents released into unrestricted areas will not exceed the limits specified in Appendix B to 10 CFR Part 20, Table 2, Column 2, as demonstrated in DCD, Tier 2, Section 12.2.2.

- The ESBWR design complies with the requirements set forth in Section II.A of Appendix I to 10 CFR Part 50 in ensuring that offsite individual doses resulting from liquid effluent releases will not exceed dose criteria, as demonstrated in DCD, Tier 2, Section 12.2.2.

- The ESBWR design demonstrates compliance with 10 CFR 50.34a, as it relates to the provision of sufficient design information and an ITAAC confirming the initial loading of the appropriate types of filtration and adsorption media in subsystem demineralizers, as set forth in the above discussion.

- By preparing a plant-specific cost-benefit analysis in accordance with RG 1.110, a COL applicant referencing the ESBWR certified design is required to demonstrate compliance with the requirements for offsite individual doses and population doses resulting from liquid effluents treated by installed waste processing subsystems, as stipulated in Sections II.A and II.D of Appendix I to 10 CFR Part 50. These requirements are the subject of COL Information Item 12.2-3-A in DCD, Tier 2, Section 12.2.4 (12.2-3-A).

- The ESBWR design has met the requirements of GDC 60 and 61 with respect to controlling releases of liquid effluents by radiation monitoring of releases from the LWMS. A radiation monitor tracks all releases and will generate a signal to terminate liquid radwaste releases before the discharge concentration exceeds a predetermined set point. The COL holder is required to identify appropriate operational set points for its LWMS radiation monitor in its plant-specific ODCM, as described in DCD, Tier 2, Section 11.5.4.

- The applicant demonstrates compliance with the requirements of GDC 61 by meeting the guidelines of RG 1.143, as supported with additional commitments described in DCD,

Tier 2, Section 12.2.2 and an ITAAC confirming the installation of steel liners in cubicles where liquid radioactive waste tanks are located. These commitments also fulfill the requirements of 10 CFR 20.1406 and guidance in RG 4.21 by minimizing the contamination of the facility and generation of radioactive waste and of IE BL 80-10 by avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases to the environment. These requirements are the subject of COL Information Items 11.2-1-A and 11.2-2-A. DCD, Tier 1, Revision 7, Section 2.10.1, and Table 2.10.1-2 describe the ITAAC for the installation of steel liners.

- The applicant demonstrates compliance with the requirements of 10 CFR 52.47(b)(1) with the inclusion of ITAACs for the LWMS. The ITAACs address the descriptions and functional arrangements of the LWMS, the integrity of the LWMS under expected operating pressures, the initial loading of the appropriate types of filtration and adsorption media LWMS subsystems, the installation of steel liners in cubicles housing LWMS tanks and vessels to ensure that in the event of a tank rupture, the effluent limits of Table 2 (Column 2) in Appendix B to 10 CFR Part 20 will not be exceeded, and the proper operation of the liquid radioactive waste discharge radiation monitor will provide automatic closure of the discharge isolation valve on receipt of a high radiation signal. If the inspections, tests, and analyses are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations.

## 11.3 Gaseous Waste Management System

### 11.3.1 Regulatory Criteria

The staff reviewed DCD, Tier 2, Revision 7, Section 11.3 ”Gaseous Waste Management System,” in accordance with the guidance and acceptance criteria described in SRP Section 11.3, “Gaseous Waste Management System.” The following acceptance criteria are applicable:

- 10 CFR 20.1302, as it relates to limits on doses to persons and gaseous effluent concentrations in unrestricted areas (these criteria apply to releases resulting from the GWMS during normal plant operations and AOOs)

- 10 CFR 20.1406, as it relates to facility design and operational procedures for minimizing the contamination of the facility and generation of radioactive waste

- 10 CFR 50.34a, as it relates to providing sufficient design information to demonstrate the effectiveness of design objectives for equipment necessary to control releases of radioactive gaseous effluents to the environment

- GDC 3, “Fire Protection,” as it relates to protecting gaseous waste handling and treatment systems from the effects of explosive mixtures of hydrogen and oxygen

- GDC 60, as it relates to the design of the GWMS to control releases of gaseous radioactive effluents

- GDC 61, as it relates to the control of radioactivity in the GWMS and building ventilation systems associated with fuel storage and handling areas

- Sections II.B, II.C, and II.D of Appendix I to 10 CFR Part 50, as they relate to the numerical guidelines for dose design objectives to meet the ALARA criterion and cost-benefit analysis

The following RGs contain the regulatory positions and guidance for meeting the relevant requirements of the regulations identified above:

- RG 1.109, as it relates to demonstrating compliance with the numerical guidelines for dose design objectives and the ALARA criterion of Appendix I to 10 CFR Part 50

- RG 1.110, as it relates to performing a cost-benefit analysis for reducing the cumulative dose to the population by using available technology

- RG 1.140, "Design, Inspection, and Testing Criteria for Air Filtration and Adsorption Units of Normal Atmosphere Cleanup Systems in Light-Water-Cooled Nuclear Power Plants," Revision 2, as it relates to the design, testing, and maintenance of normal ventilation exhaust systems at nuclear power plants

- RG 1.143, as it relates to the seismic design and quality group classification of components used in the GWMS and structures housing this system, as well as the provisions for controlling leakage

- RG 4.21, as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation

- SRP Section 11.3, BTP 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure," as it relates to assessing offsite doses associated with such a failure.

The staff performed a comparison of the SRP (Section 11.3, 1981 version) used during the review of the DCD with the 2007 version of the SRP. The 2007 version includes additional acceptance criteria and guidance addressing the requirements of 10 CFR 20.1406, when compared to the prior version of the SRP. However, the requirements of 10 CFR 20.1406 were considered in the staff's review of the DCD, given the 2007 version of the SRP. Discussions and dispositions of these items are provided in this and other supporting sections of this report. Therefore, the staff concludes that the version of the SRP used, in combination with the additional review performed by the staff, is adequate for this review.

### 11.3.2 Summary of Technical Information

There are two main sources of plant gaseous radioactive effluents. One source is from building ventilation systems servicing radiologically controlled areas, and the other is from the power cycle OGS. DCD, Tier 2, Revision 7, Section 11.3 describes the GWMS and its OGS used to control, collect, process, hold for decay, and discharge gaseous radioactive wastes generated during normal operation, including AOOs. The major components include preheaters, recombiners, cooler/condensers, dryers, activated charcoal beds (guard and delay), and associated valves, pumps, and instrumentation. The OGS is located in the turbine building.

Section 3.2 of DCD, Tier 2, Revision 7 discusses the seismic and quality group classification and corresponding codes and standards that apply to the design of the GWMS/OGS components and piping, and the structures housing the GWMS/OGS. The OGS equipment and piping are classified as non-seismic, but are designed to meet the requirements of RG 1.143.

The OGS provides a means of treating non-condensible gases removed from the condenser by the evacuation system. The sources are gases that leak into the system through components such as pump seals and valve packing; gases that become entrained in solution while in auxiliary systems, such as the CST; and any gases created through the radiolytic decomposition of water in reactor coolant. The gases removed from the condenser may be radioactive and, therefore, must be treated before being released into the environment to ensure effluent radioactivity is reduced to acceptable levels.

The OGS consists of processing equipment, with its associated monitoring instrumentation, and control components. The OGS treats the removed gases in two ways. The first method reduces the volume of the gases by recombining the hydrogen and oxygen into water. The recombination also reduces the explosion potential within the OGS. The water is removed and returned for plant process use and to protect the carbon beds. Because a buildup of explosive mixtures of hydrogen and oxygen is possible, the OGS must be designed either to withstand the effects of a hydrogen explosion or have design features that preclude the formation or buildup of explosive gas mixtures in accordance with SRP Section 11.3 guidelines. The ESBWR OGS is designed to be detonation resistant and to meet the requirements of RG 1.143. The second method for treating removed gases is to provide a holdup of gases through temporary retention. The holdup allows time for the decay of radioactive materials in the remaining gases removed from the main condenser. The delay is sufficient to achieve adequate decay of the radioactivity before the plant discharges process offgases and to ensure that radioactivity levels released into the environment meet regulatory requirements. The OGS is housed in a reinforced concrete structure to provide adequate shielding and minimize radiation exposures to personnel during operation and maintenance.

The design uses redundant, cross-connected flow paths to ensure availability of the system during maintenance or malfunction of a component. Plant operators can isolate functional groups or single units to respond to operational needs, maintenance, or equipment malfunctions, while ensuring the proper treatment of the processed gas before it is released into the environment. The system's operational configuration can be scaled to match plant power levels from startup to 100 percent power. The normal operational configuration of the OGS is in the "treat mode." The design allows the OGS to be bypassed during periods of startup or if the process gas activity is acceptable; however, the bypass can only be activated by the use of dual keyed permissive commands of the OGS.

The major inputs to the GWMS are off-gases from the main condenser evacuation system, which is described in DCD, Tier 2, Revision 7, Section 10.4.2. The flow through the OGS consists of hydrogen and a carrier gas (air from in-leakage), fission and activation gases, and water vapors. For each train, gaseous influents flow through the following major process stages of the OGS:

(1) a preheater, which preheats gases for improving recombiner efficiency;

(2) a hydrogen/oxygen recombiner, which recombines radiolytic hydrogen and oxygen into water;

(3) cooler/condenser units, which remove moisture from cooled gases to protect the charcoal beds;

(4) a dryer, which removes residual moisture from gases out of the cooler/condenser;

(5) a charcoal guard bed, which protects the delay beds from abnormal moisture carryover, or chemical contaminants, by removing them from the gas stream;

(6) two charcoal trains, each consisting of four 100 percent capacity beds, which adsorb and retain radioactive isotopes of krypton, xenon, nitrogen, oxygen, and iodines; and

(7) an off-gas post-treatment radiation monitor, which measures levels of radioactivity in the treated gaseous process stream before the gases are vented and monitored through the turbine building stack radiation monitor.

DCD, Tier 2, Revision 7, Tables 11.3-1 and 11.3-2 list the components of the OGS and the system's design parameters, which are also shown in Figure 11.3-1. The temperature in the charcoal vault, located in the turbine building, is monitored and controlled. The recombiner-dryer portion of the system consists of two trains (trains A and B), which are connected to charcoal beds consisting of tanks. The charcoal vault houses two charcoal guard tanks, and two trains of four charcoal tanks each. Each guard tank contains about 7,500 kilograms (kg) (16,500 lbs) of charcoal, and each adsorber tank contains about 27,750 kg (61,180 lbs) of charcoal, for a total amount of 222 metric tons (490,000 lbs) of charcoal. The design includes provisions to bypass the charcoal beds in the event of a fire, when excessive moisture is present, and during plant preoperational testing and startup. A nitrogen purge line and an air supply line connection are provided to the first charcoal bed. A nitrogen purge would be used if a fire were detected in charcoal beds. The air supply line would be used to dry the charcoal bed if it became saturated with moisture. A nitrogen line is also provided in servicing the main charcoal beds. The OGS includes various types of instrumentation, including oxygen and hydrogen analyzers; flow, temperature, and pressure measurements; radiation monitoring; and provisions for gas sampling. Control and monitoring occur locally and remotely in the plant's control room. Liquid waste generated by the coolers, condensers, and dryers is processed by the LWMS or routed to the condenser hot well. Radiation monitoring equipment is provided to measure radioactivity levels in the pre- and post-treatment streams leading in to and out of the charcoal vault.

The GWMS minimizes and controls releases of radioactive materials using activated charcoal adsorber beds, to retain radioactive isotopes of krypton, xenon, nitrogen, oxygen, and iodines through dynamic adsorption, resulting in significant delays during their transit through the beds. The estimated holdup time for xenon radioactive gases in charcoal beds is about 60 days. Radioiodines are adsorbed and retained on the charcoal beds. Radioactive particles are removed either through condensation by the system's cooler and condenser components or retained in charcoal beds. DCD, Tier 2, Revision 7, Section 11.3.2 and Tables 11.3-1 through 11.3-3 describe process functions, equipment, and operational parameters for the GWMS and OGS. The radiation monitoring system includes the offgas pre-treatment and offgas post treatment monitors. The offgas post-treatment monitor provides automatic closure of the OGS discharge and charcoal bypass valves on receipt of a high radiation signal exceeding a set-point value. The description of the design includes an analysis identifying potential malfunctions by specific types of components, including those that could result in increased releases of radioactivity, and precautionary design features for dealing with such malfunctions.

Monitoring of the discharge side of the OGS charcoal beds tracks the presence of radioiodines, noble gases, and particulates. The system includes provisions for the collection of grab samples for radiological analysis. Discharges from the OGS are routed to the turbine building stack, through the turbine building compartment exhaust, where gaseous effluents are monitored by the process radiation monitoring system (PRMS), as described in DCD, Tier 2, Revision 7, Section 11.5.3. DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-2, 11.5-3, 11.5-6, 11.5-8, and 11.5-9 describe the sampling requirements and operational characteristics of the OGS post-treatment and turbine building stack radiation monitor, see DCD, Tier 2, Revision 7, Section 11.5, Figure 11.5-1.

The turbine gland steam sealing (TGSS) system exhaust and the condenser air removal system (CARS) exhaust are routed to a common header that discharges to the environs through the turbine building compartment exhaust subsystem and turbine building stack. During startup and low-load operation, the TGSS system uses clean steam from the auxiliary boiler system, with main steam used as a backup supply, as described in DCD, Tier 2, Revision 7, Section 10.4.3. At plant high-power levels, the TGSS system may be supplied with steam from high-pressure turbine exhaust or from the auxiliary boiler system, as described in DCD, Tier 2, Revision 7, Sections 10.3.2 and 10.4.3. At startup, the CARS exhaust is routed to the turbine building compartment exhaust subsystem. During plant operation, the CARS exhaust is discharged to the GWMS/OGS, where it is processed as discussed earlier.

DCD, Tier 2, Revision 7, Section 11.3.7 presents an analysis of the radiological impact of a postulated failure or leak of the waste gas system, as well as the justifications for the assumptions used in that analysis. DCD, Tier 2, Revision 7, Tables 11.3-3 through 11.3-7 present the assumptions and system parameters used in the analysis and also provide the results in assessing the consequences of the postulated accident, as specified in BTP 11-5 of SRP Section 11.3. The applicant states that the results of the analysis show that the associated doses are in compliance with the SRP acceptance criteria of 25 millisieverts (mSv) (2500 millirems (mrem)) for systems designed to withstand the effects of hydrogen explosions and earthquakes

Airborne radioactive materials present in buildings are associated with process leakage and steam discharges and are handled through each building's exhaust ventilation system. These releases are in addition to those from the GWMS and OGS. With the exclusion of ventilation systems servicing clean areas of the plant, radioactive materials are released from the following buildings and systems:

- the reactor building heating, ventilation, and air conditioning (HVAC) system, consisting of the reactor building contaminated area HVAC, the refueling and pool area HVAC, and the reactor building HVAC purge exhaust

- the turbine building HVAC system, consisting of the turbine building exhaust, turbine building compartment exhaust, and turbine building decontamination room exhaust

- the fuel building HVAC system, consisting of the fuel building general area HVAC, and the fuel building fuel pool area

- the radwaste building HVAC system, consisting of the radwaste building general area HVAC

Although exhaust flows from plant building exhaust systems are not normally filtered before their release, the ventilation systems servicing the reactor building and refueling building incorporate design features that provide automatic isolation and filtration of exhaust flows before their release under certain circumstances. Specifically, a high-radiation signal from specific monitors located in or next to exhaust ducts will result in isolation of the normal supply and (unfiltered) exhaust ducts to the affected area and route the respective ventilation exhausts to the reactor building HVAC purge exhaust, where it is filtered before being discharged through the reactor building stack. The reactor building HVAC purge exhaust is also used to treat the exhaust from the fuel building. The exhaust of the radwaste building is filtered. Releases from these buildings, as well as from the turbine and radwaste building, are conducted through their individual stacks. DCD, Tier 2, Revision 7, Sections 9.4.2, 9.4.3, 9.4.4, and 9.4.6 describe the design bases, operation, and monitoring of such ventilation systems. The PRMS provides for the monitoring and control of gaseous and particulate releases, as discussed in DCD, Tier 2, Revision 7, Section 11.5.3. DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-2, 11.5-6, 11.5-8, and 11.5-9 describe the sampling requirements and operational characteristics of the related radiation monitors, including those servicing the discharge stacks of the three buildings.

### 11.3.3 Staff Evaluation

The staff reviewed the GWMS in accordance with the guidance of SRP Section 11.3. Staff acceptance of the GWMS is based on the design's meeting the requirements of 10 CFR 50.34a and GDC 3, 60, and 61. Under 10 CFR 50.34a requirements, the applicant must provide sufficient design information to demonstrate that the design objectives of the equipment necessary to control releases of radioactive effluents into the environment have been met. GDC 3 requires that the design protect gaseous waste handling and treatment systems from the effects of an explosive mixture of hydrogen and oxygen gases. The relevant requirements of GDC 60 and 61 are met by using the regulatory positions contained in RG 1.143, Revision 2, as it relates to the seismic design, quality group classification of components used in the GWMS and structures housing the systems, the provisions used to control leakage, and definitions of discharge paths beginning with interfaces with plant primary systems and terminating at the point of controlled discharges to the atmosphere through their respective building stacks.

In reviewing the GWMS, the staff evaluated the system construction standards, seismic design, and quality group classification of components. The structures housing these systems should conform to the guidelines of RG 1.143, Revision 2. The design should include precautions to stop continuous leakage paths. The staff reviewed the system process flow outlines and descriptions and materials. The OGS review included an examination of the adequacy of the design to withstand the effects of a hydrogen explosion. The applicant did not exercise the option of using gas analyzers with automatic control functions to preclude the formation or buildup of explosive mixtures; instead, the ESBWR OGS is designed to be detonation resistant.

The OGS minimizes and controls releases of radioactive materials by delaying the flow of gases using activated charcoal adsorber beds. The charcoal adsorber beds retain radioactive isotopes of krypton, xenon, nitrogen, oxygen, and iodines through dynamic adsorption, resulting in significant delays during their transit through the beds. The estimated holdup time for xenon radioactive gases in charcoal beds is about 60 days, about 80 hours for krypton, and about 30 hours for argon based on the stated dynamic absorption coefficients. Radioiodines are adsorbed and retained on the charcoal beds. Because the charcoal bed system design contains about 222 metric tons (490,000 lbs) of charcoal, the iodine removal efficiency is assumed to be

about 99.99 percent using the guidance of RG 1.140, Revision 2, given the large amount of charcoal used. Radioactive particles are removed either through condensation by the system's cooler and condenser components or retained in charcoal beds. There are provisions for periodic inspection of major components to ensure the capability and integrity of the subsystems. The COL holder will subject the GWMS and OGS to preoperational tests in accordance with DCD, Tier 2, Section 14.2. Chapter 14.2 of this report addresses the adequacy of the preoperational testing program for the GWMS. As a result, the OGS satisfies GDC 60, as it provides sufficient holdup capacity for the retention of radioactive gaseous effluents.

The GWMS and OGS generate a liquid radioactive waste phase from the associated coolers/condensers, where the liquid phase can potentially cross-contaminate nonradioactive systems and result in unmonitored and uncontrolled radioactive releases. In DCD, Tier 2, Revision 7, Sections 11.3.1 and 11.3.2, the applicant states that the design of the OGS follows the guidance of IE BL 80-10 and 10 CFR 20.1406. The design includes drains and vents to route radioactive process or waste streams and avoids interconnections between plant systems that could become radioactive through improper interfaces with radioactive systems. The liquid phases from coolers and condensers are routed to the turbine hotwell or the LWMS. The air supply and nitrogen purge systems are protected from backflow by dual check valves and tell-tale leak-off connections to prevent the contamination of clean air and nitrogen supply sources. The staff finds such design features acceptable and in compliance with the requirements of 10 CFR 20.1406 and the guidelines of IE BL 80-10 and RG 4.21. DCD, Tier 2, Revision 7, Section 12.6 outlines design concepts and features to address such concerns using the guidance in RG 4.21.

In DCD, Tier 2, Revision 7, Section 11.3.7 the applicant provided the analysis of a waste gas system leak or failure, as well as the justification for the assumptions used in that analysis. The applicant performed the analysis to demonstrate that the OGS design meets the applicable guidelines of BTP 11-5. This BTP stipulates that the total body dose at the exclusion area boundary (EAB) as a result of the release of radioactivity for 2 hours from a postulated failure of the OGS, calculated in accordance with BTP assumptions, should not exceed 2.5 rem (25 mSv). The applicant analyzed the accident using a short-term (0–2 hours) X/Q of $2 \times 10^{-3}$ seconds per cubic meter at the EAB, a release duration of 1 hour, instead of 2 hours, as suggested by the BTP, and a noble gas release rate of 16,700 MBq per second (450,000 $\mu$Ci per second). The applicant justified a release duration of 1 hour as consistent with the isolation time of the system. The applicant calculated a total body dose of 0.62 rem (6.2 mSv) over the assumed duration of the event. The dose result is in compliance with the guideline of BTP 11-5 for systems designed to withstand the effects of hydrogen explosions and earthquakes, given the acceptance criterion of 2500 mrem (25 mSv). Based on the above, the staff finds the results of this analysis acceptable.

In DCD, Tier 2, Revision 7, Sections 9.4.2, 9.4.3, 9.4.4, and 9.4.6 state that exhaust air filtration units are equipped with air filtration systems that comply with the guidelines of RG 1.140. The containment purge system has high-efficiency particulate air (HEPA) filters and charcoal adsorbers for mitigating and controlling releases of radioactive materials from the reactor building and fuel building. The air filtration units are designed and tested in accordance with ASME Standards N-509-2002 and ASME/ANSI AG-1-2003. These standards discuss requirements for the installation, inspection, and verification of system airflow rates, air temperatures, and filter pressure drops. On the basis of the above discussion and the evaluation presented in Section 9.4 of this report, the staff finds that the GWMS complies with GDC 61 and meets the guidelines of RG 1.140, as they relate to normal ventilation exhaust

systems and design features to control releases of radioactivity through the turbine building stack.

The PRMS provides monitoring and control of gaseous and particulate releases, as discussed in DCD, Tier 2, Revision 7, Section 11.5.3. In DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-2, 11.5-6, 11.5-8, and 11.5-9 describe the sampling requirements and operational characteristics of the related detectors of the radiation monitoring systems (RMS). The staff finds these design features acceptable. Based on the above, the staff finds that the GWMS/OGS complies with GDC 60 and 61, as they relate to monitoring and controlling radioactivity releases from ventilation systems associated with fuel storage and handling areas. The applicant conclusion that the designs of the GWMS and OGS meet the requirements of 10 CFR 20.1301 and 10 CFR 20.1302 and Sections II.B and II.C of Appendix I to 10 CFR Part 50 was part of the review of DCD, Tier 2, Revision 7, Section 12.2.2. Section 12.2 of this report addresses the staff's evaluation of radiological impacts associated with releases of radioactive materials from the GWMS/OGS via the turbine building stack and all building ventilation systems (reactor and fuel building stack, and radwaste building stack). The staff finds that the results of the applicant's analysis comply with 10 CFR 20.1301, 10 CFR 20.1302, and Sections II.B and II.C of Appendix I to 10 CFR Part 50.

A COL holder referencing the ESBWR certified design should either identify the operational set points for its GWMS and turbine building stack radiation monitors in its plant-specific ODCM, or include a description of the methodology for establishing these set points in the description of the operational program for the ODCM. In addition, the COL applicant should describe the SRECs for monitoring and controlling releases of radioactive materials into the environment, which thus eliminate the potential for unmonitored and uncontrolled releases. The staff will review this information on a plant-specific basis for each COL application, including the following:

- the building stacks RMS (reactor and fuel building, turbine building, and radwaste building)
- the reactor building HVAC exhaust RMS and its subsystems
- the containment purge exhaust RMS
- the turbine building combined ventilation exhaust RMS and its subsystems
- the radwaste building ventilation exhaust RMS
- the fuel building combined ventilation exhaust and its RMS subsystems

Section 11.5 of this report addresses these aspects as a COL information item.

Under the requirements of Sections II.B, II.C, and II.D of Appendix I to 10 CFR Part 50, a COL applicant is responsible for addressing the requirements of the design objectives in Appendix I to 10 CFR Part 50 in controlling doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. The requirements define dose criteria for gaseous effluents and mandate a cost-benefit analysis in justifying installed processing and treatment systems as permanently installed equipment. Section 12.2 of this report addresses these aspects as ~~a~~ COL Information Item 12.2-2-A.

In reviewing the prior versions of DCD Tier 2, the staff found that it did not have information to allow it to determine the acceptability of the GWMS. The staff issued a number of RAIs, not listed here for the sake of brevity, during the review of the application. These RAIs involved requests for the applicant to provide clarifications for technical completeness, provide details supporting design bases and design descriptions in demonstrating compliance with regulatory requirements, revise and update system drawings for consistency with system descriptions, revise technical and regulatory references, and provide information for the staff to conduct independent evaluations of results presented in the application. These RAIs were satisfactorily resolved by the applicant and closed by the staff in DCD, Tier 2, Revision 6. The following paragraphs discuss the staff's evaluation of the applicant's responses to the staff's RAIs on important technical and regulatory topics.

In RAI 11.3-2, the staff asked the applicant to describe how the classifications and design criteria applied to the OGS satisfy the requirements of GDC 61 with respect to designing radioactive waste systems to ensure adequate safety under accident conditions. In its response, the applicant stated that the OGS was designed to Quality Group D and modified in accordance with the guidance set forth in RG 1.143, Revision 2, Section 7 and Table 1. DCD, Tier 2, Revision 7, Section 11.3.7.1 states that the OGS meets all criteria in RG 1.143. The staff reviewed the response to RAI 11.3-2 and DCD, Tier 2, Revision 7, relating to whether the OGS was consistent with RG 1.143, Revision 2. The compliance with RG 1.143 forms the bases for satisfying GDC 61, and the staff finds the response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.3-3, the staff asked the applicant to describe how the OGS design pressure of the components was selected to enable them to withstand an internal hydrogen explosion. In addition, the staff asked the applicant to provide numerical performance criteria for the hydrostatic test demonstrating this capability. In its response, the applicant stated that the ESBWR OGS design used the methodology outlined in the GEH report NEDE-11146, "Pressure Integrity Design Basis for New Gas Systems," to establish hydrogen explosion pressure integrity in off-gas piping. The NRC has previously approved NEDE-11146, which was submitted for the staff to evaluate and establish design pressure integrity for the Grand Gulf Nuclear Station's OGS for internal hydrogen explosions. The staff evaluated the specifications and performance of the hydrogen and oxygen recombiner system and related gas analyzer instrumentation used to monitor and control the presence of explosive gas mixtures. DCD, Tier 2, Revision 7, Sections 11.3.2.2, 11.3.5, and 11.3.6 describe the system. The staff's evaluation of the OGS system, as described in DCD Tier 2, Table 11.3-2 reveals that it is designed to sustain an internal explosion without loss of integrity. The staff found this methodology to be adequate, and Section 11.3.2.6 of DCD, Tier 2, Revision 7 references the NEDE report. In addition, the applicant identified a COL information item in Section 11.3.8 of DCD, Tier 2, Revision 2. The staff asked the applicant to define the OGS design parameters- major equipment items as well as other system data- as shown in DCD, Tier 2, Table 11.3-2. This COL information item

addressed a portion of the RAI and was identified as COL Information Item 11.3.8-1. However, in DCD, Tier 2, Revision 3, the applicant removed COL Information Item 11.3.8-1. In a letter dated July 23, 2007, the applicant explained the reasons for the removal of this COL item using the following rationale:

> The COL item was removed because the OGS is a GEH permanent plant designed system without mobile systems that are used in the liquid and solid radioactive waste system designs. Table 11.3-2 in DCD, Tier 2, Revision 5 is the final OGS major equipment design parameters. If a COL Applicant chooses to make changes to the GEH permanent plant OGS design, a departure with justification and design details will be required in the COL application.

The staff found the above reasons acceptable; therefore, RAI 11.3-3 is resolved. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

A COL applicant referencing the ESBWR certified design should describe the QA program for design, fabrication, procurement, construction of structures, and installation of permanent GWMS and OGS systems and components in the plant in accordance with its overall QA program. However, DCD, Tier 2, Revision 5, Section 11.3.8 does not commit the COL applicant to conforming with the QA guidance specified in RGs 1.21, 1.33, and 4.15. In a global response to RAI 11.5-44, the applicant proposed changes to all related sections of Chapter 11 on this topic and stated that the applicable QA requirements are described in DCD, Tier 2, Table 17.0-1. As a result, the applicant has revised DCD, Tier 2, Section 11.3.5, to reference the QA requirements of Chapter 17 for the design, fabrication, procurement, and installation of the gaseous radioactive waste system in accordance with the COL holder's overall QA program. In a letter dated July 23, 2007, the applicant committed to placing this information in DCD Tier 2. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

As part of RAI 12.2-9, the staff asked the applicant to provide information describing the amounts of charcoals present in each charcoal guard and main tank and to include this information either in DCD, Tier 2, Revision 3, Table 11.3-2 or Table 12.2-15. The staff finds the inclusion of this information necessary in evaluating the performance of the charcoal delay beds and assessing releases of noble gases into the environment. In DCD, Tier 2, Revision 5 the applicant provided information on the amounts of charcoal contained in each type of tank, as described in DCD, Tier 2, Revision 7, Tables 12.2-15 and 11.3-1. The staff finds the inclusion of this information adequate. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

DCD, Tier 2, Revision 7, Section 9.4 describes the exhaust ventilation systems servicing buildings containing radioactive systems that are expected to generate airborne radioactivity. The reactor building and refueling building incorporate design features that automatically isolate and filter exhaust flows before their release in some circumstances. The exhaust of the radwaste building is filtered. Releases from these buildings, as well as from the turbine building and radwaste building, are conducted through their respective stacks. As part of RAI 12.2-9, the staff asked the applicant to confirm the use of charcoal and HEPA filters in controlling radioactive releases into the environment for consistency with the HVAC system descriptions in DCD, Tier 2, Revision 3, Section 9.4. The staff finds the inclusion of this information important for evaluating the design of the HVAC systems and assessing releases of radioactivity into the

environment. In DCD, Tier 2, Revision 7 the applicant updated the listing of systems using charcoal and HEPA filters, as described in DCD, Tier 2, Revision 7, Section 9.4 and Tables 9.4-4, 9.4-7, and 9.4-15. The staff finds the inclusion of this information satisfactory. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In addressing the requirements of 10 CFR 52.47(b)(1), which states that a DC application must contain the proposed ITAAC, the applicant has included specific ITAACs for the GWMS. The ITAACs are described in DCD, Tier 1, Revision 7, Section 2.10.3 and Table 2.10.3-1. Three ITAACs address the descriptions and functional arrangements of the GWMS, confirm the integrity of the GWMS to withstand internal hydrogen explosions, and assess leakage when subjected to testing pressures expected during operation. An ITAAC is assigned to confirm that the initial loading of the appropriate amounts of charcoal adsorbers in the guard beds and decay beds will meet or exceed the delay times listed in DCD, Tier 2, Revision 5, Table 11.3-1. Another ITAAC focuses on a test to confirm that the offgas post-treatment radiation monitor provides automatic closure of the OGS discharge and charcoal bypass valves on receipt of a high radiation signal exceeding a set-point value. If the inspections, tests, and analyses are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the certified ESBWR design and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations.

A review of DCD, Tier 2, Revision 5, Section 11.3.2, indicates a number of inconsistencies in the description of offgas equipment design criteria and code requirements, and in equipment descriptions. In RAI 11.3-13, the staff asked the applicant to address the following:

(a) The preheater tube side design temperature is 302 degrees Celsius ($^{o}$C) (575 degrees Fahrenheit ($^{o}$F)), but the shell side design is 232$^{o}$C (450$^{o}$F). The applicant was requested to clarify what safety considerations were taken in the event of tube failure when 302$^{o}$C (575$^{o}$F) gas leaks into the shell side. Also, the applicant was requested to clarify pressure design considerations in the event of tube failure, where tube-side design pressure is 8.6 MegaPascal (MPa) gauge (1250 pounds per square inch (PSI) gauge) and shell-side design pressure is 2.41 MPa gauge (350 PSI gauge) based on applicable ASME code specifications.

(b) There is a TEMA C code requirement for the cooler-condenser, but not for the preheater and catalyst (both are shell and tube (S&T) heat exchangers). The applicant was requested to identify the proper design codes for the preheater and catalyst.

(c) A review of DCD, Tier 2, Revision 5, Figure 11.3-1, OGS flow diagram shows a preheater- recombiner- cooler, as one assembly. This was found confusing since in DCD, Tier 2, Section 11.3.2.2, the recombiner assembly includes a preheater, catalyst, and condenser sections. The applicant was requested to clarify this inconsistency in the text and flow diagram.

(d) The OGS flow diagram, Figure 11.3-1, also shows eight charcoal beds and two guard beds, with DCD, Tier 2, Table 11.3-2 calling for 10 vessels to be "filled with activated charcoal." The applicant was requested to clarify this inconsistency in the flow diagram.

(e) A review of DCD, Tier 2, Revision 5, Section 11.3.2.5.4 (Drying) did not make it clear as to what type of dryer design will be used (e.g., a refrigerant dryer or a desiccant dryer?). The applicant was requested to provide specific details.

(f) DCD, Tier 2, Revision 5, Figure 11.3-1, OGS, has a note "Material per requirements of RG 1.143." However, Table 1 of this RG is very specific as to the types of materials and grade being required for pressure retaining parts, while DCD, Tier 2, Revision 5, Table 11.3-2 did not specify the actual type of materials and grade. The applicant was requested to provide more details on materials and grade used in the design of this system.

In its response, dated November 13, 2008, the applicant provided technical clarifications for the above noted RAI items and discussed the bases of the turbine auxiliary steam system (TASS) design temperature and operating temperature. The staff finds the responses acceptable as to the inclusion of additional information and technical clarifications, with one exception. A review of DCD, Tier 2, Revision 5, Table 11.3-1, OGS Design Parameters, showed that steam supply temperature was not given in the design parameters in that table. Therefore, in supplemental RAI 11.3-13 S01, the staff asked the applicant to include the TASS temperature design value in Table 11.3-1. In its response dated February 24, 2009, the applicant provided a proposed revision to DCD, Tier 2, Table 11.3-1 and Section 11.3.2.5.1 for inclusion in DCD, Tier 2, Revision 6. The proposed revision updates the information on design temperature specifications. The staff found the proposed changes acceptable. Based on the applicant's response, these RAIs were resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6.

The staff's review revealed that the description of OGS components in DCD, Tier 2, Revision 5, Section 11.3.2.3, under process facilities, was incomplete as it did not include all equipment described in DCD, Tier 2, Section 11.3.2.2. Specifically, the text of DCD, Tier 2, Section 11.3.2.3, beyond the first paragraph, repeated some of the information already presented in DCD, Tier 2, Section 11.3.2.1 and did not include a discussion of process equipment and the locations in process facilities. For example, DCD, Tier 2, Section 11.3.2.3 did not address the OGS pre-heaters, recombiners, dryers, and monitoring instrumentation and controls. Accordingly, in RAI 11.3-14, the staff asked the applicant to revise the discussions in DCD, Tier 2, Section 11.3.2.3 to include all equipment described in DCD, Tier 2, Section 11.3.2.2. In its response dated February 24, 2009, the applicant provided a proposed revision to DCD, Tier 2, Sections 11.3.2.2 and 11.3.2.3 for inclusion in DCD, Tier 2, Revision 6. The proposed revision updates the information on system descriptions and locations of major components in the turbine building. The staff found the proposed changes acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6.

The staff's review also found an improper reference to a DCD, Tier 2, Revision 5, Section 12.2, Table 12.2-18b which should be Table 12.2-17, some listed references that were not cited in the text, e.g., Ref. 11.3-10 and the reference list included improper regulatory citations, (e.g., Ref. 11.3-1). In RAI 11.0-1, the staff asked the applicant to make the appropriate corrections. In its response dated November 13, 2008, the applicant agreed to make the appropriate corrections and provided proposed changes to be included in DCD, Tier 2, Revision 6. The staff found the proposed changes acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6.

In RAI 11.3-15, the staff noted that Section 11.3.2.6.2 states that the OGS's radioactive gaseous pressure relief discharge is piped to the main condenser, but it is not clear if the design considers the effects of back pressure on relief setting and capacity. The applicant was requested to explain if back pressure was taken into consideration in the design, since excessive back pressure in the condenser can affect the relief setting and relieving capacity. The DCD should confirm that back pressure spikes will not compromise pressure relief setting and relieving capacity. In a response dated May 7, 2009, the applicant described the operational features of the condenser and pressure trip points at which alarms would be activated in the control room, and a turbine trip and reactor scram would occur, followed by the closure of the main steam isolation valves, if internal pressure levels were to increase further. In its discussion, the applicant refers to supporting information presented in DCD, Tier 2, Revision 5, Section 10.4.1, Table 10.4-1. The staff finds the description of these operational features satisfactory. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.3-16, the staff noted that Section 11.3.2.6.8 states that channeling in the OGS charcoal beds is prevented by a high charcoal bed height-to-particle diameter ratio. The word "particle" is deemed to be incorrect in the proposed context. The applicant was requested to consider whether "particle" should be changed to read "diameter" instead, since flow channeling is affected first by bed-height to bed-diameter ratio of the vessel. In a response dated May 7, 2009, the applicant described the relationship between charcoal bed-to-particle diameter ratio and flow profiles across the cross-sectional area of the charcoal bed as a function of charcoal particle size. In its discussion, the applicant refers to supporting information on charcoal particle sizes used in the design of the OGS, as presented in DCD, Tier 2, Revision 5, Section 11.3.1, Table 11.3-1. The staff finds the supplemental information satisfactory. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

### 11.3.4 Conclusions

Based on the information discussed above, the staff concludes that the GWMS/OGS (as permanently installed systems) and building HVAC systems include the equipment necessary to manage and treat process streams and control releases of radioactive materials in gaseous effluents in accordance with 10 CFR 20.1302 and 10 CFR 20.1406; Appendix I to 10 CFR Part 50; GDC 3, 60, and 61; and 10 CFR 50.34a. This conclusion is based on the following requirements that:

- The ESBWR design meets the dose requirements of 10 CFR 20.1302 by ensuring that the annual average concentration of radioactive materials in gaseous effluents released into unrestricted areas will not exceed the limits specified in Appendix B to 10 CFR Part 20, Table 2, Column 1, as demonstrated in DCD, Tier 2, Revision 7, Section 12.2.2.

- The ESBWR design complies with the requirements of Sections II.B and II.C of Appendix I to 10 CFR Part 50, in ensuring that offsite individual doses resulting from gaseous effluent releases will not exceed dose criteria, as demonstrated in DCD Tier 2, Revision 7, Section 12.2.2. These requirements are the subject of COL Information Item 12.2-2-A in DCD, Tier 2, Revision 7, Section 12.2.4.

- The ESBWR design demonstrates compliance with 10 CFR 50.34a requirements for sufficient design information, as set forth in the above discussion.

- When preparing a plant-specific cost-benefit analysis in accordance with RG 1.110, a COL applicant referencing the ESBWR certified design is required to demonstrate compliance with the requirements of Sections II.B, II.C, and II.D of Appendix I to 10 CFR Part 50 for offsite individual doses and population doses resulting from gaseous effluents treated by the GWMS and OGS systems.

- The ESBWR design meets the requirements of GDC 3 in protecting the OGS from the effects of explosive gas mixtures of hydrogen and oxygen.

- The portions of the GWMS design features requiring normal ventilation and venting of specific components, as described in DCD, Tier 2, Revision 7, Sections 9.4 and 12.2, satisfies the guidance in RG 1.140.

- The design features of the OGS satisfy the guidance in RG 1.143, as it relates to the certification of pressure-retaining components and material specifications in withstanding an explosion without the loss of integrity.

- The design features of the OGS charcoal delay bed ensure conformance with the BTP 11-5 dose guidelines for the analysis of a postulated failure of a component for a receptor located at the EAB.

- The ESBWR design meets the requirements of GDC 60 and 61 with respect to controlling releases of gaseous effluents by radiation monitoring of releases from the GWMS. Radiation monitors track all releases and will generate an alarm, a signal, or both to divert gaseous effluent releases before discharge concentrations exceed a predetermined set point. A COL holder will identify the operational set points for its GWMS/OGS radiation monitors in its plant-specific ODCM, or discuss the process in description of the operational program for the ODCM, as discussed in DCD, Tier 2, Revision 7, Section 11.5.4.

- Compliance with the requirements of GDC 61 has been demonstrated by meeting the guidelines in RGs 1.140 and 1.143. This commitment also fulfills the requirements of 10 CFR 20.1406 and guidance in RG 4.21 by minimizing the contamination of the facility and the generation of radioactive waste and in IE BL 80-10 in avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases to the environment.

- The applicant demonstrates compliance with the requirements of 10 CFR 52.47(b)(1) with the inclusion of ITAACs for the GWMS. The ITAACs address the descriptions and functional arrangements of the GWMS, the integrity of the GWMS under expected operating pressures and internal hydrogen explosions, the initial loading of the appropriate amounts of charcoal media, and the proper operation of the offgas post treatment radiation monitor in providing automatic closure of OGS discharge isolation valves on receipt of a high radiation signal. If the inspections, tests, and analyses are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations.

## 11.4 Solid Waste Management System

### 11.4.1 Regulatory Criteria

The staff reviewed DCD, Tier 2, Revision 7, Section 11.4 in accordance with the guidance and acceptance criteria described in SRP Section 11.4, "Solid Waste Management System." The following acceptance criteria are applicable:

- 10 CFR 20.1302, as it relates to radioactive materials released in gaseous and liquid effluents and doses to persons in unrestricted areas (criteria that apply to releases resulting from the SWMS during normal plant operations and AOOs)

- 10 CFR 20.1406, as it relates to facility design and operational procedures for minimizing the contamination of the facility and the generation of radioactive waste

- 10 CFR 20.2006, "Transfer for Disposal and Manifests," and Appendix G, "Requirements for Transfers of Low-Level Radioactive Waste Intended for Disposal at Licensed Land Disposal Facilities and Manifests," to 10 CFR Part 20, as they relate to the transfer and manifesting of radioactive waste for disposal at licensed land disposal facilities

- 10 CFR 50.34a, as it relates to providing adequate system design information to demonstrate that design objectives have been met for equipment necessary to control releases into the environment of radioactive effluents resulting from SWMS operation

- GDC 60, as it relates to the design of the SWMS incorporating the means to handle solid wastes produced during normal plant operation, including AOOs

- GDC 63, "Monitoring Fuel and Waste Storage," as it relates to the design of the radioactive management systems to control releases of radioactivity

- 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," as it relates to the classification, processing, and disposal of solid radioactive wastes

- 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," as it relates to the packaging of radioactive materials

- 10 CFR Parts 171–180, as they relate to the packaging of waste, labeling of waste containers, placarding of waste shipments, and transportation of radioactive materials

Specific acceptance criteria for the relevant requirements identified above are as follows:

- SRP Section 11.4, BTP 11-3, "Design Guidance for Solid Radioactive Waste Management Systems Installed in Light-Water-Cooled Nuclear Power Reactor Plants"

- Appendix 11.4-A, "Design Guidance for Temporary Storage of Low-Level Radioactive Waste," to SRP Section 11.4. Appendix 11.4-A addresses the guidance of Generic Letter (GL) 80-009 on low level radioactive waste disposal; GL 81-038 on the storage of low level radioactive waste at reactor sites; and GL 81-039 on the NRC low level radioactive waste volume reduction policy

- RG 1.143, with respect to specific guidelines for solid radwaste systems; seismic qualification; general guidelines for design, construction, and testing criteria for radwaste systems; and general QA guidelines for radwaste management systems

- RG 4.21, as it relates to minimizing the contamination of equipment, plant facilities, and environment, and minimizing the generation of radioactive waste during plant operation

- The provisions of GL 89-001, "Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications" (Supplement No. 1, dated November 14, 1990), as it relates to the restructuring of the RETS and PCP

- Guidance of NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for BWRs," April 1991, for BWR plants, as it relates to the development of a plant-specific process control program (PCP). Alternatively, a COL applicant may use NEI PCP Template 07-10A (Rev. 0, March 2009) for the purpose of meeting this regulatory milestone until a plant-specific PCP is prepared, before fuel load, under the requirements of a license condition described in FSAR Section 13.4 of the COL application. The results of the staff's evaluation are presented in ML082910077 and the NEI PCP Template 07-10A is presented in ML091460236.

- NRC Regulatory Issue Summary (RIS) 2008-32, "Interim Low Level Radioactive Waste Storage at Reactor Sites," December 30, 2008

The staff performed a comparison of the SRP (Section 11.4, 1981 version) used during the review of the DCD with the 2007 version of the SRP. The 2007 version includes additional acceptance criteria and guidance addressing the requirements of 10 CFR 20.1406, when compared to the prior version of the SRP. The requirements of 20.1406 were considered in the staff's review of the DCD, given the 2007 version of the SRP. Discussions and dispositions of these items are provided in this and other supporting sections of this report. Therefore, the staff concludes that the version of the SRP used, in combination with the additional review performed by the staff, is adequate for this review.

### 11.4.2 Summary of Technical Information

DCD, Tier 2, Revision 7, Section 11.4 describes the SWMS used to control, collect, handle, process, package, and temporarily store wet and dry solid radioactive wastes before shipment. Radioactive wastes will be generated during normal operation and AOOs. The SWMS is located in the radwaste building. The SWMS has no safety-related function. Failure of the subsystem does not compromise any safety-related system or component, nor does it prevent the safe shutdown of the plant. No interface with the Class IE electrical system exists. The SWMS is designed to meet the requirements in RG 1.143, with regard to its seismic qualifications. DCD, Tier 2, Revision 7, Sections 3.2 and 3.8 discuss the seismic and quality group classification and corresponding codes and standards that apply to the design of the SWMS components and piping and the structures housing the SWMS.

The SWMS processes wastes from the LWMS, RWC/SCS, fuel and auxiliary pools cooling system (FAPCS), and condensate purification system. DCD, Tier 2, Revision 7, Figures 11.4-1 to 11.4-4 show the functional arrangements of SWMS components, which are described in DCD, Tier 2, Revision 7, Table 11.4-1. The SWMS can be operated from local panels and from the radwaste building control room. The instrumentation monitors such features as tank levels,

process flow rates, and radiation levels. There are no provisions to release liquid wastes from the SWMS. Releases of liquid wastes are conducted through the LWMS. The SWMS is comprised of the following four subsystems:

(1) the SWMS collection subsystem;
(2) the SWMS processing subsystem;
(3) the dry solid waste accumulation and conditioning subsystem; and
(4) the container storage subsystem.

The SWMS collection subsystem consists of high and low activity resin holdup tanks, phase separators, a condensate resin holdup tank, decant pumps, sampling points, control panels, instrumentation, vents and drains, and high and low activity transfer pumps. The operation of the system is supported by plant service utilities, such as compressed air, water, electricity, ventilation, and radiation monitoring. Radioactive wastes processed by the SWMS collection subsystem include spent resins from the reactor water cleanup system (RWCS) and the FAPCS, resins from the equipment and floor drain ion-exchangers, dewatering fill head, concentrated wastes, condensate filter backwash drains, equipment and floor drain filter backwash drain, reject waste from the equipment and floor drain osmosis units, chemical drain collection tanks, and condensate demineralizers. Tank overflows are routed to radwaste equipment drains and tanks are vented through filtration systems and monitored for radioactivity before being discharged to the environment via the radwaste building stack.

The SWMS design includes six tanks: a high-activity tank and a low-activity tank each with a nominal capacity of about 70,000 liters (18,500 gallons); two low-activity low-phase separator tanks with a nominal capacity of about 55,000 liters (14,500 gallons) each; one condensate resin holdup tank with a nominal capacity of about 70,000 liters (18,500 gallons); and one concentrated waste tank with a nominal capacity of about 60,000 liters (15,800 gallons). This SWMS design includes four decant pumps, each with a nominal flow rate of about 330 liters per minute (88 gallons per minute); four high and low activity resin transfer pumps, each with a nominal flow rate of about 380 liters per minute (100 gallons per minute); two circulation concentrated waste pumps, each with nominal flow rates of about 1333 liters per minute (352 gallons per minute); and two resin transfer pumps with a nominal flow rate of about 379 liters per minute (100 gallons per minute) each.

The SWMS processing subsystem consists of a dewatering head, a liner, a fill head, and a dewatering pump. Radioactive wastes processed by the SWMS processing subsystems include concentrated wastes and resins from the SWMS collection subsystem, and resins and sludge from the spent resin and phase separator tanks. The dewatering skid returns the liquid waste to the low and high activity phase separators for reuse or further processing. Condensate water may be used for flushing purposes through the fill head. The two dewatering pumps have a rated capacity of 75 liters per minute (20 gallons per minute) each. The dewatering skid drain is routed to radwaste equipment drains, and the fill head is vented through filtration systems and monitored for radioactivity before being discharged to the environment through the radwaste building stack.

The container storage subsystem and the dry solid waste accumulation and conditioning subsystem are designed to process solid wastes. Solid wastes include spent filter cartridges, HEPA filters, paper, rags, plastics, protective clothing, tools, and contaminated equipment generated during plant operations and refueling and maintenance outages. DCD, Tier 2, Revision 7, Figures 11.4-1 and 11.4-4 provide a conceptual description of the process flow used

in handling dry solid and wet wastes. The COL holder will address the actual process under operational programs and procedures developed by taking into consideration the regulatory requirements for the processing, storage, packaging, shipment, radiological monitoring, and disposal of radioactive wastes of the NRC, the U.S. Department of Transportation (DOT), and State and local agencies.

Spent activated charcoals from the GWMS/OGS are not expected to be routinely disposed of as radioactive waste. Rather, spent activated charcoals will be regenerated in place within the OGS. The COL holder will address the replacement of the charcoals in affected beds under operational programs and procedures, in the event that activated charcoals contained in the guard or main beds become contaminated with chemicals or saturated with water.

DCD, Tier 2, Revision 7, Table 11.4-2 lists the expected amounts of radioactive waste generated yearly. The estimates include about 363 $m^3$ (12,830 cubic feet) for dry active solid waste, and 111 $m^3$ (3,922 cubic feet) for wet solid wastes. Dry solid wastes include combustible and compressible materials and other unspecified waste forms. Wet solid wastes are comprised of spent resins, filter sludge, and waste concentrates from the LWMS. The estimated generated amounts are about 55 $m^3$ (1,943 cubic feet) for spent resins, about 6 $m^3$ (212 cubic feet) for filter sludge, and about 50 $m^3$ (1770 cubic feet) for waste concentrates. The estimated amounts of mixed waste are about 0.42 $m^3$ (14.7 cubic feet).

Onsite storage capacity is designed for 6 months of waste generation and stored as packaged waste. Waste packaging includes 55-gallon (about 210-liter) drums, high-integrity containers (HICs), and shielded filter containers. The specific design features of the solid waste processing subsystem are not described in the DCD, Tier 2, Revision 7, Section 11.4, the COL holder will define specifications and procurement through qualified vendors. The services may include skid-mounted waste treatment systems and the use of offsite waste processing services, such as for waste compaction, treatment, and decontamination. The COL applicant is expected to assess whether expanded low level waste (LLW) storage capacity, beyond 6 months, is required in light of operating practices, as actual waste or projected generation rates, and whether the COL applicant has access to LLW disposal facilities. Appendix 11.4-A, “Design Guidance for Temporary Storage of Low-Level Radioactive Waste,” to SRP Section 11.4 and RIS 2008-32 provide guidance on waste storage at reactor sites.

The SWMS is serviced by the exhaust system of the radwaste building, which includes a HEPA filtration system. Airborne effluent releases from this building are conducted and monitored through the radwaste building stack. DCD, Revision 7, Section 9.4.3, describes the design bases, operation, and monitoring of the radwaste building ventilation system. The PRMS provides for the monitoring and control of gaseous and particulate releases from the radwaste building stack, as described in DCD, Tier 2, Revision 7, Section 11.5.3. DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-2, 11.5-6, 11.5-8, and 11.5-9, and Figure 11.5-1 describe the sampling requirements and operational characteristics of the related radiation monitors. All liquid radioactive effluents are processed and discharged through the LWMS. DCD, Tier 2, Revision 7, Sections 11.2 and 11.3 describe plant systems used to process and treat liquid and gaseous effluents, respectively. DCD, Tier 2, Revision 7, Section 12.2.2 describes the methods used to assess doses to members of the public associated with liquid and gaseous effluent releases from the SWMS, as combined with all other radioactive releases from the radwaste building.

In DCD, Tier 2, Revision 7, Section 11.4.6 the applicant identified five COL information items. These items address requirements associated with the guidance in RGs 1.143 and 8.8,

"Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable," Revision 3, for the testing and operation of all SWMS subsystems, identifying system connections to non-radioactive systems that could become contaminated through improper interfaces, description of a plant-specific PCP, the consideration of LLW storage in an overall site waste management plan, and compliance with 10 CFR 20.1406 in minimizing contamination of the facility. The COL information items are:

- COL Information Item 11.4-1-A - The COL applicant is responsible for ensuring that SWMS subsystems comply with the guidance in RG 1.143, Revision 2 and RG 8.8 for the testing and operation of all SWMS subsystems.

- COL Information Item 11.4-2-A - The COL applicant is responsible for evaluating SWMS subsystems, using the guidance and information in IE BL 80-10, for the purpose of identifying and rectifying connections to systems that are considered nonradioactive but that could become radioactive through improper interfaces with radioactive systems (i.e., a nonradioactive system that could become contaminated through leakage, valving errors, or other operating conditions in radioactive systems).

- COL Information Item 11.4-3-A - The COL applicant is responsible for the description of a plant-specific PCP addressing operating procedures and technical specifications, as they relate to the classifying, treatment, and disposal of radioactive wastes processed by the SWMS in accordance with regulatory requirements of the NRC, DOT and State and local agencies.

- COL Information Item 11.4-4-A - The COL applicant is responsible for the development of an overall site management plan for the storage of radioactive waste using the guidance in Section 11.4 of the SRP. The NRC guidance also includes RIS 2008-32.

- COL Information Item 11.4-5-A - The COL applicant is responsible for including site specific information describing the implementation of operating programs and procedures in accordance with the requirements of 10 CFR 20.1406 and guidance of RG 4.21. The objectives are to minimize the contamination of plant facilities and environment, facilitate decommissioning, and minimize the generation of radioactive wastes.

### 11.4.3 Staff Evaluation

The staff reviewed the SWMS in accordance with the guidance of SRP Section 11.4. Staff acceptance of the SWMS is based on the design meeting the requirements of 10 CFR 50.34a GDC 60, 61, and 63, and RGs 1.143 and 8.8. Under 10 CFR 50.34a, an applicant is required to provide sufficient design information to demonstrate that the design objectives of equipment necessary to control releases of radioactive effluents into the environment have been met. An applicant meets the relevant GDC requirements by using the regulatory positions in RG 1.143, as they relate to the seismic design and quality group classification of components used in the SWMS and structures housing the systems, and those addressing leakage control. RG 8.8 addresses design and operational features to ensure occupational exposures from ambient radiation levels remain ALARA.

The staff reviewed the system design according to the guidelines of RG 1.143 and BTP 11-3. The seismic design and quality group classification of components used in the SWMS and

structures housing these systems should conform to the guidelines of RG 1.143. The staff reviewed the system construction standards and proposed construction methods. The staff reviewed the system process flow outlines and evaluated the anticipated operational requirements. The staff reviewed material specifications and potential leakage paths for those areas that conduct fluid separations.

The ESBWR design to process liquid, wet, and solid wastes relies on the use of two processing subsystems integrated with the operation of other permanently installed equipment. The other two elements of the SWMS, the container storage subsystem and the dry solid waste accumulation and conditioning subsystem, are conceptual descriptions of methods for COL holders to handle and process solid wastes and packaged solid wastes. As such, the process is described without the inclusion of equipment. DCD, Tier 2, Revision 7, Figures 11.4-1 and 11.4-4 provide conceptual overviews of the processes used in handling dry solid and wet wastes. The COL holder will define and implement the actual process under operational programs and procedures developed by taking into consideration the regulatory requirements for the processing, storage, packaging, shipment, radiological monitoring, and disposal of radioactive wastes of the NRC, DOT, and State and local agencies.

The subsystems are designed to process waste efficiently, provide operational versatility, and minimize the generation of extraneous radioactive wastes. The types of waste processing methods and waste processing capacities are selected to be commensurate with the expected types of wastes to be generated and waste generation rates. The following paragraphs summarize the operation of the proposed waste processing subsystems:

- For liquid and wet wastes, processing subsystems will be used to treat spent resins, filter and tank sludge, and concentrated wastes. When sufficient amounts of waste have been collected in the high- or low-activity holdup tank, they will be mixed and routed to the appropriate mobile waste processing system. Pumps are used to decant, circulate, and transfer wet wastes to various tanks and waste processing units. The subsystem, in conjunction with other permanently installed equipment, is used to further process wet wastes and to convey liquid and wet wastes to containers for storage or shipment, with excess water routed back to low-activity phase separators or to equipment and floor drain collection tanks, based on water quality. Depending on radioactivity and radiation levels, the COL holder may erect additional temporary radiation shielding around waste processing units to minimize radiation exposures and doses to plant workers.

- For dry solid wastes, the processing subsystem will be used to process waste collected in containers at specific workstations and brought to the radwaste building. Such stations include control points located throughout the plant or set up to support specific plant evolutions, such as refueling and other types of outages. Given that most of the solid waste is characterized by low levels of radioactivity, the applicant expects that dry waste containers will be handled manually and by forklifts and stored in the radwaste building. Before shipment, wastes will be sorted and packaged into suitable containers that meet DOT shipping and disposal facility requirements or specifications of an offsite waste processor. The waste will be separated into specific categories, such as non-contaminated wastes, contaminated compressible wastes, and contaminated non-compressible wastes. Contaminated compressible wastes include such items as discarded anti-contamination clothing, plastic, glass, paper, and HEPA filters. Contaminated non-compressible wastes include such items as discarded tools, wood, components, and debris. Depending on radioactivity and radiation levels, the COL

holder may erect temporary radiation shielding around specific containers to minimize radiation exposures and doses to plant workers.

DCD, Tier 2, Revision 7, Section 11.4 provides design features, operating characteristics, and piping and instrumentation diagrams for the SWMS collection subsystem and the SWMS processing subsystem. The staff has reviewed the system construction standards; system process flow outlines and descriptions; sources of liquid input volumes; collection points of liquid waste; flow paths of liquids through the system, including potential bypasses; provisions for monitoring radioactivity levels in effluent releases; and points of release of liquid effluents to the environment. The SWMS design includes provisions for sampling at specific process points and protects against accidental discharges by the detection of abnormal conditions, as managed under administrative controls by the COL holder. The system incorporates design and operational flexibility by providing redundancy in processing wastes to route process streams among subsystems and sufficient storage capacity using multiple collection tanks. The applicant describes provisions for periodic inspection of major components to ensure the capability and integrity of SWMS subsystems. The staff finds the design acceptable with respect to meeting the criteria of GDC 60, 61, 63, and 64; 10 CFR 20.1406; 10 CFR 50.34a; Appendix I to 10 CFR Part 50; and the design guidelines of SRP Section 11.4; and RGs 1.143, 8.8, and 8.10, "Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable," issued May 1977. The applicant has indicated that the SWMS is covered by the overall QA program described in Chapter 17. Specifically, the QA requirements address the design, fabrication, procurement, and installation of radioactive waste processing systems.

Once all waste processing subsystems are installed, the COL applicant will subject each to the preoperational tests described in DCD, Tier 2, Revision 7, Section 14.2 and associated QA tests. The COL holder will conduct periodic inspections of subsystem components to confirm the performance and integrity of all operational functions. The COL applicant and holder will be responsible for ensuring that the initial installations and future modifications of processing subsystems comply with the requirements of 10 CFR 20.1406 and the guidance in IE BL 80-10 and RG 4.21 to avoid the cross-contamination of non-radioactive systems and unmonitored and uncontrolled radioactive releases into the environment, and to minimize the contamination of the facility and environment. The staff finds this approach acceptable.

DCD, Tier 2, Revision 7, Sections 11.4.2 and 11.4.6 state that waste disposal containers will be selected from options that meet (1) the disposal requirements of 10 CFR Part 61, (2) the specific criteria of the chosen disposal facility or waste processor, and (3) the radioactive waste transportation requirements of 10 CFR Part 71 and relevant DOT regulations under 10 CFR Parts 171–180. The verification of waste characteristics, waste packaging, and waste disposal are within the purview of the COL holder. The staff expects that the COL holder, referencing the ESBWR certified design, will develop a plant specific PCP, in compliance with 10 CFR Part 61, that identifies the operating procedures (i.e., boundary conditions for a set of process parameters, such as settling time, drain time, drying time) for processing wet solid wastes and parallel sets of conditions to process and prepare dry solid wastes. Therefore, for each COL application, the staff will review the PCP, including dewatering, stabilization, solidification (if performed), and compaction, and determine whether the COL application demonstrates that the SWMS complies with the requirements of 10 CFR 61.55, "Waste Classification;" 10 CFR 61.56, "Waste Characteristics;" 10 CFR Part 71; and relevant DOT regulations. The scope of the SWMS PCP should include a discussion of conformance to RGs 1.143, 8.8, and 4.21, and it should address the issues raised in GL 80-009, "Low Level

Radioactive Waste Disposal," dated January 29, 1980; GL 81-039, "NRC Volume Reduction Policy," dated November 30, 1981; and GL 89-001, and the guidelines of SRP Section 11.4, including BTP 11-3, Appendix 11.4-A, and NRC RIS 2008-32 for short and extended storage capabilities. It should also include a discussion of equipment containing wet and liquid wastes located in the non-seismic-rated radwaste building. In DCD, Tier 2, Revision 7, Section 11.4.6, the applicant identifies COL information items to meet the above requirements and guidance concerning the processing of wet and dry solid wastes. The staff finds the proposed approach and the integration of SWMS operational requirements into the PCP acceptable. The staff also finds the COL information items acceptable.

The design of components and subsystems of mobile waste processing systems that are used by contractors to process wet and solid wastes and chemical wastes on behalf of a COL holder are not within the scope of the ESBWR certified design. The portion of the SWMS that is within the scope of the ESBWR certified design complies with the provisions of RG 1.143, with respect to specific guidelines for solid radwaste systems; general guidelines for design, construction, and testing criteria for radwaste systems; and general guidelines for providing QA for radwaste management systems. DCD, Tier 2, Revision 7, Sections 3.2 and 3.8 discuss how the design of the SWMS and the radwaste building meet the applicable guidelines of RG 1.143 and the codes and standards listed in Table 1 of RG 1.143. The COL applicant is also responsible for testing all waste processing subsystems installed in the plant. Chapter 14 of this report addresses the adequacy of the preoperational testing program for the SWMS.

The design of the radwaste building includes an onsite storage capacity of up to 6 months. Based on the applicant's projected waste generation rates, the staff finds that the ESBWR design has sufficient onsite storage capacity only in the short term. The need for storage space capacity beyond 6 months is left to the determination of the COL applicant or holder. The design conforms to the guidelines of BTP 11-3 and Appendix 11.4-A to SRP Section 11.4. In GL 81-038, "Storage of LLW at Power Reactor Sites," dated November 10, 1981, the NRC provides guidance to licensees on the addition of onsite storage facilities for low-level radioactive wastes generated onsite. Appendix 11.4-A, "Design Guidance for Temporary Storage of Low-Level Radioactive Waste," to SRP Section 11.4 and RIS 2008-32 provide guidance on waste storage at reactor sites. Appendix 11.4-A addresses the guidance of GL 80-009 on low level radioactive waste disposal; GL 81-038 on the storage of low level radioactive waste at reactor sites; and GL 81-039 on the NRC low level radioactive waste volume reduction policy. The guidance addresses technical issues in considering the duration of the intended storage, types and forms of wastes, selection and expected long-term integrity of storage containers, and amounts of radioactive materials contained in wastes to ensure public health and safety, minimize doses to operating personnel, and protection of the environment. In considering the design and construction of an onsite LLW storage facility or modifications to existing storage capacity, the COL holder is expected to follow the requirements of the change process that will be outlined in the ESBWR DC rule (similar to the process included in 10 CFR 50.59, "Changes, Tests and Experiments"), as it relates to facility modifications, changes in structures, systems, and components that could affect performance and compliance with the requirements in 10 CFR Part 20 and Part 50, and changes in methods described in the FSAR and operating procedures.

The staff recognizes that the need for additional onsite storage capacity for LLW is a plant-specific consideration, that depends, in part, on whether the State or a regional LLW compact has provided a facility for long-term storage and disposal. The availability of offsite LLW storage space is beyond the control of the COL applicant or holder. Consequently, when

offsite storage or disposal capacity becomes available, the COL applicant or holder should submit to the NRC the details of arrangements about long-term onsite storage or disposal of LLW. The COL applicant or holder should evaluate the need for any additional waste storage capability and the design features of such a facility using the requirements of the change process that will be outlined in the ESBWR DC rule and the technical guidance in Section 11.4 of the SRP, NRC RIS 2008-32, and RG 1.143, 4.21, 8.8, and 8.10. The staff will review and evaluate such a proposed additional plant-specific facility against the guidelines in GL 81-038, which is similar to the guidance in Appendix 11.4-A to SRP Section 11.4. In light of the above considerations, the applicant revised DCD, Tier 2, Revision 7, Section 11.4.6 to identify the need for LLW storage as part of an overall site management plan as COL Information Item 11.4-4-A. The staff finds the proposed approach and revision to DCD, Tier 2, Revision 7, Section 11.4.6 acceptable.

According to the dose objectives in Appendix I to 10 CFR Part 50, the COL applicant is responsible for addressing the requirements for controlling doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. Sections II.A, II.B, II.C, and II.D contain the requirements. The requirements define dose objectives for liquid and gaseous effluents and require a cost-benefit analysis in justifying installed processing and treatment systems for liquid and gaseous radioactive wastes. The LWMS and GWMS will control liquid and gaseous effluents, respectively, generated by the SWMS. Accordingly, compliance with the requirements of Appendix I for the SWMS is subsumed in the respective COL information items noted in Section 11.2 of this report for the LWMS and Section 11.3 of this report for the GWMS.

The SWMS subsystems generate liquid and wet radioactive wastes from the associated operation of the SWMS collection subsystem and the SWMS processing subsystem. Such liquid and wet wastes could potentially cross-contaminate non-radioactive systems, and result in the contamination of nearby facilities and equipment, as well as unmonitored and uncontrolled radioactive releases to the environment. In DCD, Tier 2, Revision 7, Sections 11.4.1 and 11.4.2, the applicant states that the design of SWMS subsystems follows the guidance in IE BL 80-10 and the requirements of 10 CFR 20.1406. The design includes drains and vents to route radioactive process or waste streams and avoids interconnections between plant systems that could become radioactive through improper interfaces with radioactive systems. In addition, the DCD commits the COL applicant to ensure that system interfaces and connections and component design features comply with the associated requirements and guidance. The staff finds such design features and COL commitments acceptable and in compliance with the requirements of 10 CFR 20.1406 and the guidelines of IE BL 80-10 and RG 4.21. DCD, Tier 2, Revision 7, Section 12.6 outlines design concepts and features that are expected to address such concerns using the guidance of RG 4.21.

In reviewing the prior versions of DCD Tier 2, the staff found that some information was not sufficient for it to determine the acceptability of the SWMS. The staff issued a number of RAIs, not listed here for the sake of brevity, during the review of the application. These RAIs involved requests for the applicant to provide clarifications for technical completeness, provide details supporting design bases and design descriptions in demonstrating compliance with regulatory requirements, revise and update system drawings for consistency with system descriptions, revise technical and regulatory references, and provide information for the staff to conduct independent evaluations of results presented in the application. These RAIs were satisfactorily resolved by the applicant and closed by the staff in DCD, Tier 2, Revision 6. The applicant

responded to the staff's RAI, and the following paragraphs discuss the staff's evaluations of responses on important technical and regulatory topics.

In RAI 11.4-13, the staff requested additional information on how large system components (e.g., pumps, vessels, etc.) or voluminous amounts of waste (e.g., spent charcoal) will be handled and disposed of as radioactive wastes. In response, the applicant stated that such wastes will be handled on a specialized basis using offsite waste processors, as needed. For OGS spent charcoal adsorbers, the approach describes a method by which spent activated charcoals will be regenerated within the OGS. If activated charcoals in the guard or main beds become contaminated with chemicals or saturated with water, the COL holder will address the replacement of the charcoals in affected beds under operational programs and procedures. In general, large components and other voluminous amounts of waste can be temporarily held in the radwaste building or in other staging areas, or they can be decontaminated and shipped to offsite facilities for processing, storage, and disposal, given access to appropriate disposal facilities. Alternatively, a COL applicant or holder may propose the design and construction of a separate onsite radioactive storage building to supplement the storage capacity of the radwaste building. The decision to build a dedicated onsite radioactive waste storage building may depend, in part, on the availability of waste storage and disposal space provided by the State or regional LLW compacts. In either case, the staff finds such considerations plausible and acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

The applicant indicates a similar approach for managing mixed wastes (i.e., those with radiological and chemical hazardous properties). The facility will collect mixed wastes and store them in appropriate containers, such as 55-gallon (208-liter) drums, and ship them offsite to authorized processing facilities. In some instances, the plant may use other types of containers, such as HICs, based on the radiological and chemical properties of specific mixed wastes. Regulations of the NRC and the U.S. Environmental Protection Agency (EPA) control the storage of mixed wastes, which must be shipped in accordance with applicable EPA and DOT requirements. Some States require a COL applicant or holder to comply with additional regulations addressing the characterization, treatment, transportation, and disposal of mixed wastes. The staff finds this approach acceptable in dealing with requirements governing the presence of any other toxic or hazardous properties of materials that may be disposed of under the NRC regulations. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.4-15, the staff requested the addition of ITAAC to verify that the plant configuration is consistent with the described operations and process diagram. In its response, the applicant stated that the SWMS is not safety-related and does not qualify as a regulatory treatment of non-safety systems (RTNSS), and thus, it is not safety significant. Therefore, under the guidance in SRP Sections 14.3 through 14.3.11 and RG 1.206, "Combined License Applications for Nuclear Power Plants," issued June 2007, only the system name is required to be included in DCD, Tier 1. DCD, Tier 1 currently contains some design descriptions without an ITAAC table and, therefore, already contains more information than is required. Consequently, DCD Tier 1 requires no additional information for the SWMS. The staff reviewed the above response to RAI 11.4-15 and found the response not acceptable. The staff determined that the safety significance of the SWMS is at the same level as that of the LWMS and GWMS. The level of detail for the SWMS ITAAC should be similar to that of LWMS and GWMS, which include an ITAAC table to describe "design commitment," "inspection, tests, and analyses," and "acceptance criteria." In response to a supplemental RAI, the applicant proposed, in a letter

dated August 31, 2007, to include specific ITAAC for the SWMS addressing the requirements of 10 CFR 52.47(b)(1). The ITAACs are described in DCD, Tier 1, Revision 7, Section 2.10.2 and Tables 2.10.2-1 and 2.10.2-2. Two ITAAC address the descriptions and functional arrangements of the SWMS, confirm the integrity of the SWMS against leakage when subjected to testing pressures expected during operation, and verify the nominal capacities of the major processing tanks, including the high and low activity resin holdup tanks, the condensate resin holdup tank, the phase separator tanks, and the concentrated waste tank. If the inspections, tests, and analysis are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

A COL applicant referencing the ESBWR certified design should describe the QA program for design, fabrication, procurement, construction of structures, and installation of permanent or skid-mounted SWMS and its components in the plant in accordance with its overall QA program. However, DCD, Tier 2, Revision 3, Section 11.4.6 did not commit the COL applicant to conform to the QA guidance specified in RGs 1.21, 1.33, and 4.15. In a global response to RAI 11.5-44, the applicant proposed changes to all related sections of Chapter 11 on this topic and stated that the applicable QA requirements are described in DCD, Tier 2, Table 17.0-1. As a result, the applicant has revised the text of DCD, Tier 2, Section 11.4.4 to reference the QA requirements of Chapter 17 for the design, fabrication, procurement, and installation of solid and wet radioactive waste systems in accordance with the COL holder's overall QA program. In a letter dated July 23, 2007, the applicant committed to placing this information in DCD, Tier 2, Revision 4. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.4-18, the staff asked the applicant to revise DCD, Tier 2, Revision 3, Section 11.4.2 and DCD, Tier 1, Revision 3, Section 2.10.2 to indicate that the solid and wet radioactive waste mobile processing system is a conceptual design and should include a COL information item committing the COL applicant to provide complete descriptions and specifications of the mobile SWMS and its subsystems so as to meet the specifications described in DCD, Tier 2, Revision 3, Table 11.4-1 and Figure 11.4-1. The staff evaluated the SWMS and use of mobile waste processing systems and concluded that the design of the SWMS is conceptual and, therefore, not in the scope of DC, given the requirements of 10 CFR 52.47(a). Alternatively, the applicant may provide final descriptions and specifications of the mobile SWMS and its subsystems in the DCD rather than conceptual design information, with ITAACs included as appropriate. In the context of DCD Tier 1 requirements, design descriptions and interface requirements are intended to serve as binding requirements for the purpose of confirming that the plant will be built according to the design features and specifications described in DCD, Tier 1.

In responses dated November 16, 2007 and March 17, 2008, the applicant agreed to remove the conceptual designs of the SWMS processing systems from the DCD and instead provide full descriptions of SWMS subsystems in DCD, Tier 2, Revision 7, Section 11.4 and DCD, Tier 1, Section 2.10.2. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

The staff's review found that Figure 11.4-4 is included but not cited in the text, some of the listed references are not cited in the text, e.g., Ref. 11.4-5, and the reference list includes improper

regulatory citations, e.g., Ref. 11.4-8. In RAI 11.0-1, the staff asked the applicant to make the appropriate corrections. In its response dated November 13, 2008, the applicant agreed to make the appropriate corrections and provided proposed changes to be included in DCD, Tier 2, Revision 6. The staff found the proposed changes acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6.

In DCD, Tier 2, Revision 7, Section 11.4.6 the applicant identified COL Information Items 11.4-1-A through 11.4-5-A. The five COL information items identify responsibilities in following the guidance of RG 1.143, Revision 2, RG 8.8 and IE BL 80-10. The COL items also address compliance with 10 CFR 20.1406 and the guidance of RG 4.21 in minimizing the contamination of plant facilities and environment. Finally, the COL items assign responsibilities for the management and storage of LLW via the implementation of plant specific PCP. The staff finds the inclusion of these five COL information items acceptable.

In addressing, Task Action Plan, Item C-17 (Interim Acceptance Criteria for Solidification Agents for Radioactive Solid Waste), DCD, Tier 2, Section 11.4 describes the design features of the SWMS to collect, process, and package wet and dry solid wastes before shipment to disposal sites or offsite waste processors. As a result, the COL applicant is responsible for the implementation of a plant-specific Process Control Program (PCP) presenting operating procedures and technical specifications for the classification, treatment, and disposal of radioactive wastes in accordance with regulatory requirements of the NRC, DOT and State and local agencies. The parameters and criteria used to process, treat, store, and ship wastes are to be included in a plant-specific PCP and implementing procedures. Guidance on the development of a plant-specific PCP is contained in GL 89-001 and NUREG 1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for BWRs." The commitment to develop a PCP is identified under COL Information Item 11.4-3-A in DCD, Tier 2, Section 11.4. In fulfilling this requirement, the COL applicant has two options, (a) prepare a plant-specific PCP using NRC criteria and guidance, or (b) adopt by reference NEI PCP Template 07-10A (Revision 0, March 2009) in meeting this regulatory milestone until a plant-specific PCP is prepared before fuel load under the requirement of a license condition described in FSAR Section 13.4 of COL applications. The results of the staff's evaluation are presented in ML082910077 and the NEI PCP Template 07-10A is presented in ML091460236. Accordingly, the option of preparing and submitting a plant-specific PCP under FSAR COL Item 11.4-3-A, or adopting by reference NEI PCP Template 07-10A and preparing a plant-specific PCP before fuel load is deemed acceptable by the staff. Either option is acceptable in complying with Item C-17 of the Task Action Plan.

### 11.4.4 Conclusions

Based on the information as discussed above, the staff concluded that the SWMS (as a permanently installed system and in combination with other plant systems) includes the equipment necessary to manage and treat process and waste streams and control releases of radioactive materials in liquid and gaseous effluents in accordance with 10 CFR 20.1302 and 10 CFR 20.1406, Appendix I to 10 CFR Part 50, GDC 60, 61, 63 and 64, and 10 CFR 50.34a. This conclusion is based on the following requirements:

- In conjunction with the LWMS and GWMS, the SWMS design meets the dose requirements of 10 CFR 20.1302 by ensuring that the annual average concentration of radioactive materials in liquid and gaseous effluents released into unrestricted areas will not exceed the limits specified in Appendix B to 10 CFR Part 20, Table 2, Columns 1 and 2, as demonstrated in DCD, Tier 2, Section 12.2.2.

- In conjunction with the LWMS and GWMS, the SWMS design complies with the requirements set forth in Sections II.A, II.B, and II.C of Appendix I to 10 CFR Part 50, by ensuring that offsite individual doses resulting from liquid and gaseous effluent releases will not exceed dose criteria, as demonstrated in DCD, Tier 2, Section 12.2.2.

- The SWMS design provides sufficient information to demonstrate that it is in compliance with 10 CFR 50.34a, as set forth in the above discussion.

- A COL applicant referencing the ESBWR certified design will demonstrate compliance by preparing a plant-specific cost-benefit analysis in accordance with the guidance in RG 1.110 and the requirements of Sections II.A, II.B, II.C, and II.D of Appendix I to 10 CFR Part 50 for offsite individual and population doses resulting from the operation of waste processing subsystems to treat solid and wet wastes. These requirements are the subject of two COL information items in DCD, Tier 2, Section 12.2.4 (12.2-2-A, and 12.2-3-A).

- The SWMS design meets the requirements of GDC 60, 61, 63, and 64 with respect to controlling releases of liquid and gaseous effluents by radiation monitoring of such releases in conjunction with the operation of the LWMS and GWMS. Radiation monitors track all releases and will generate a signal to alert or terminate effluent releases before the discharge concentration exceeds a predetermined set point. A COL holder will identify the operational set points for its LWMS and GWMS radiation monitors in its plant-specific ODCM, as described in DCD, Tier 2, Section 11.5.4.

- The applicant demonstrates compliance with the requirements of GDC 61 by meeting the guidelines in RG 1.143. This commitment also fulfills the requirements of 10 CFR 20.1406 to minimize the contamination of the facility and the generation of radioactive waste and the guidance in IE BL 80-10 and RG 4.21 concerning the avoidance of cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases into the environment.

- The design of the radwaste building can provide up to 6 months of onsite storage for processed solid and wet wastes. The design conforms to the guidelines of BTP 11-3 and Appendix 11.4-A to SRP Section 11.4. The need for storage capacity beyond 6 months is left to the determination of the COL applicant or holder.

- A COL applicant referencing the ESBWR certified design will be responsible for the description of a PCP. The applicant's proposed PCP should address operating procedures and technical specifications, as they relate to the classifying, treatment, and disposal of radioactive wastes processed by the SWMS in accordance with the requirements of 10 CFR 20.2006; 10 CFR 20.2007, "Compliance with Environmental and Health Protection Regulations," 10 CFR 20.2108, "Records of Waste Disposal," 10 CFR Part 61 and 10 CFR Part 71; and applicable DOT regulations under 10 CFR Parts 171–180.

- In addressing 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC, the applicant has included specific ITAAC for the SWMS. DCD, Tier 1, Revision 7, Section 2.10.2 and Tables 2.10.2-1 and 2.10.2-2 describe the ITAAC. The ITAACs address the descriptions and functional arrangements of the SWMS, confirm the integrity of the SWMS against leakage during operation, and verify the nominal capacities of major processing tanks. If the inspections, tests and analysis are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the design certification will meet the provisions of the AEA and NRC regulations.

## 11.5 Process Radiation Monitoring System

### 11.5.1 Regulatory Criteria

The staff reviewed DCD, Tier 2, Revision 7, Section 11.5 in accordance with the guidance and acceptance criteria provided in SRP Section 11.5, "Process and Effluent Radiological Monitoring Instrumentation and Sampling Systems." The following acceptance criteria are applicable:

- 10 CFR 20.1301 and 10 CFR 20.1302, as they relate to limits on doses to persons and on liquid and gaseous effluent concentrations in unrestricted areas. These criteria apply to all effluent releases resulting from normal plant operations and AOOs

- 10 CFR 20.1406, as it relates to facility design and operational procedures for minimizing the contamination of the facility and the generation of radioactive waste

- GDC 19, "Control Room," as it relates to provisions used in controlling radiation exposures and doses to control room operators during normal operations and postulated accident conditions

- GDC 60, as it relates to controlling releases of radioactive materials into the environment

- GDC 63, as it relates to monitoring fuel and waste storage

- GDC 64, "Monitoring Radioactivity Releases," as it relates to monitoring radioactive releases from the containment and effluent discharge pathways in plant environs

- 10 CFR 50.34a, as it relates to the design of equipment and procedures to control releases of radioactive materials into the environment within the numerical guidance provided in Appendix I to 10 CFR Part 50

- Appendix I to 10 CFR Part 50, as it relates to numerical guides for design objectives to meet the requirements of 10 CFR 50.34a and 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors," which specify that radioactive effluents released to unrestricted areas will be kept ALARA

- 10 CFR 50.34(f)(2)(xvii) and 50.34(f)(2)(xxvii), as they relate to monitoring radiation and radioactivity levels for routine operating and accident conditions, consistent with the requirements of GDC 63 and 64 (TMI-related requirements II.F.1, and III.D.3.3)

- 10 CFR 50.34(f)(2)(viii), as it relates to providing the ability to obtain and analyze samples from the reactor coolant system and containment without exceeding occupational radiation exposure dose limits (TMI-related requirement II.B.3)

- 10 CFR 50.34(f)(2)(xxviii), as it relates to monitoring radiation and radioactivity levels and control room habitability, consistent with the requirements of GDC 19 (TMI-related requirement III.D.3.4)

The relevant requirements of the regulations identified above are met by using the regulatory positions and guidance contained in the following RG and industry standards:

- The design of systems should meet the provisions of the applicable regulatory positions given in RGs 1.21; 1.33; 1.97, "Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants," issued June 2006; and 4.15, and guidance from Appendix 11.5-A, "Design Guidance for Radiological Effluent Monitors Providing Signals for Initiating Termination of Flow or Other Modification of Effluent Stream Properties," to SRP Section 11.5, as well as in RG 1.45, "Guidance on Monitoring and responding to Reactor Coolant System Leakage" issued May 2008, and RG 4.21.

- Monitoring and sampling of the gaseous and liquid process streams, or effluent release points, should occur according to Tables 1 and 2 of SRP Section 11.5

- The design of aerosol sampling systems should follow the guidance in ANSI/Health Physics Society (HPS) ANSI/HPS N13.1-1999

- The design of continuous RMS should follow the guidance of ANSI N42.18-2004

- The design of the instrumentation and sampling systems used in the event of a postulated accident should meet the provisions of SRP Sections 9.3.2, 11.2, and 11.3

- The description of the operational program should address the development of the plant's SRECs, ODCM, and radiological environmental monitoring program (REMP), which should meet the provisions of GL 89-001 (Supplement No. 1), Radiological Assessment Branch Technical Position (Revision 1, November 1979) included as Appendix A in NUREG-1302, as ODCM guidance for BWR plants, and the guidance in NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978. Alternatively, a COL applicant may use NEI ODCM Template 07-09A (Revision 0, March 2009) to meet this regulatory milestone until a plant and site-specific ODCM is prepared, before fuel load, under the requirements of a license condition described in FSAR Section 13.4 of the COL application. The staff has reviewed NEI ODCM Template 07-09A and found it acceptable. (See the staff's analysis in "Final Safety Evaluation for NEI 07-09, Revision 4, 'Generic Final Safety Analysis Report Template Guidance for Offsite Dose Calculation Manual (ODCM) Program Description,' " dated January 27, 2009, The results of the staff's evaluation are presented in "Final Safety Evaluation for NEI 07-09, Revision 4, 'Generic Final Safety Analysis Report Template Guidance for Offsite Dose Calculation Manual (ODCM) Program Description,' " dated January 27, 2009 (ADAMS accession number ML083530745) and the NEI ODCM Template 07-09A (ADAMS accession number ML091460258).

The staff performed a comparison of the SRP (Section 11.5, 1981 version) used during the review of the DCD with the 2007 version of the SRP. The 2007 version includes additional acceptance criteria and guidance addressing the requirements of 10 CFR 20.1406, when compared to the prior version of the SRP. However, the requirements of 20.1406 were considered in the staff's review of the DCD, given the 2007 version of the SRP. Discussions and dispositions of these items are provided in this and other supporting sections of this report. Therefore, the staff concludes that the version of the SRP used, in combination with the additional review performed by the staff, is adequate for this review.

### 11.5.2 Summary of Technical Information

The primary purpose of the PRMS is to provide information characterizing the types and amounts of radioactivity contained in process streams and liquid and gaseous effluents. Other objectives are to alert control room operators of abnormal levels of radioactivity in process streams and liquid and gaseous effluents, and to provide signals that initiate automatic safety functions, isolate process streams, and terminate effluent discharges if predetermined radioactivity levels or release rates exceed alarm set points. Another function of the PRMS is to provide the means to collect samples from process and effluent streams for radiological analysis. The design objectives and criteria of the PRMS are based on requirements that address the following:

- radiation monitoring instrumentation required for plant safety and protection
- radiation instrumentation required for monitoring plant operation

The PRMS consists of skid-mounted and permanently installed sampling and monitoring equipment designed to indicate operational radiation levels and releases of radioactive materials, equipment or component failures, and system malfunctions or improper operation. The PRMS includes beta and gamma radiation sensitive detectors working in redundant channels, as required for each subsystem. The radiation detectors are capable of detecting the types and energies of radiation emitted from fuel, radioactive wastes, and process and effluent streams. Local readout and alarm modules are located at specific areas to provide information on the radiological status of plant systems and to alert personnel of abnormal or accident conditions. The PRMS generates signals to initiate the operation of certain safety-related equipment to control radioactive releases under normal and abnormal operations and accident conditions. The COL holder will subject the PRMS to preoperational tests. The COL holder also is responsible for testing all skid-mounted RMS installed in the plant. There are provisions for periodic inspection of major components to ensure the capability and integrity of all PRMS subsystems.

DCD, Tier 2, Revision 7, Sections 11.5.1 and 11.5.2, Table 11.5-3, and Figure 11.5-1 list the design bases and criteria and describe the locations of the PRMS components in plant buildings. DCD, Tier 2, Revision 7, Tables 11.5-1, 11.5-2, 11.5-4, and 11.5-9 describe the key operational features of the PRMS, including configurations, dynamic detection ranges, principal radionuclides on which initial instrumentation responses are based and types of trip and alarm functions. DCD, Tier 2, Revision 7, Section 12.2, presents information on expected radiation or radioactivity levels in various plant systems. DCD, Tier 2, Revision 7, Tables 11.5-5 through 11.5-8 describe provisions for sampling and analyzing process and effluent streams. DCD, Revision 7, Figure 11.5-2 presents the PRMS interface with the plant's instrumentation and control system, as described in DCD, Tier 2, Revision 7, Sections 7.1 and 7.5. DCD, Tier 2, Revision 7, Section 11.5.4 presents a regulatory evaluation of the PRMS basis for the selection

of the locations of subsystem components, expected radiation or radioactivity levels, instrumentation and sample collection, and requirements for establishing alarm or trip instrumentation set points.

DCD, Tier 2, Revision 7, Section 11.5.2.1 indicates that the PRMS subsystems required for plant safety and protection incorporate the following major design requirements:

- be capable of withstanding the effects of natural phenomena without the loss of operational function;
- perform intended safety related functions during normal and abnormal conditions;
- meet the reliability, testability, independence, and failure mode requirements of engineered safety systems;
- use redundant channels satisfying the separation and single-failure criteria for the initiation of safety functions;
- provide compatibility with expected radiation levels and ranges under normal operation, abnormal operation, and accident conditions;
- provide the means for checking the availability and operational status of each RMS channel and calibration and functional checks;
- provide continuous RMS output and alarm levels in the plant's control room;
- initiate protective action when operational limits are exceeded; and
- register full-scale if radiation detection levels exceed full-scale.

The following PRMS subsystems provide signals and initiate automatic safety functions for the building HVAC exhausts:

- reactor building HVAC exhaust RMS
- refuel handling area HVAC exhaust RMS
- control building air intake HVAC RMS
- isolation condenser vent exhaust RMS
- fuel building general area HVAC RMS
- fuel building fuel pool HVAC RMS
- containment purge exhaust RMS

The safety-related portions of the PRMS are classified as safety Class 2, seismic Category I, and conform to the QA requirements of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50.

DCD, Tier 2, Revision 7, Section 11.5.2.2 states that the PRMS subsystems required for plant operation incorporate the following major functional requirements:

- provide the operational range response of each subsystem under normal operation, AOOs, and accident conditions

- provide self-diagnosis for instrumentation malfunctions, with annunciation provided in the plant's control room and isolation of effluent discharges

- ensure compatibility with expected radiation levels and ranges under normal operation, abnormal occurrences, and accident conditions

- monitor a representative sample of bulk stream or volume of process and effluent streams

- incorporate provisions for instrumentation calibration and functional checks

- register full-scale if radiation detection levels exceed full scale

- monitor selected non-radioactive systems for the intrusion of radioactivity

The other subsystems of the PRMS monitor plant operations and provide information on levels of radioactivity present in process streams and liquid and gaseous effluents.

As compared to the prior revisions of the DCD, Tier 2, Revision 5 incorporated a major design change associated with the original plant stack design. The prior design (DCD, Tiers 1 and 2, up to Revision 4) included a single plant stack for all buildings. The single stack was designed as the single point of releases for all gaseous effluents. In DCD, Tiers 1 and 2, Revision 5 the design included three discharge stacks, the reactor and fuel building as one, and separate stacks for the turbine building and radwaste building. Given this change, the PRMS design includes three PRMS subsystems, one for each of the three building stacks. The following PRMS subsystems meet design criteria and provide the means to collect process and effluent samples for radiological analysis:

- PRMS subsystems for gaseous effluents

  – reactor and fuel building stack RMS
  – turbine building stack RMS
  – radwaste building stack RMS
  – turbine building normal ventilation air HVAC RMS
  – turbine building compartment area air HVAC RMS
  – turbine building combined ventilation exhaust RMS
  – radwaste building ventilation exhaust RMS
  – main turbine gland seal steam condenser exhaust RMS
  – fuel building combined ventilation exhaust RMS

- PRMS subsystems for liquid effluents

  – liquid radwaste discharge RMS

- PRMS subsystems for gaseous process streams

  – main steamline RMS
  – off-gas pretreatment RMS
  – off-gas post-treatment RMS

– charcoal vault ventilation RMS
– drywell fission product RMS

- PRMS subsystems for liquid process streams

  – reactor component cooling water intersystem leakage RMS
  – drywell sumps low and high conductivity waste discharge RMS

- PRMS subsystems for gaseous intake streams

- technical support center HVAC air intake RMS

DCD, Tier 2, Revision 7, Sections 11.5.5, 7.5.3, and 9.3.2 describe the features of the process monitoring and sampling that would be used for normal operations and under accident conditions. DCD, Revision 7, Tables 11.5-1, 11.5-2, 11.5-5 through 11.5-8, and Table 9.3.1 describe the design for monitoring and sampling these process and effluent streams. The system consists of permanently installed sampling lines, sampling panels with analyzers and associated sampling equipment, provisions for local sampling, and permanently installed radiation shielding. The descriptions include a list of process and effluent systems with operational features, the selection of locations for the placement of RMS monitors, the number of RMS channels, provisions for grab sampling, expected radiation levels, and types of alarms and trips.

Sampling stations or points are provided for the following systems:

- reactor building

  – RWC/SCS
  – fuel and auxiliary pool cooling system

- fuel building

  – spent fuel pool treatment system

- turbine building

  – condensate and feedwater system
  – moisture separator and reheater system
  – heater drain and vent system
  – generator cooling system
  – turbine main steam system

- condensate polishing

  – condensate and feedwater system
  – condensate purification system

- condenser

  – main condenser OGS and auxiliaries

- radwaste building

  - equipment and floor drain input
  – chemical waste drain
  – detergent waste drain
  – sample tanks

- local grab sampling stations and points

  – reactor component cooling water system
  – turbine component cooling water system
  – plant service water system
  – chilled water system
  – circulating water system
  – standby liquid control system
  – condensate storage and transfer system
  – CST basin sump
  – equipment and floor drain system
  – storm and underdrain water system (COL applicant item)
  – non-contaminated waste water system (COL applicant item)

For gaseous effluents, the system provides for continuous and representative sampling of radioactive airborne particulates, radioiodines, and noble gases from the three building stacks. The PRMS subsystems also provide the means for the grab sampling of noble gases, radioiodines, particulates, and tritium for the listed gaseous radwaste discharges. For liquid process and effluent streams, the system provides grab sampling and analysis capability for gross radioactivity determination, identification of principal radionuclides and alpha emitters, and measurement of their concentrations. DCD, Tier 2, Revision 7, Sections 7.5.1 through 7.5.3, and 9.3.2 describe the features of the post-accident sampling system and process sampling system. DCD, Tier 2, Section 9.3.2.6 commits the COL applicant (COL Information Item 9.3.2-1-A) to develop a post-accident sampling program to monitor plant systems listed in DCD, Tier 2, Table 9.3-1.

DCD, Tier 2, Revision 7, Sections 11.5.3.1.4 and 11.5.3.2.12 describe the designs of the PRMS subsystems used to monitor the air intakes of the control building and technical support center, respectively, as being compliant with GDC 19. Each RMS subsystem includes provisions to initiate the isolation of the outside air intake and exhaust dampers and startup of the emergency air filtration system when doses to control room operators and occupants of the technical support center are expected to exceed 0.05 Sv (5 rem) during a postulated accident.

DCD, Tier 2, Revision 7, Section 11.5.6 describes the requirements for the calibration, inspection, testing, and maintenance of the PRMS. The PRMS includes provisions for self-diagnosis and online calibrations of process monitors that operate continuously. Each monitor channel has provisions to conduct periodic calibrations using standard radiation sources or electronic test signals. The PRMS includes design features to facilitate such maintenance using modules that can be removed for repairs or replacement. The derivation of each subsystem's lower dynamic range and sensitivity (as the lower limit of detection) is left to the COL applicant, based on site-specific conditions, types of RMS installed, and operating characteristics of each installed subsystem.

In DCD, Tier 2, Revision 7, Section 11.5.7 “COL Information,” the applicant listed the following five COL information items:

- COL Information Item 11.5-1-A - The COL applicant is required to derive the lower limit of detection for each effluent PRMS subsystem and response sensitivity for each process PRMS subsystem installed, taking into consideration plant and site-specific conditions.

- COL Information Item 11.5-2-A - The COL applicant is required to develop a plant- and site-specific ODCM for calculating offsite doses resulting from liquid and gaseous effluents and planned discharge flow rates.

- COL Information Item 11.5-3-A - The COL applicant is responsible for implementing the requirements in RGs 1.21 and 4.15, and ANSI/HPS N13.1-1999 in developing a process to monitor and extract samples from all identified process and effluent streams.

- COL Information Item 11.5-4-A - The COL applicant is responsible for addressing the requirements of the dose objectives in Appendix I to 10 CFR Part 50 for controlling doses to a hypothetical maximally exposed member of the public and populations living near the proposed nuclear power plant. Sections II, III, and IV of Appendix I to 10 CFR Part 50 contain the requirements. A separate set of COL Information Items (DCD, Tier 2, Revision 7, Section 12.2.4 ) addresses the requirements in complying with dose objectives for liquid and gaseous effluents and the conduct of a cost-benefit analysis in justifying installed systems for processing and treating liquid and gaseous radioactive wastes.

- COL Information Item 11.5-5-A - The COL applicant is responsible for defining instrumentation response sensitivities, and sampling and analytical frequencies for all listed liquid and gaseous samples extracted from process and effluent streams.

### 11.5.3 Staff Evaluation

The staff reviewed the PRMS in accordance with the guidance of SRP Section 11.5. Staff acceptance of the PRMS is based on the design meeting the requirements of 10 CFR 20.1301 and 10 CFR 20.1302; 10 CFR 20.1406; 10 CFR 50.34a; 10 CFR 50.36a; Appendix I to 10 CFR Part 50; GDC 60, 63, and 64; and 10 CFR 50.34(f)(2)(viii), 50.34(f)(2)(xvii), (f)(2)(xxvii), and 50.34(f)(2)(xxviii).

Under 10 CFR 50.34a and 50.36a, the applicant is required to demonstrate that sufficient design information is provided to comply with the ALARA design objectives of Appendix I to 10 CFR Part 50 for equipment necessary to control releases of radioactive effluents into the environment. The relevant requirements of GDC 60, 63, and 64 are met by using the regulatory positions in RG 1.143, as they relate to the seismic design and quality group classification of components used in plant systems and structures housing the PRMS.

DCD, Tier 2, Revision 7, Sections 11.5.1 and 11.5.2, Table 11.5-3, and Figure 11.5-1 list the design bases and criteria and place the locations of the PRMS components in plant buildings. DCD, Tier 2, Revision 7, Section 11.5.2.1 identifies radiation monitors required for plant safety and protection, and Section 11.5.2.2 describes radiation monitors required for plant operation. DCD, Revision 7, Tables 11.5-1, 11.5-2, 11.5-4, and 11.5-9 describe the key operational

features of the PRMS, including configurations, dynamic detection ranges, principal radionuclides on which instrumentation responses are based, and types of trip and alarm functions. DCD, Tier 2, Revision 7, Section 12.2, presents information on expected radiation or radioactivity levels in various plant systems. DCD, Tier 2, Revision 7, Tables 11.5-5 through 11.5-8 describe provisions for the sampling and analyzing of process and effluent streams. DCD, Tier 2, Revision 7, Figure 11.5-2 presents the PRMS interface with the plant's instrumentation and control system, as described in DCD, Tier 2, Revision 7, Sections 7.1 and 7.5. DCD, Tier 2, Revision 7, Section 11.5.4 presents a regulatory evaluation of the PRMS that addresses the basis for the selection of the locations of subsystem components, instrumentation and sample collection, and requirements for establishing alarm or trip instrumentation set points. The staff evaluated the safety-related portions of the PRMS, classified as safety Class 2, seismic Category I by the applicant, and considered whether those portions of the PRMS conform to the QA requirements of Appendix B to 10 CFR Part 50.

In addressing the sampling and analysis of process and effluent streams, the applicant follows the NRC and industry guidance. RG 1.21 addresses requirements associated with to the ability to perform specific types of radiological analysis, and RG 4.15 covers requirements to calibrate, maintain and inspect instrumentation used to monitor the presence of radioactivity in process and effluent streams, as well as methods to measure effluent discharge flow and radioactivity release rates. Finally, ANSI/HPS N13.1-1999 provides guidance on sampling and monitoring from building stacks, vents, and ducts containing radioactivity; and the ANSI/Institute of Electrical and Electronics Engineers document ANSI/IEEE N42.18-2004 addresses instrumentation designed for continuous monitoring. In DCD, Tier 2, Revision 7, Section 11.5.4.6, the applicant stated that the requirements of these two RGs and industry guidance are endorsed by reference and are the responsibility of the COL applicant under COL Information Item 11.5-3-A. Two other COL Information Items (11.5-1-A and 11.5-5-A) require COL applicants to define appropriate PRMS instrumentation detection limits and response sensitivities for process and effluent monitors as well as the frequencies and basis for liquid and gaseous sample collection and analysis. DCD, Tier 2, Revision 7, Tables 11.5-7 and 11.5-8 present summaries of the radiological sampling and analyses programs for liquid and gaseous effluents, based on the guidelines in RGs 1.21 and 4.15. The staff finds this approach acceptable.

Under the requirements of 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii), the applicant must provide the means to monitor radiation and radioactivity levels for routine operating and accident conditions, consistent with the requirements of GDC 63 and 64. The staff finds the range provided in DCD, Tier 2, Revision 7, Tables 11.5-1 and 11.5-9 for radiation measurement and sampling of noble gases, particulates, and radioiodines from potential release points to be acceptable because it meets the range criterion for such monitors specified in NUREG-0737, "Clarification of TMI Action Plan Requirements," Three Mile Island (TMI) Item II.F.1, Attachment 3, "Containment High-Range Radiation Monitori," dated November 1980. DCD, Tier 2, Revision 7, Section 12.3 and Section 12.3 of this report evaluate the high-range containment radiation monitors.

The staff finds the ranges specified in DCD, Tier 2, Revision 7, Table 11.5-1 for the control building radiation monitor to be acceptable as they are consistent with applicable NRC guidance. RGs 1.45, and RG 1.97 present guidance for sampling and monitoring process and effluent streams and analyzing samples, including the proposed analytical programs, during postulated accidents, in accordance with the requirements of 10 CFR 50.34(f)(2)(viii) (TMI-related requirement II.B.3), 10 CFR 50.34(f)(2)(xvii) (TMI-related requirement II.F.1), and

10 CFR 50.34(f)(2)(xxvii) (TMI-related requirement III.D.3.3). DCD, Tier 2, Revision 7, Sections 13.3, 13.5, 7.5.1, and 9.3.2 and BTP 7-10, "Guidance on Application of Regulatory Guide 1.97," of SRP Section 7.5 provide more specific information on the application of Revision 4 of RG 1.97, to the ESBWR design. The applicant has adopted the option of BTP 7-10 to define instrumentation response ranges using the provisions of Revision 3 of RG 1.97 (DCD, Tier 2, Revision 7, Tables 7.1-1 and 1.9-21). In addition, the staff has determined that these aspects will be integrated as part of the human factors engineering process described in DCD, Tier 1, Section 3.7. Section 7.5 of this report presents the staff's evaluation of the provisions associated with the guidelines of Revision 4 of RG 1.97. On the basis of the above discussions, the staff finds that these special-purpose monitors comply with GDC 60 and 64 in terms of their ability to control and monitor the release of radioactive materials into the environment.

Under 10 CFR 50.34(f)(2)(xxviii) (TMI-related requirement III.D.3.4), the applicant must provide the means to monitor radiation and radioactivity levels and control room habitability, consistent with the requirements of GDC 19, during normal operations and postulated accident conditions. DCD, Tier 2, Revision 7, Sections 11.5.3.1.4 and 11.5.3.2.12 describe the designs of the PRMS subsystems used to monitor the air intakes of the control building and technical support center, respectively, as complying with GDC 19. Each PRMS subsystem includes provisions to initiate the isolation of the outside air intake and exhaust dampers and the startup of the emergency air filtration system when doses to control room operators and occupants of the technical support center are expected to exceed 0.05 Sv (5 rem) during a postulated accident. The staff finds the design and provisions for automatic closure of the air intake and initiation of the emergency air intake system to be acceptable. DCD, Tier 2, Revision 7, Section 6.4 and Section 6.4 of this report discuss the habitability of the control building.

The COL holder will subject the PRMS, in conjunction with sampling equipment and portions of process or effluent system components that are activated by the PRMS, to preoperational tests and calibration, as well as maintenance. DCD, Tier 2, Revision 7, Section 11.5.6 presents the requirements for the operational programs involving calibration, maintenance, inspections, and tests. The staff finds the scope of the program to be acceptable. Chapter 14 of this report addresses the adequacy of the preoperational testing program for the PRMS.

In DCD, Tier 2, Revision 7, Sections 11.5.2, 11.5.3, and 11.5.4.6, the applicant states that the PRMS is designed in accordance with ANSI/HPS N13.1-1999 and applicable RGs 1.21 and 4.15. DCD, Tier 2, Section 11.5.7 states that the COL applicant referencing the ESBWR certified design, is responsible for ensuring that the process and effluent monitoring and sampling program conforms to the guidelines of ANSI/HPS N13.1-1999 and RGs 1.21 and 4.15. This requirement is identified as COL Information Item 11.5-3-A. The staff finds this approach acceptable.

DCD, Tier 2, Revision 7, Section 11.5.5.9 discusses provisions to collect radioactive samples from radioactive process streams. The applicant states that the sample points are described in DCD, Tier 2, Sections 7.5.2 and 9.3.2 and listed in DCD, Tier 2, Revision 7, Table 9.3-1. The sampling system is designed according to the requirements and guidelines of 10 CFR 20.1101(b); 10 CFR 50.34(f)(2)(viii) (TMI-related requirement II.B.3), 10 CFR 50.34(f)(2)(xvii) (TMI-related requirement II.F.1), and 10 CFR 50.34(f)(2)(xxvii) (TMI-related requirement III.D.3.3); GDC 19, 60, 63, and 64; RGs 1.21, 1.33, 1.97, and 8.8; NUREG-0737 (TMI Action Plan); and ANSI/HPS N13.1-1999. The systems identified in DCD, Tier 2, Revision 7, Table 9.3-1 include the RWC and SCS, FAPCS, main steam line, condensate

purification system, and liquid radwaste system effluent sample tank. Additional sampling stations are provided for other systems, including the condensate and feedwater system, turbine main steam, reactor component cooling water system, standby liquid control system, LWMS, and GWMS. The types of measurements are identified as broad categories, such as gross activity, activity caused by corrosion and activation products, iodine-131, gaseous fission products (xenon and krypton), and principal radionuclides and alpha emitters. DCD, Tier 2, Revision 7, Section 9.3.2.6 requires a COL Information Item (9.3.2-1-A) to develop a post-accident sampling and monitoring program based on the information presented in DCD, Tier 2, Revision 7, Table 9.3-1 and the NRC guidance of SRP Section 9.3.2. DCD, Tier 2, Chapter 12 describes plant design features (shielding and ventilation) and operational programs that will maintain occupational radiation exposures within NRC limits and ALARA during accident conditions in complying with TMI action plan items. The process sampling system consists of permanently installed lines, sampling panels equipped with instrumentation and the associated equipment, provisions for local grab sampling, provisions for obtaining representative samples, heat tracing and cooling for sample conditioning, provisions to purge and flush sampling lines, and permanent shielding. The design also includes provisions to minimize leakage and spillage, return flushing fluids to their appropriate process streams or send them to the radwaste system, and reduce radiation exposures to plant personnel while working at sampling stations. Based on the above, the staff finds that the design is acceptable.

In reviewing DCD, Tier 2, Revision 1 the staff found some of the information was not sufficient for it to determine the acceptability of the PRMS and requested additional information. The staff issued a number of RAIs, not listed here for the sake of brevity, during the review of the application. These RAIs involved requests for the applicant to provide clarifications for technical completeness, provide details supporting design bases and design descriptions in demonstrating compliance with regulatory requirements, revise and update system drawings for consistency with system descriptions, revise technical and regulatory references, and provide information for the staff to conduct independent evaluations of results presented in the application. These RAIs were satisfactorily resolved by the applicant and closed by the staff in DCD, Tier 2, Revision 6. The following paragraphs discuss the staff's evaluations of the applicant's responses to RAIs on important technical and regulatory topics.

In RAI 16.2-9, as it relates to the submission of an ODCM, as described in DCD, Tier 2, Revision 3, Section 11.5.7.2 and the administrative requirements of DCD, Tier 2, Revision 1, Section 16.5.5.1.c, and the COL items listed in DCD, Tier 2, Revision 3, Section 11.5.7, the staff finds the listed items adequate given that the development process of a plant- and site-specific ODCM, and its associated documents is required to follow the NRC requirements and guidance. A COL applicant should base its ODCM, SREC, and REMP, or the description of their associated operational programs, on the guidance of NUREG-1302 for BWR plants; NUREG-0133; RGs 1.21, 1.33, and 4.15; ANSI/HPS N13.1-1999 and ANSI N42.18-2004; Appendix 11.5-A (Section 11) to the SRP; GL 89-001 (Supplement No. 1); and Radiological Assessment Branch Technical Position (Revision 1). Alternatively, a COL applicant may use NEI ODCM Template 07-09A (Revision 0, March 2009) to meet this regulatory milestone until a plant and site-specific ODCM is prepared, before fuel load, under the requirements of a license condition described in FSAR Section 13.4 of the COL application. The staff has reviewed NEI ODCM Template 07-09A and found it acceptable. The results of the staff's evaluation are presented in ML083530745 and the NEI ODCM Template 07-09A is presented in ML091460258.

In this context, the ODCM, or the description of the operational program for the ODCM, should present the plant's SREC and the REMP. The ODCM, or the description of the operational program for the ODCM, should describe programs and identify procedures used in implementing effluent discharges, define effluent discharge flow rates, provide the basis for liquid effluent dilution factors and atmospheric dispersion and deposition parameters for gaseous effluents, and identify exposure pathways and dose receptors using data from the current local land-use census. The ODCM, or the description of the operational program for the ODCM, should contain the methodology and parameters used for calculating offsite doses to members of the public from gaseous and liquid effluents to demonstrate compliance with the numerical objectives of Appendix I to 10 CFR Part 50; the dose limits of 10 CFR 20.1301 for members of the public; the effluent concentration limits of Appendix B (Table 2) to 10 CFR Part 20; and the compliance requirements of 10 CFR 20.1302. The ODCM, or the description of the operational program for the ODCM, should present methods and parameters used to determine operational set points for effluent radiation monitors in limiting releases of radioactive materials into the environment within the liquid and gaseous effluent concentration limits of Table 2 of Appendix B to 10 CFR Part 20. The ODCM, or the description of the operational program for the ODCM, should also provide instructions for identifying and eliminating the potential for unmonitored and uncontrolled releases. In DCD, Tier 2, Revision 7, Section 11.5.7 the applicant states that the development of the ODCM, or the description of the operational program for the ODCM, is the responsibility of the COL applicant under COL Information Items 11.5-2-A and 11.5-4-A. DCD, Tier 2, Revision 7, Section 13.4 identifies these milestones as being due before fuel loading, given the requirements of SECY-05-0197, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria," dated October 28, 2005; RG 1.206, and SRP Section 13.4. The staff finds this approach acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-5, the staff asked the applicant to provide further elaboration on complying with 10 CFR 20.1406 and using the guidance of IE BL 80-10. In Revision 3 of DCD, Tier 2, Sections 11.5.2, 11.5.4, and 11.5.5, the applicant did not indicate whether the design of the process and effluent sampling systems follows the guidance of IE BL 80-10 and whether the design avoids interconnections with non-radioactive systems that could become radioactive through improper interfaces with radioactive systems. Similarly, the applicant did not indicate whether the design of the process and effluent sampling systems complies with the requirements of 10 CFR 20.1406, as it relates to the design and operational procedures to minimize contamination and the generation of radioactive wastes. While DCD, Tier 2, Revision 3, Section 12.6, addresses some requirements associated with 10 CFR 20.1406, the discussions of DCD, Tier 2, Section 12.6 are broadly generic and do not focus on specific design issues for the PRMS. In response to a supplemental RAI, the applicant proposed, in a letter dated August 31, 2007, to revise DCD, Tier 2, Sections 11.5.6.4 and 11.5.6.5 by providing more technical details to demonstrate compliance with the guidance of IE BL 80-10 and implementation of 10 CFR 20.1406. The response acknowledges that a potential exists for interconnections with non-radioactive systems and describes design features to prevent the contamination of non-radioactive systems and to minimize radioactive contamination during operation. The applicant describes provisions to protect the clean supply of purge air and water used to flush contaminated subsystems and makeup water used in filling loop seals, and measures to prevent spills and leaks. With the supplemental information presented in DCD, Tier 2, Revision 5, Sections 9.3.2, 11.5.6.4, 11.5.6.5, and 12.6. The staff finds the response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-6, as it relates to DCD, Tier 2, Revision 1, Sections 11.5.3 and 11.5.4 the staff asked the applicant to describe how the reactor building HVAC exhaust system captures discharges from the isolation condenser vent exhaust. In DCD Tier 2, Revision 3, Section 11.5.3.1.5, the discussion regarding the air exhaust from the atmospheric area above each condenser pool is incomplete. Although the exhaust is monitored by the isolation condenser vent exhaust RMS, it was not clear from this discussion and the information presented in DCD, Tier 2, Revision 3, Sections 5.4.6.5 and 5.1.2 and Figure 5.1-3 what design features are provided to prevent the exhaust from the atmospheric area above each condenser pool from becoming an uncontrolled and unmonitored release into the environment. In response to a supplemental RAI, the applicant proposed, in a letter dated August 9, 2007, to revise DCD, Tier 2, Section 11.5.3.1.5 (now 11.5.3.1.6 in Revision 7), to amplify the operational description of the isolation condenser vent exhaust and the related response of radiation monitors that initiate closure of the containment isolation valves for the affected condensers in the event of a condenser tube leak. The supplemental information indicates that the condenser pool is filled with non-radioactive water supplied by the makeup water system. During normal operation, the pool does not become radioactive and the steam generated during boiloff is removed as moisture by a dryer and drained back to the pool. The radiological consequences following a leak from the isolation condenser and the closure of the affected isolation condenser by the radiation monitor is treated generically in DCD, Tier 2, Revision 7, Section 15.4.8. The staff finds the response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-8, as it relates to DCD, Tier 2, Revision 1, Sections 11.5.3 and 11.5.4, the staff asked the applicant to resolve inconsistencies in addressing competing objectives of RGs 1.21 and 1.97 in describing dynamic response ranges and expected activity levels. The specific information ~~is~~ was presented in DCD, Tier 2, Revision 1, Tables 11.5-1, 11.5-2, 11.5-4, and 11.5-9. In Revision 3 of DCD, Tier 2, Section 11.5.2.1 and Table 11.5-9, the applicant stated that the PRMS dynamic instrumentation response ranges are consistent with system designs and qualifications under the provisions of RG 1.97. A review of DCD, Revision 3, Section 7.5, indicates that the instrumentation design requirements are based on Revision 4 of RG 1.97. A review of Revision 4 of the RG indicates that it did not provide criteria for instrumentation variables as do Revisions 2 and 3 of the same guide. In Revision 4, the RG states that the basis and numerical values for instrumentation are to be established in the licensing basis documentation, which is nonexistent at this time, given the endorsement of IEEE Std 497-2002 in the regulatory position of RG 1.97, Revision 4. In addressing conformity with RG 1.97, DCD, Revision 3, Section 7.5.1.3, states that conformance to these requirements will be addressed during the design process using inputs from various design analyses and human factor engineering. In response to RAI 11.5-8, supplemental RAI 11.5-46, and other RAIs issued against DCD, Tier 2, Section 7.5.1, the applicant discussed compliance with RG 1.97 for post-accident radiation monitoring instrumentation described in DCD, Tier 2, Section 7.5.1.3, and notes that these aspects will be integrated as part of the human factors engineering process described in DCD, Tier 1, Section 3.7. As part of this process, the applicant agreed, in DCD, Tier 2, Revision 5, to address design and performance criteria in defining instrumentation response ranges using the provisions of RG 1.97, Revision 4, against the post-accident monitoring variables applicable to radiation monitors installed in building stacks. Section 7.5.1 of this report presents the staff's evaluation of the provisions associated with compliance of Revision 4 of RG 1.97 and associated BTP of Section 7.5 of the SRP. The staff finds the response acceptable and the two RAIs are closed in the context of DCD, Tier 2, Revision 7, Section 11.5.

In RAI 11.5-23, the staff's review of DCD, Tier 2, Revision 1, Sections 10.4.2, 11.3, 11.5, 12.3.1, and 12.3.2 found no discussion addressing plant design features to mitigate radiation exposures and doses to members of the public associated with the production of N-16 and skyshine outside of the turbine building, in the context of 10 CFR 20.1302, 10 CFR 20.1301(e), and 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations." In response to RAI 11.5-23, the applicant stated that the related topics were also addressed in the responses to RAI 12.3-5 and 12.3-5 S01. DCD, Tier 2, Revision 3, Section 12.2.1.3 discusses the analysis and dose results, with references given for other sections of DCD Tier 2 containing information on the N-16 radiological source term and shielding provided by structures, systems, and components. The applicant proposed to add a requirement in DCD, Tier 2, Section 11.5.7, that a COL holder consider in its ODCM site-specific conditions and requirements to assess radiation exposures and doses to members of the public located in unrestricted areas, in accordance with the requirements of 10 CFR 20.1301(e) and 10 CFR 20.1302. The staff finds these responses acceptable in the context of DCD, Tier 2, Section 11.5. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD, Tier 2, Revision 4. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-24, the staff's review of DCD, Tier 2, Revision 1, 11.5 and SRP Sections 9.3.2 and 11.5, found no discussions on whether the design considered the acceptance criteria and guidance of SRP Section 9.3.2.II on the process sampling system and post-accident sampling system. The staff asked the applicant to:

- address how the applicable requirements of SRP Section 9.3.2.II were met in DCD, Tier 2, Sections 11.5.5 and 9.3.2 for gaseous/liquid process and effluent streams;
- update the text in DCD, Tier 2, Sections 11.5.5 and 9.3.2 and DCD, Tier 2, Tables 9.3-1 and 11.5-1 to reflect the applicable criteria of SRP Section 9.3.2.II;
- update the text in DCD, Tier 2, Section 11.5.5 by adding internal cross-references to DCD, Tier 2, Section 9.3.2; and
- describe the operational considerations that would be addressed by the COL applicant in DCD, Tier 2, Section 11.5.7 and SRP Sections 9.3.2 and 11.5.7.

In its response to RAI 11.5-24, the applicant stated that a new section (11.5.5.9) would be created to address these issues and that it would include a cross-reference to DCD, Tier 2, Revision 5, Section 9.3.2 where information can be found on the consideration of station layout and design criteria in selecting locations for sampling from process and effluent streams against specific GDC, regulatory requirements, and regulatory guidance. Also, DCD, Tier 2, Section 11.5.5.9 documents the requirements to maintain radiation exposure to workers ALARA and reducing leakages and spills. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD, Tier 2, Revision 4. The staff finds the applicant's technical response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

The staff's review indicated that DCD, Tier 2, Revision 3, Section 11.5.7 did not commit the COL applicant to conforming to the QA guidance specified in RGs 1.21, 1.33, and 4.15. A COL applicant referencing the ESBWR certified design should describe the QA program for design,

fabrication, procurement, construction of structures, and installation of permanent or skid-mounted PRMS subsystems and components in the plant in accordance with its overall QA program. In a global response to RAI 11.5-44, the applicant proposed changes to all related sections of Chapter 11 on this topic and stated that the applicable QA requirements are described in DCD, Tier 2, Chapter 17, Table 17.0-1. As a result, the applicant has revised the text of DCD, Tier 2, Section 11.5.6.1 to reference the QA requirements of Chapter 17 for the design, fabrication, procurement, and installation of process and effluent radiation monitoring subsystems in accordance with the COL holder's overall QA program. In a letter dated July 23, 2007, the applicant committed to placing this information in DCD, Tier 2, Revision 5. The staff finds the applicant's technical response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-46, the staff noted that DCD, Tier 2, Revision 3, Section 11.5.7 should commit the COL applicant to establishing operational procedures for the associated post-accident RMS. DCD, Tier 2, Revision 3, Sections 11.5.1, 11.5.4, and 11.5.5 describe operational requirements of the post-accident sampling system and the operational range of each PRMS to ensure that they are consistent with the requirements of 10 CFR 50.34(f)(2)(viii), 10 CFR 50.34(f)(2)(xvii), 10 CFR 50.34(f)(2)(xxvii), and 10 CFR 50.34(f)(2)(xxviii) and the guidance of RG 1.97 and NUREG-0737 (TMI-related Item II.F.1). However, DCD, Revision 3, Section 11.5.7, did not commit the COL applicant to establish operational procedures for the associated RMS. The staff asked the applicant to update this section of DCD Tier 2 to add this COL information item. In a letter dated July 23, 2007, the applicant committed to clarifying compliance with the guidance of RG 1.97 and TMI-related action items in DCD, Tier 2, Revision 4, Sections 11.5.2, 11.5.3, and 13.5.3.4 without a COL information item. The staff finds the applicant's technical response acceptable given more specific information provided in DCD, Tier 2, Revisions 6, Sections 2.5, 9.3.2, 12.3 and 12.5. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In RAI 11.5-47, the staff noted that in DCD, Tier 2, Revision 3, Chapter 11 the applicant identified COL holder items encompassing operational programs including ODCM, PCP, REMP, radiological effluent technical specifications, and SRECs. In accordance with SECY-05-0197, COL applicants should fully describe these operational programs in their COL applications and should propose implementation milestones (license conditions) for staff review. The staff asked the applicant to revise the DCD to include COL applicant items rather than COL holder items for these operational programs. In a letter dated July 23, 2007, the applicant committed to changing "COL holder items" to "COL applicant items" in DCD, Tier 2, Revision 4, Sections 11.5.4 and 11.5.7. DCD, Tier 2, Revision 7, Section 13.4 assigns the development of operational programs and implementation milestones as two COL information items (COL 13.4-1-A and 13.4-2-A) being due before fuel loading. The staff finds the applicant's technical response acceptable. Based on the applicant's response, this RAI was resolved. The staff confirmed that this change was included in DCD, Tier 2, Revision 7.

In DCD, Tier 2, Revision 3, Section 11.5.7 the applicant identified COL Information Items 11.5-1-A through 11.5-5-A. The staff finds the inclusion of these five COL information items acceptable, based on the above discussions.

In addressing 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC, the applicant has included specific ITAAC for the PRMS. The ITAAC are described in DCD, Tier 1, Revision 7, Section 2.3.1 and Tables 2.3.1-1 and 2.3.1-2 and Figure 2.3.1-1. The ITAAC address the descriptions and functional arrangements of the PRMS for safety and non-

safety-related subsystems. For safety-related PRMS subsystems, ITAAC are assigned to confirm the source of electrical power, seismic qualifications, instrumentation indications of radiation or radioactivity levels, alarms on exceeding set-point values, alarms on inoperative conditions, and initiation of protective actions and isolation or termination of plant processes or effluent releases. For non-safety-related PRMS subsystems, ITAAC are assigned to confirm instrumentation indications of radiation or radioactivity levels, alarms on exceeding set-point values, and alarms on inoperative conditions. The ITAAC refer to DCD, Tier 1, Revision 7, Tables 2.10.1-2 and 2.10.3-1 for PRMS subsystems designed for the initiation of isolation or termination of plant effluent releases in demonstrating compliance with 10 CFR Part 20.1301 doses to members of the public or effluent concentration limits in Table 2 (Columns 1 and 2) of Appendix B to 10 CFR Part 20. If the inspections, tests and analyses are performed and the acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations.

The review of DCD, Tier 2, Revision 5, revealed a number of inconsistencies in internal citations and references, incorrect conversions from the International System of Units (système internationale d'unités) to conventional radiological units, and an incomplete list of radiological sampling points. Specifically, in RAI 11.01-1.a to d, the staff asked the applicant to review and resolve these items in Tables 11.5-2 and 11.5-9; to resolve inconsistent references to stack design changes in Sections 11.5.3.2.13 and 7.5.3; and to correct Section 9.2.6.2 and Table 11.5-5 , which lacked a line item entry identifying sampling provisions for condensate water that might be present in the CST basin before discharge to the storm drain. In its response dated November 13, 2008, the applicant agreed to make the appropriate corrections and provided proposed changes to be included in DCD, Tier 2, Revision 7. The staff found the proposed changes acceptable, except for that proposed in response to RAI 11.01-1.d.

The staff reviewed GEH's response to RAI 11.0-1, item (d). The staff found that the intended purpose of Footnote 9 in DCD, Tier 2, Table 11.5-5 was acceptable, but that its defined objective was improperly stated. The purpose of the RAI was to ensure that sampling of contaminated condensate water in the retention basin would be accomplished following a tank rupture or overflow. DCD, Tier 2, Section 9.2.6 acknowledges the possibility of such an event and states that sampling would be performed to assess whether condensate water held in the retention basin could be released to the storm drain or pumped back to the LWMS depending on radioactivity levels. However, the proposed Footnote 9 refers to sampling following a "rain event." Given the design features of the condensate storage and transfer system and the purpose of the retention basin, reference to a "rain event" is inconsistent with the system's design bases and underlying radiological concerns. In RAI 11.0-1 S01, the staff asked the applicant to remove "rain event" from Footnote 9 as the rationale for sampling and instead indicate that manual sampling will be performed following the observation of water in the retention basin. Also, the applicant should make Footnote 9 consistent in its terminology with other sections of the DCD, as it refers to "CST Containment Dike" while DCD, Tier 2, Section 9.2.6 refers to a "retention area" and "retention basin." Accordingly, the staff asked the applicant to revise proposed Footnote 9 to Table 11.5-5 to make it consistent with system descriptions and design bases of DCD, Tier 2, Section 9.2.6. In a response dated February 24, 2009, the applicant agreed to remove "rain event" from Footnote 9 and use a consistent nomenclature for the retention area around the condensate storage tank (CST). The staff reviewed the proposed changes to be included in DCD, Tier 2, Revision 6 and found the corrections acceptable. Based on the applicant's response, these RAIs were resolved. The staff confirmed that these changes were included in DCD, Tier 2, Revision 6.

In addressing Task Action Plan, Subtask 1 of Item B-67 (Effluent and Process Monitoring Instrumentation) for normal plant operation and AOO effluents, DCD, Tier 2, Section 11.5 is consistent with the acceptance criteria and guidance of SRP Section 11.5. The associated TMI-related items in monitoring radioactive effluents under accident conditions are covered in DCD, Tier 2, Sections 7.5.1, 7.5.3, and 9.3.2. The staff's evaluations of these DCD sections are addressed in their respective sections of this report.

In addressing Task Action Plan, Subtask 2 of Item B-67, the radiological impacts at the EAB associated with an OGS leak or component failure is addressed in DCD, Tier 2, Section 11.3.7. The assumptions and dose results of the radiological analysis were found to be in compliance with the SRP acceptance criteria and guideline of SRP Section 11.3, BTP 11-5, for systems designed to withstand the effects of hydrogen explosions and earthquakes. The staff finds the results of this analysis acceptable. Section 11.3 of this report addresses this issue and presents the results of the staff's analysis.

In addressing Task Action Plan, Subtask 3 of Item B-67, the radiological impact associated with the failure of a liquid radwaste tank is addressed in DCD, Tier 2, Section 15.3.16. The assessment considers the potential impacts of the release of radioactive materials on the nearest potable water supply located in an unrestricted area. The design features include the use of steel liners in cubicles where radwaste storage tanks are located in containing liquid radioactive waste and avoiding releases of radioactive materials in the environment. The staff finds such design features and results of the analysis acceptable. Chapter 15 of this report addresses this issue and presents the results of the staff's analysis.

In addressing Task Action Plan, Subtask 4 of Item B-67, DCD, Tier 2, Section 11.4 describes the installation and use of permanently installed radwaste processing subsystems. This approach is consistent with the acceptance criteria and guidance of SRP Section 11.4 and found acceptable by the staff. Section 11.4 of this report addresses this issue and presents the results of the staff's analysis.

### 11.5.4 Conclusions

Based on the information provided, COL information items, as discussed above, the staff concludes that the PRMS (as permanently installed system components in combination with skid-mounted RMS) includes equipment necessary to measure and control releases of radioactive materials in plant process streams and liquid and gaseous effluents; alert the control room of abnormal levels of radioactivity in process streams and liquid and gaseous effluents; provide signals that initiate automatic safety functions, isolate process streams, and terminate effluent discharges if predetermined radioactivity levels or release rates exceed alarm set points; and provide the means to collect samples from process and effluent streams for radiological analysis. Based on this evaluation, the staff finds the PRMS to be in compliance with the requirements of GDC 19, 60, 63, and 64; 10 CFR 50.34a and 50.36a; Appendix I to 10 CFR Part 50; 10 CFR 20.1301 and 20.1302; 10 CFR 50.34(f)(2)(viii), 10 CFR 50.34(f)(2)(xvii), (f)(2)(xxvii), and 50.34(f)(2)(xxviii); and associated guidance in RGs 1.21, 1.45, 1.97, 4.15, and 4.21. This conclusion is based on the following:

- The staff reviewed the provisions proposed in DCD, Tier 2 for automatic termination of effluent releases and for control over discharges, in accordance with GDC 60 and 63. Sections 11.2 and 11.3 of this report discuss systems used in controlling releases of

radioactive materials from the GWMS exhaust and LWMS discharge line. The PRMS monitors discharges or releases from the reactor and fuel building stack, turbine building stack, and radwaste building stack. The PRMS also monitors exhaust and process streams for the reactor building HVAC exhaust and its subsystems, containment purge exhaust, turbine building combined ventilation exhaust and its subsystems, radwaste building ventilation exhaust, and fuel building combined ventilation exhaust and its subsystems.

- The staff reviewed the provisions proposed in DCD, Tier 2 that are required for plant safety. These PRMS subsystems provide signals and initiate automatic safety functions for the following systems: reactor building HVAC exhaust, refuel handling area HVAC exhaust, control building air intake HVAC, isolation condenser vent exhaust, fuel building general area HVAC, fuel building fuel pool HVAC, and containment purge exhaust. The safety-related portions of the PRMS are classified as safety Class 2, seismic Category I, based on the QA requirements of Appendix B to 10 CFR Part 50.

- The staff reviewed the provisions proposed in DCD, Tier 2, Revision 3 that are required for plant operation. These PRMS subsystems provide signals and initiate automatic functions for the following plant systems: main steam line, off-gas pre-treatment, off-gas post-treatment, charcoal vault ventilation, drywell fission product, reactor component cooling water intersystem leakage, drywell sumps LCW/HCW discharge, liquid radwaste discharge line, and technical support center HVAC air intake.

- The staff reviewed the provisions in DCD, Tier 2 for systems to sample and monitor plant effluents in accordance with GDC 64. These systems include instrumentation to monitor and sample radioactivity in contaminated liquid and gaseous process and effluent streams. The staff evaluated the design features provided for process and effluent streams identified in DCD, Tier 2, Section 11.5.3, and DCD, Tier 2, Table 11.5-1 and Tables 11.5-5 through 11.5-8.

- The staff reviewed the provisions for conducting sampling and analytical programs in accordance with RGs 1.21, 1.45, and 4.15, as well as the provisions for sampling and monitoring process and effluent streams during postulated accidents in accordance with RG 1.97. Section 9.3.2 of this report presents the staff's evaluation of the compliance of the related design provisions of the process sampling system.

- The staff reviewed the requirements specified in 10 CFR 50.34(f)(2)(xvii) and 50.34(f)(2)(xxvii) in DCD, Tier 2, Sections 11.5, 7.5.2, and 9.3.2, for monitoring gaseous effluents from potential accident release points. DCD, Tier 2, Revision 5, Section 9.3.2 commits the COL applicant to develop a post-accident sampling program to monitor the parameters identified in DCD, Tier 2, Table 9.3-1. Section 7.5.1 of this report addresses the design features of the post-accident monitoring instrumentation and compliance with RG 1.97 in defining the response range of instrumentation. Chapters 6 and 12 of this report address design features and operational programs in maintaining occupational radiation exposures under NRC limits and ALARA as they relate to 10 CFR 50.34(f)(2)(viii) and 10 CFR 50.34(f)(2)(xxviii).

- The staff reviewed the provisions proposed in DCD, Tier 2 that are required for the development and implementation of operational programs. The DCD identifies the implementation of technical specifications/SREC, ODCM, and REMP, as COL Information Item 11.5-4-A. The operational programs include administrative programs. Operational procedures associated with their implementation by the COL holder should be consistent with the guidance of GL 89-001 and NUREG-1302 for BWR plants; NUREG-0133; RG 1.21, 1.33, 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," issued April 1975; 4.8, "Environmental Technical Specifications for Nuclear Power Plants (for Comment)," issued December 1975; and 4.15; guidance from Radiological Assessment Branch Technical Position (Revision 1); and RIS 2008-03.

- The design of the PRMS, operating in conjunction with the LWMS, GWMS, and SWMS to control and monitor radioactive effluent releases into the environment, meets the dose requirements of 10 CFR 20.1301 and 10 CFR 20.1302 by ensuring that annual average concentrations of radioactive materials in liquid and gaseous effluents released into unrestricted areas will not exceed the limits specified in Appendix B to 10 CFR Part 20 (Table 2, Columns 1 and 2). DCD, Tier 2, Section 12.2.2 presents this information and Section 12.3.3.2 of this report presents the staff's evaluation.

- In conjunction with the operation of the LWMS, GWMS, and SWMS, the design of the PRMS complies with the requirements of Sections II.A, II.B, and II.C of Appendix I to 10 CFR Part 50 in ensuring that offsite individual doses resulting from liquid and gaseous effluent releases will be ALARA, will not exceed dose criteria, and will comply with the requirements of 10 CFR 50.34a and 50.36a. DCD, Tier 2, Revision 5, Section 12.2.2 addresses the requirements associated with Section II.D of Appendix I on the conduct of cost-benefit analyses and ALARA in assessing the augmentation of effluent treatment systems. DCD, Tier 2, Section 12.2.4 addresses these requirements under two COL Items (12.2-2-A and 12.2-3-A) and Section 12.3.3.2 of this report presents the staff's evaluation.

- The staff reviewed the applicant's QA provisions for the PRMS, the quality group classifications used for PRMS components, and the seismic design applied to structures housing these systems. The design of the systems and the structures housing these systems meets the guidance of RG 1.143, as described in DCD, Tier 2, Revision 3, Sections 3.2 and 3.8. Sections 3.2 and 3.8 of this report present the staff's evaluation.

- The applicant demonstrates compliance with the requirements of GDC 61 by meeting the guidelines of RGs 1.143 and 4.21. This commitment also fulfills the requirements of 10 CFR 20.1406 to minimize the contamination of the facility and the generation of radioactive waste and the guidance of IE BL 80-10 and RG 4.21 to avoid cross-contamination of non-radioactive systems and un-monitored and uncontrolled radioactive releases into the environment, and to minimize the contamination of the facility.

- In addressing the requirements of 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC, the applicant has included specific ITAAC for the PRMS. The ITAAC address the descriptions and functional arrangements of the PRMS for safety and non-safety-related subsystems. ITAAC are assigned to confirm the source of electrical power, seismic qualifications, instrumentation indications of radiation or radioactivity levels, alarms on exceeding set-point values, alarms on inoperative

conditions, and initiation of protective actions and isolation or termination of plant processes or effluent releases in demonstrating compliance with 10 CFR 20.1301 doses to members of the public or effluent concentration limits in Table 2 (Columns 1 and 2) of Appendix B to 10 CFR Part 20. If the inspections, tests and analyses are performed and the COL acceptance criteria met, the proposed ITAAC provide reasonable assurance that a plant that incorporates the ESBWR DC and operates in accordance with the DC will meet the provisions of the AEA and NRC regulations.