11. RADIOACTIVE WASTE MANAGEMENT

11.1 Source Terms

11.1.1 Regulatory Criteria

There are no specific regulatory criteria 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 3, in evaluating the liquid and gaseous waste management systems described in DCD Tier 2, Revision 3, Section 11.2 "Liquid Waste Management System," and Section 11.3, "Gaseous Waste Management System." Sections 11.2 and 11.3 of this safety evaluation report (SER) detail the staff's evaluation of DCD Tier 2, Revision 3, Sections 11.2 and 11.3, respectively.

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

- Title 10, Part 20, "Standards for Protection Against Radiation," of the *Code of Federal Regulations* (10 CFR), as it relates to dose limits for members of the public 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 "as low as is reasonably achievable" (ALARA) criterion in Appendix I

- 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 Section 11.1 of DCD Tier 2, Revision 3 in evaluating plant radioactive sources described in DCD Tier 2, Revision 3, Sections 12.2 "Plant Sources," and 12.3, "Radiation Protection." Sections 12.2 and 12.3 of this SER describe the staff's evaluation of DCD Tier 2, Revision 3, 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," issued March 2007, 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, 1979

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 gaseous waste management system (GWMS), and the solid waste management system (SWMS). Section 11.1 of DCD Tier 2, Revision 3 describes the sources of radioactivity (source terms) processed by the radioactive waste management system.

DCD 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), by way of defects in the fuel cladding. The applicant described two types of source terms for the reactor primary coolant and steam. The first addresses 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 RWMS design and shielding analysis. DCD Tier 2, Revision 3, 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 0.1 curie (Ci) per second (3700 megabecquerels (MBq) per second (s) 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 because it is readily measurable and historically consistent with the nominal 30-minute off-gas system (OGS) designed and provided by current operating BWRs by the General Electric Company.

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 700 microcuries (μCi) per second (26 MBq/s) 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 other 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, noncoolant activation products, tritium, and argon. Coolant activation products include nitrogen-16 (N-16) and tritium (H-3). The concentrations of N-16 and tritium are based on ANSI/ANS 18.1-1999. The presence of N-16 results from the neutron activation of naturally occurring oxygen-16 (O-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 thermal 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 noncoolant activation products in the coolant. The concentration of noncoolant activation products is based on ANSI/ANS 18.1-1999. The applicant assumed the ratio of the concentration of noncoolant 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, “Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage,” to 10 CFR Part 20, 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 concentrations 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 0.02 Ci per second (740 MBq/s) of noble gases release after 30-minute decay. For radioiodines, the estimated release rate is 100 µCi per second (3.7 MBq/s). 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 3 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, “Radioactive Source Term for Normal Operation of Light Water Reactors.” 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 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 Sections 11.2, 11.3, and 12.2.2 of the DCD to calculate the quantity of radioactive materials released annually in liquid and gaseous effluents during normal plant operation, including AOOs, and thereby 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 as low as reasonably achievable (ALARA) design objectives of Appendix I to 10 CFR Part 50.

While reviewing Revision 1 of DCD Tier 2, the staff asked the applicant to provide additional information. The following paragraphs discuss the staff's evaluations of the applicant's responses to these requests for additional information (RAIs).

In RAI 11.1-1a, the staff requested that the applicant provide information on the parameters used to calculate concentrations of radioactive materials in primary and secondary coolant to ensure 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 Chapter 12. The staff found in DCD Tier 2, Section 12.2.2 and in the responses provided to RAIs in Chapter 12 that the applicant used ANSI/ANS 18.1-1999 to calculate concentrations of radioactive materials in the primary coolant and steam. RG 1.112 considers this an acceptable alternative method to that of NUREG-0016. Therefore, RAI 11.1-1a is resolved.

In RAI 11.1-1b, the staff requested that the applicant 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" (hereafter 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 Standard Review Plan (SRP) Section 11.1 as sources of liquid and gaseous waste. Therefore, RAI 11-1b is resolved.

In RAIs 11.1-2 and 11.1-3, the staff asked the applicant to provide the realistic source term for fission, activation, and corrosion products in reactor water and steam and to provide all calculational parameters used to determine the realistic source term. The applicant provided Tables 11.1-1 through 11.1-7b in DCD Tier 2, Revision 3, which list the normal operational source term. The staff performed an independent confirmatory calculation of the normal operational source term using the methodology provided in ANS/ANSI 18.1-1999 and found that the applicant's values are acceptable. Therefore, RAIs 11.1-2 and 11.1-3 are resolved.

In RAI 11.1-4, the staff requested that the applicant 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 confirmatory calculation, the staff considers RAI 11.1-4 to be resolved.

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 3, Section 11.1 are acceptable for evaluating the LWMS and GWMS described in DCD Tier 2, Revision 3, 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 3, Section 11.2 "Liquid Waste Management System," 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 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, 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,” issued March 1976, as it relates to performing a cost-benefit analysis for reducing 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,” issued November 2001, as it relates to the seismic design and quality group classification of components used in the LWMS and structures housing this system, as well as the provisions used to control leakages

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

11.2.2 Summary of Technical Information

DCD Tier 2, Revision 3, 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 nonsafety-related system and serves no safety functions except for the isolation of radioactive releases. 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 3, 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 3, Figure 11.2-1 provides an LWMS process diagram depicting all subsystems. Figure 11.2-2 of the DCD provides a LWMS process stream information directory and simplified flow diagram. Sections 9.2 and 10.4 of the DCD describe the origins and discharges of nonradioactive effluents. The LWMS does not normally process nonradioactive secondary system effluent. The LWMS 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 3, Figure 11.2-1 shows the tanks,

processing equipment, pumps, valves, ion exchangers, filters, degasifier, and other components. All LWMS tank overflows are routed to building sumps and drains, which are pumped to their respective drain tanks. 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 two types of major subsystems, permanently installed equipment, and mobile treatment systems connected to permanently installed equipment. Section 11.2 of the DCD Tier 2 does not provide descriptions of the design and specifications of each described mobile treatment subsystem. The LWMS is divided into several subsystems such 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 is inoperative. The LWMS normally operates on a batch basis. The system provides for sampling at important process points, as discussed in SER Section 11.5.2. Administrative controls and detection and alarm of abnormal conditions protect against accidental discharges into the environment.

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

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

(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 reactor water cleanup and shutdown cooling system, fuel auxiliary pools cooling system, condensate demineralizer, and equipment drains in the reactor building, turbine building, and radwaste building. 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 mobile treatment system consists of pre- and main filters, pretreatment and polishing resin ion exchangers, a chemical injection unit, and an intermediate storage tank. The subsystem's processing capacity is rated at about 330 liters per minute (88 gallons per minute).

The floor drain subsystem processes liquid wastes (low purity) from the reactor drywell and from floor drains in the reactor building, turbine building, and radwaste building. This subsystem can also receive liquid waste from the equipment drain, chemical drain, or detergent drain subsystems. The permanently installed 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 mobile treatment system consists of pre- and main filters, a reverse osmosis unit, pretreatment and polishing resin ion exchangers, and an intermediate storage tank. The subsystem's processing capacity is rated at about 250 liters per minute (66 gallons per minute).

The chemical drain subsystem processes liquid wastes from the reactor building, turbine building, and radwaste building. This subsystem can also receive liquid waste from the detergent drain subsystem. 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 associated mobile treatment system consists of a chemical neutralization unit.

The detergent drain subsystem processes liquid wastes from the hot-laundry and hot-shower facilities, and decontamination drains from the reactor building, turbine building, and radwaste building. 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 mobile treatment system 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).

When liquid wastes are processed, treated wastes return to the LWMS for eventual discharge to the environs. Liquid wastes that cannot be discharged return to their specific collection tanks for reprocessing or reuse in plant systems. Any liquid wastes that cannot be treated on site are placed in tanks or containers and shipped off site for processing and disposal. Process discharge is normally aligned to one of the subsystem sample tanks. Before discharge, liquid wastes are sampled for radiological analysis and compliance with local requirements for nonradioactive contaminants. DCD Tier 2, Revision 3, Sections 9.3.2 and 11.5.5 describe the features of the LWMS process sampling system. DCD 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. The release of processed liquid wastes from any sample tank to the environs is permitted only when the analysis of the tank's contents indicates that such a release meets the requirements of 10 CFR Part 20 and Appendix I to 10 CFR Part 50. During discharges, liquid wastes are mixed with and diluted by the discharge canal, with a flow rate of about 20,000 liters per minute (5,300 gallons per minute), as described in DCD Revision 3, Table 12.2-20a. The discharge flow rate from the LWMS is controlled to ensure that radionuclide concentration

levels in unrestricted areas comply with concentration limits in Appendix B to 10 CFR Part 20, Table 2, Column 2.

Based on DCD Tier 2, Revision 3, Table 11.2-4, the estimated combined normal generation rate of liquid wastes serviced by the four subsystems is about 83,000 liters per day (21,900 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 about 7 hours for the floor drain subsystem to about 0.2 hour 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. The radiation monitor provides a signal to terminate liquid waste releases before discharge concentrations exceed predetermined set points, based on effluent limits in Appendix B to 10 CFR Part 20, Table 2, Column 2. The radiation monitor used in controlling and monitoring releases of radioactive materials in liquid effluents to unrestricted areas conforms with GDC 60. DCD Tier 2, Revision 3, Tables 11.5-1, 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.

In DCD Tier 2, Revision 3, Section 11.2.6 the applicant identified two combined license (COL) information items.

In the first COL Information Item (No. 11.2.6.1), the COL applicant is responsible for identifying mobile/portable LWMS connections that are considered nonradioactive but that could later become radioactive through improper interfaces with radioactive systems. In identifying such connections, the applicant must use the guidance and information in IE Bulletin 80-10, "Contamination of Non-Radioactive System and Resulting Potential for Unmonitored, Uncontrolled Release to Environment." The applicant does not describe the specific design and detailed operational features of each mobile subsystem, as these items are left to the COL applicant to define specifications for each subsystem through qualified vendors. Collectively, these issues are identified as **COL Action Item 11.2.6-1.** This COL action item does not apply to wastes processed by offsite contractors on behalf of an ESBWR COL holder.

In the second COL Information Item (No. 11.2.6.2), the COL applicant is responsible for demonstrating compliance with 10 CFR 20.1406 as this section relates to the design and operational procedures of mobile treatment systems to minimize contamination, facilitate eventual decommissioning, and minimize the generation of radioactive waste. This is **COL Action Item 11.2.6-2.**

11.2.3 Staff Evaluation

The staff reviewed the LWMS in accordance with the guidance of SRP Section 11.2. Staff acceptance of the LWMS is based on the design meeting the requirements of 10 CFR 50.34a and GDCs 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, Section 11.2 that the LWMS complies with the guidance in RG 1.143, Revision 2, issued November 2001. 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 mobile waste processing systems installed in the plant, as described in DCD Tier 2, Chapter 14. Chapter 14 of the SER 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 in the radwaste building. The LWMS is designed to the seismic criteria of RG 1.143, Class RW-IIa. The associated subsystems and components, such as ion exchangers, filters, degasifier, pumps, applicable valves, and mobile 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 via the plant vent. The staff finds the above design aspects of the LWMS to be 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 condensate storage tank (CST), there are no LWMS tanks likely to contain radioactivity located in yard areas outside of buildings. The CST is the only tank that is expected to contain low levels of radioactivity. There are no other tank interfaces necessary with the LWMS. The LWMS has no interconnections with the potable and sanitary water systems, and it does not normally process nonradioactive 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 GDCs 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 and structures housing the systems and the provisions used to control leakage.

The LWMS is designed to handle most process and effluent streams and other anticipated events, using both permanently installed and mobile processing equipment. However, for events occurring at very 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 mobile treatment system bay. Connections to various portions of LWMS subsystems facilitate the use of mobile processing equipment. These allow the use of mobile equipment applied in series or parallel with installed equipment as an alternative to returning treated liquid wastes to the LWMS, or use the mobile 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 use of mobile 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 processed by mobile waste processing systems. DCD Tier 2, Revision 3, 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 for use as input parameters with the BWR-GALE code, 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 mobile liquid waste processing systems will rely on the use of ion exchange or filtration media that will meet or exceed the DFs listed in DCD 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, Section 12.2.2. Applying the guidelines of RG 1.143, the staff will review the proposed use of any mobile processing equipment for treating liquid radwaste on a plant-specific basis for particular COL applications. A COL applicant should discuss how mobile processing equipment intended for the processing of liquid radwaste will 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 Section II.A 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 part of its review of DCD Revision 3, Section 12.2.2 and is addressed in Section 12.2 of this SER.

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 the system, 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 important process points and protect against accidental discharges by the detection and alarm 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 via 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 all liquid mobile waste processing systems installed in the plant. The staff finds the design acceptable with respect to meeting the criteria of 10 CFR 50.34a, GDCs 60 and 61, and the guidance of RG. 1.143, provided that the overall QA program described in Chapter 17 of a particular COL application is acceptable. 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 mobile 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 3, 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 in the environment. Chapter 15 of this SER addresses this issue.

DCD Tier 2, Revision 3, Section 12.6 addresses compliance with 10 CFR 20.1406, as it relates to facility design and operational procedures for permanently installed systems 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 Inspection and Enforcement (IE) Bulletin 80-10 to avoid the cross-contamination of nonradioactive systems and unmonitored, uncontrolled radioactive releases to the environment.

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 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 SER addresses this as a **COL action item**.

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 dose 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 objectives for liquid effluents and stipulate a cost-benefit analysis in justifying installed processing and treatment systems as permanently installed equipment and mobile systems, using the guidance of RG 1.110.

In reviewing DCD Tier 2, Revision 1 the staff could not confirm that the ESBWR LWMS were consistent with some NRC regulatory requirements and guidance. The staff asked the applicant to provide additional information. The following paragraphs discuss the staff's evaluations of the applicant's responses to the staff's RAIs.

In RAI 11.2-4, the staff requested that the applicant revise Table 11.2-1 of DCD Tier 2 to reflect the guidance of RG 1.143, Revision 2, for atmospheric tanks. In its response, the applicant agreed to revise the table in accordance with RG 1.143. The staff reviewed the revised table attached to the applicant's response letter and included in Revision 3 of DCD Tier 2. The staff found that the applicant retained a footnote which adds 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 must justify deviations from the established review criteria, as stated in the applicable SRP section. Therefore, the staff requests that the applicant either provide documentation to demonstrate that the use of fiberglass reinforced tanks for retention of liquids containing radioactive waste is acceptable and that this will not pose a risk to the health and safety of the public or plant workers, or else remove the provision to use fiberglass reinforced plastic tanks. In a letter dated July 19, 2007, the applicant agreed to delete the footnote in Table 11.2-1 of the DCD Tier 2 about using fiberglass tanks. Therefore, this RAI becomes **Confirmatory Item 11.2-4**.

In RAI 11.2-5, the staff requested that the applicant revise Table 11.2-1 to reflect the guidance of RG 1.143, Revision 2, for tanks rated in the pressure range of 0–15 pounds 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 Revision 3 of DCD Tier 2. The staff found that the applicant retained a footnote which adds the use of fiberglass reinforced tanks constructed in accordance with the requirements of ASME BPVC Section X. Based on the same reasons discussed in the above evaluation for the RAI 11.2-4 response, the staff finds 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 allowing the use of fiberglass tanks to contain liquid radioactive waste. The footnote (No. 3) to Table 11.2-1 will be deleted in Revision 4 of the DCD, Tier 2. Therefore, this RAI becomes **Confirmatory Item 11.2-5 S01.**

In RAI 11.2-11, the staff requested additional details on Figure 11.2-1, "Liquid Waste Management System Process Diagram." For example, the diagram does 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 staff 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 DCD 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 11.2-2 in the text of Section 11.2. The staff reviewed the revised figures in Revision 3 of DCD Tier 2 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, GEH agreed to revise Figures 11.2-1 and 11.2-2 of the DCD Tier 2 to identify the release point(s). Therefore, this RAI becomes **Confirmatory Item 11.2-11.**

In RAI 11.2-13, the staff asked the applicant to describe how the classifications and design criteria apply to the liquid RWMS (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 RAIs 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 or mobile LWMS systems and components in the plant in accordance with its overall QA program. However, DCD Revision 3, Section 11.2.6 does not commit the COL applicant to conform with the QA guidance specified in RGs 1.21, 1.33, and 4.15. In RAI 11.2-13 S01, the staff requested the applicant to update the DCD to address this aspect. In a global response to RAIs 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, Chapter 17, Table 17.0-1. As a result, the applicant is revising DCD Section 11.2.4 to reference the QA requirements of 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. In a letter dated July 23, 2007, the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.2-13 S01.**

In RAI 11.2.3-1, 11.2.3-2, and 11.2.2-4, the staff requested the applicant to clarify the basis of the DFs listed in DCD Tier 2, Revision 1, Table 11.2-3 and their applications in deriving the estimated radioactive liquid effluent source term identified in DCD Tier 2, Revision 3, Section 12.2.2.3. DCD Tier 2, Revision 3, Table 11.2-3 presents 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 finds 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 does not commit the COL applicant to the description and 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 requested 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 are being 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, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.2.3-1 S01.**

In RAI 11.2-16, the staff requested 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 mobile liquid radioactive waste processing system is a conceptual design and include a COL action 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 use of mobile waste processing systems is that the design of the LWMS is conceptual and, therefore, not in the scope of design certification, given the requirements of 10 CFR 52.47(a). 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 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 given the design features and specifications described in Tier I. In the context of COL action items, a COL applicant referencing the ESBWR certified design is responsible for:

- the selection of appropriate mobile processing equipment considering the most effective treatment technologies that will meet or exceed the decontamination factors listed in DCD Tier 2, Table 11.2-3, based on expected chemical and radiological properties of process and effluent liquid wastes to be treated,

- providing details on system interface requirements between mobile LWMS processing equipment and permanently installed plant systems and components. The interface should address the integration of mobile equipment with sources liquid wastes and process flows, describe key components and discharge paths, ensure that mobile systems can accommodate expected process and effluent flow rates and capacities, identify process and effluent sampling points, identify system interface features designed to prevent bypasses to non-radioactive systems, and describe instrumentation used to control and monitor system performance and prevent unmonitored and uncontrolled releases of radioactivity in the environment,

- ensuring that the design of the initial mobile waste processing systems, including subsystems and components, and operational features of each type of installed mobile waste processing system, is consistent with the descriptions in DCD Tier 2, Section 11.2.2, Tables 11.2-2a through 11.2-2c, Tables 11.2-3 and 11.2-4, and Figure 11.2-1;

- ensuring that resulting radiological liquid effluent releases and doses to members of the public are consistent with the radiological assessment presented in DCD Tier 2, Section 12.2.2 and comply with Section II.A of Appendix I to 10 CFR Part 50, as it relates to the numerical guidelines for dose design objectives to meet the ALARA criterion for individual doses;

- complying with 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 for liquid effluents treated by the LWMS consisting of permanently installed and mobile waste processing equipment;

- describing the quality assurance (QA) program for the specifications, procurement, installation, and testing of mobile systems in accordance with DCD Tier 2, Chapters 14 and 17 and its overall QA program; and

- complying with the requirements of SRP Section 11.2; 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; RG 1.33, “Quality Assurance Program Requirements (Operation),” issued February 1978; RG 1.143; RG 4.15, “Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment,” issued July 2007; RG 8.8, “Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable,” issued June 1978; and RG 8.10, “Operating Philosophy for Maintaining Occupational Radiation Exposures as Low as Is Reasonably Achievable,” issued September 1975.

Pending the applicant’s response and staff evaluation of the response, this RAI is identified as **Open Item 11.2-16**.

In Revision 3 of DCD Tier 2, Section 11.2.6 the applicant identified **COL Action Items 11.2.6-1 and 11.2.6-2.** The staff finds the inclusion of these COL action items acceptable, pending the resolution of all open RAIs and confirmatory items.

11.2.4 Conclusions

Due to the open RAI and confirmatory items described above, the staff was unable to finalize its conclusions regarding acceptability that the LWMS (as a permanently installed system and in combination with mobile systems) 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 GDCs 60 and 61; and the requirements of 10 CFR 50.34a.

11.3 Gaseous Waste Management System

11.3.1 Regulatory Criteria

The staff reviewed DCD Tier 2, Revision 3, 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 RWMS 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 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," issued June 2001, 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

- SRP Section 11.3, Branch Technical Position (BTP) 11-5, "Postulated Radioactive Releases Due to a Waste Gas System Leak or Failure"

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 off-gas system (OGS). DCD Tier 2, Revision 3, 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, and associated valves, pumps, and instrumentation. The OGS is located in the turbine building. Section 3.2 of DCD Tier 2, Revision 3 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 nonseismic, but are designed to meet the requirements of RG 1.143.

The OGS provides a means of treating noncondensible gases removed from the condenser by the evacuation system. The sources of gases 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 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 radioactivity levels are 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 back 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 meet the requirements of RG 1.143. The second method for treating removed gases is by providing holdup of gases as 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 off-gases 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 design allows the OGS to be bypassed during periods of startup or if the process gas activity is acceptable.

The major inputs to the GWMS are off-gases from the main condenser evacuation system, which is described in DCD Tier 2, Revision 3, 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 eight 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) a cooler, which cools effluent gases out of the recombiner

(4) a cooler/condenser, which removes moisture from cooled gases to protect the charcoal beds

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

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

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

(8) an off-gas post-treatment radiation monitor, which measures levels of radioactivity in the treated gaseous process stream before it is vented to the plant stack

DCD Tier 2, Revision 3, 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 charcoal vault, located in the turbine building, is temperature 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 pounds (lbs)) of charcoal, and each adsorber tank contains about 27,750 kg (61,180 lbs) of charcoal, as listed in DCD Tier 2, Revision 3, Table 12.2.15. 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 to and out of the charcoal vault.

The GWMS 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 via 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 via condensation by the system's cooler and condenser components or retained in charcoal beds. DCD Tier 2, Revision 3, Section 11.3.2 and Tables 11.3-1 through 11.3-3 describe process functions, equipment, and operational parameters of the GWMS and OGS. The description of the design includes an analysis identifying 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 plant stack, via the turbine building compartment exhaust, where gaseous effluents are monitored by the process radiation monitoring system (PRMS), as described in DCD Tier 2, Revision 3, Section 11.5.3. DCD Tier 2, Revision 3, 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 OGS post-treatment and plant stack radiation monitors.

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 via the turbine building compartment exhaust subsystem and plant stack. During startup and low-load operation, the TGSS uses clean steam from the auxiliary boiler system, with main steam used as a backup supply, as described in DCD Tier 2, Revision 3, Section 10.4.3. At plant high-power levels, the TGSS may be supplied with steam from high-pressure turbine exhaust or from the auxiliary boiler system, as described in DCD Tier 2, Revision 3, 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 3, 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 justification for the assumptions used in that analysis. DCD Tier 2, Revision 3, 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 reveal that the associated doses are in compliance with the SRP acceptance criteria of 5 millisieverts (mSv) (500 millirems (mrem)).

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

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

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

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

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

Although 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 via the plant vent. 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 building and radwaste building, are conducted through the plant stack. DCD Tier 2, Revision 3, 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 3, Section 11.5.3. DCD Tier 2, Revision 3, 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.

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 GDCs 3, 60, and 61. Under 10 CFR 50.34a requirements, the applicant must 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. GDC 3 requires that the design protect gaseous waste handling and treatment systems from the effects of an explosive mixture of hydrogen and oxygen. The relevant requirements of GDCs 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 GWMS and structures housing the systems and the provisions used to control leakage.

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 via 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 via 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 capability and integrity of the subsystems. The COL holder will subject the GWMS and OGS to preoperational tests. Chapter 14 of the SER 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 retention of radioactive gaseous effluents.

The GWMS and OGS generate a liquid radioactive waste phase from the associated coolers/condensers, and this liquid phase potentially can cross-contaminate nonradioactive systems and result in unmonitored and uncontrolled radioactive releases. In DCD Tier 2, Revision 3, Sections 11.3.1 and 11.3.2, the applicant states that the design of the OGS follows the guidance of IE Bulletin 80-10. 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 staff finds such design features acceptable and in compliance with the requirements of 10 CFR 20.1406 and the guidelines of IE Bulletin 80-10.

In DCD Tier 2, Revision 3, 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 ETSB 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 0.5 rem (5 mSv). The applicant analyzed the accident using a short-term (0–2 hours) X/Q of $1x10^{-3}$ 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 450,000 µCi per second (16,700 MBq/s). 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 0.31 rem (3.1 mSv) over the assumed duration of the event. The dose result is in compliance with the guideline of BTP ETSB 11-5. Based on the above, the staff finds the results of this analysis acceptable.

In DCD Tier 2, Revision 3, 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 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 the SER, 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 via the plant stack.

The PRMS provides monitoring and control of gaseous and particulate releases, as discussed in DCD Tier 2, Revision 3, Section 11.5.3. DCD Revision 3, 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. The staff finds these design features acceptable. Based on the above, the staff finds that the GWMS/OGS complies with GDCs 60 and 61, as they relate to monitoring and controlling radioactivity releases from ventilation systems associated with fuel storage and handling areas. The applicant's evaluation that the designs of the GWMS and OGS are acceptable in meeting 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 is conducted as part of the review of DCD Tier 2, Revision 3, Section 12.2.2. SER Section 12.2 addresses the staff's evaluation of radiological impacts associated with releases of radioactive materials from building ventilation systems and the GWMS/OGS via the plant 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 applicant referencing the ESBWR certified design should either identify the operational set points for its GWMS and plant 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 standard radiological effluent controls (SREC) 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:

- plant stack RMS
- reactor building HVAC exhaust RMS and its subsystems

- containment purge exhaust RMS
- turbine building combined ventilation exhaust RMS and its subsystems
- radwaste building ventilation exhaust RMS
- fuel building combined ventilation exhaust and its RMS subsystems

Section 11.5 of this SER addresses these aspects as a **COL action 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 dose 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 objectives for gaseous effluents and require a cost-benefit analysis in justifying installed processing and treatment systems as permanently installed equipment.

In reviewing DCD Tier 2, Revision 1 the staff found that some information was not sufficient to allow it to determine the acceptability of the GWMS. The staff asked the applicant to provide additional information. The following paragraphs discuss the staff's evaluation of the applicant's response to the staff's RAI.

In RAI 11.3-2, the staff requested that the applicant 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 by RG 1.143, Revision 2, Section 7 and Table 1. DCD Tier 2, Revision 3, Section 11.3.7.1 states that the OGS meets all criteria of RG 1.143. The staff reviewed the response to RAI 11.3-2 and DCD Tier 2, Revision 3, relating to the OGS being 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.

In RAI 11.3-3, the staff requested 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 General Electric Hitachi Nuclear America, LLC (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 OGS during 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 3, Sections 11.3.2.2, 11.3.5, and 11.3.6 describe the system. The staff's evaluation of the related monitoring equipment reveals that the OGS is designed to withstand the effects of a hydrogen explosion. The staff finds this methodology to be adequate, and Section 3.2.2 of DCD Tier 2, Revision 3 does reference the NEDE report. In addition, the applicant identified a COL item in Section 11.3.8 of DCD Tier 2, Revision 2. The COL applicant is to define the OGS design parameters—major equipment items as well as other system data—as shown in DCD Tier 2, Revision 3, Table 11.3-2. This COL action item addressed a portion of the RAI and was identified as COL Information Item 11.3.8-1. Based on

the methodology and COL action item, the staff considered RAI 11.3-3 to be resolved. However, in DCD Tier 2, Revision 3, the applicant removed COL Information Item 11.3.8-1. The removal of this COL item is not acceptable. In a letter dated July 23, 2007, the applicant explained the reasons for the removal of this COL item.

> The COL item was removed because the offgas system 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 3 is the final OGS major equipment design parameters. If a COL Applicant chooses to make changes to the GEH permanent plant offgas system 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.

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 mobile GWMS and OGS systems and components in the plant in accordance with its overall QA program. However, DCD Tier 2, Revision 3, Section 11.3.8 does not commit the COL applicant to conform 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, Chapter 17, Table 17.0-1. As a result, the applicant is revising 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, Revision 4. This is **Confirmatory Item 11.5-44.**

As part of No. RAI 12.2-9, the staff requested 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 Table 11.3-2 of DCD Tier 2, Revision 3, Section 11.3.2 or in Table 12.2-15 of DCD Tier 2, Revision 3, Section 12.2.2. The staff finds the inclusion of this information important for evaluating the performance of the charcoal delay beds and assessing releases of noble gases into the environment. In DCD Tier 2, Revision 3 the applicant provided information on the amounts of charcoal contained in each type of tank, as described in DCD Tier 2, Revision 3, Table 12.2-15. The staff finds the inclusion of this information adequate.

Section 9.4 of DCD Tier 2, Revision 3 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 the plant stack. As part of No. RAI 12.2-9, the staff asked the applicant to confirm the use of charcoal and high-efficiency particulate air (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 and Tables 9.4-3 through 9.4-11. 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 3 the applicant updated the listing of systems using charcoal and HEPA filters, as described in DCD Tier 2, Revision 3, Section 9.4 and Tables 9.4-3 through 9.4-11. The staff finds the inclusion of this information satisfactory.

11.3.4 Conclusions

Staff will verify the satisfactory inclusion of confirmatory items identified in this section in the applicant's DCD. Based on the information discussed above, the staff concludes that the GWMS/OGS (as a permanently installed system) 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; GDCs 3, 60, and 61; and 10 CFR 50.34a. This conclusion is based on the 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 Section 12.2.2 of DCD Tier 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 Section 12.2.2 of DCD Tier 2.

- The ESBWR design demonstrates compliance with 10 CFR 50.34a requirement 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, Sections 9.4 and 12.2, satisfies the guidance of RG 1.140.

- The design features of the OGS satisfies the guidance of 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 capability of the OGS charcoal delay bed design features ensures conformance with BTP 11-5 dose guidelines for the analysis of a postulated failure of a component.

- The ESBWR design meets the requirements of GDCs 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 and/or signal to divert gaseous effluent releases before discharge concentrations exceed a predetermined set point. A COL applicant 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.

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

11.4 Solid Waste Management System

11.4.1 Regulatory Criteria

The staff reviewed DCD Tier 2, Section 11.4 "Solid Waste Management," 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 (these criteria 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 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 for equipment necessary to control releases of radioactive effluents into the environment resulting from SWMS operation have been met

- 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

- 49 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

- 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

- The provisions of Generic Letter (GL) 89-01, “Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications” (Supplement No. 1, dated Nov. 14, 1990), and the guidance of NUREG-1302, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for BWRs,” April 1991, for BWR plants, as they relate to the development of a plant-specific process control program (PCP)

11.4.2 Summary of Technical Information

DCD Tier 2, Revision 3, 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 shutdown of the plant. No interface with the Class IE electrical system exists. The SWMS is designed to meet the requirements of RG 1.143, with regard to its seismic qualifications. Sections 3.2 and 3.8 of DCD Tier 2, Revision 3 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 system processes wastes from the LWMS, reactor water cleanup/shutdown cooling system, fuel and auxiliary pools cooling system, and condensate purification system. DCD Tier 2, Revision 3, Figure 11.4-1 shows the components of the SWMS, which are described in DCD Tier 2, Revision 3, Table 11.4-1. The SWMS system 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 system. Releases of liquid wastes are conducted through the LWMS. The SWMS is comprised of the following four subsystems:

(1) wet solid waste collection subsystems
(2) mobile wet solid waste processing subsystem
(3) dry solid waste accumulation and conditioning subsystem
(4) container storage subsystem

The design and operation of the SWMS is characterized by the use of mobile processing subsystems to process wet and solid wastes, with no details provided on the specific design features and operating characteristics in DCD Tier 2, Revision 3. The wastes originate from the wet solid waste collection system, including the high- and low-activity resin holdup tanks, low-activity sludge phase separator tanks, condensate resin tanks, and floor drain concentrate waste tank. Each mobile waste processing subsystem has provisions to return waste to permanently installed plant equipment, including to the high-activity resin holdup tank, the low-activity phase separator, and the floor drain collection tank. The major components of the mobile waste processing subsystems include dewatering fill heads, feed tanks, feed and return pumps, thermal dryer, waste sorting tables, and waste conditioning and packaging modules.

The permanently installed equipment includes six holdup tanks, recirculation and decant pumps, valves, piping, vents, control panels, and instrumentation. The high-activity tank and the low-activity tank have a nominal capacity of about 70,000 liters (18,500 gallons) each, and the two low-activity low-phase separator tanks have a nominal capacity of about 55,000 liters (14,500 gallons) each. This system is equipped with two decant pumps, each with a nominal flow rate of about 330 liters per minute (88 gallons per minute); two resin transfer pumps, each with a nominal flow rate of about 380 liters per minute (100 gallons per minute); and three circulation pumps, each with nominal flow rates of about 3330 liters per minute (880 gallons per minute). The condensate resin holdup tank has a nominal capacity of about 70,000 liters (18,500 gallons). The condensate resin system is equipped with a circulation pump with a nominal flow rate of about 3330 liters per minute (880 gallons per minute), and a resin transfer pump with a nominal flow rate of about 379 liters per minute (100 gallons per minute). The concentrated waste tank has a nominal capacity of about 60,000 liters (15,800 gallons). This system is equipped with two pumps, each with a nominal flow rate of about 1330 liters per minute (350 gallons per minute).

The container storage subsystem is 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 3, Figure 11.4-1 provides a conceptual description of the process flow used in handling dry solid and wet wastes.

Spent activated charcoals from the GWMS/OGS are not expected to be routinely disposed of as radioactive waste. Rather, the spent activated charcoal will be regenerated in place by the OGS. The replacement of the charcoals in affected beds will be addressed by the COL holder 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 3, 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 135 m^3 (4,777 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 80 m^3 (2800 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 stored as packaged waste. Waste packaging includes such features as 55-gallon (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, Section 11.4, and are left to the COL applicant to define specifications and procurement through qualified vendors. The services may include truck-mounted waste treatment systems and the use of offsite waste processing services, such as for waste compaction, treatment, and decontamination.

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 via the plant stack. DCD Revision 3, Section 9.4.3, describes the design bases, operation, and monitoring of the radwaste building ventilation system. The process radiation monitoring system provides for the monitoring and control of gaseous and particulate releases from the plant stack, as described in DCD Tier 2, Revision 3, Section 11.5.3. DCD Tier 2, Revision 3, 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. All liquid radioactive effluents are processed and discharged via the LWMS. DCD Tier 2, Revision 3, Sections 11.2 and 11.3 describe the plant systems used to process and treat liquid and gaseous effluents, respectively. DCD Tier 2, Revision 3, Section 12.2.2 describes the methods used to assess doses to members of the public associated with effluent releases from the SWMS.

In DCD Tier 2, Revision 3, Section 11.4.6 the applicant identified 12 COL action items. The COL action items address requirements associated with the proper selection and installation of mobile waste processing systems, operational interface with plant systems to avoid the contamination of nonradioactive systems and unmonitored and uncontrolled releases, and compliance 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. The balance of the COL action items address requirements associated with operational programs and compliance with regulatory criteria addressing the design and operational features of each type of installed mobile waste processing system, as described in DCD Tier 2, Revision 3, Section 11.4.2, Table 11.4-1 and Figure 11.4-1. The selection of mobile waste processing subsystems is expected to consider most effective treatment technologies, based on chemical and radiological properties of wastes to be processed over the life of the plant. The applicant does not describe the specific design and detailed operational features of each mobile subsystem, as these items are left to the COL applicant to define specifications for each subsystem through qualified vendors. Collectively, these issues are identified as **COL Action Item 11.4.6-1.** This COL action item does not apply to wastes processed by offsite contractors on behalf of an ESBWR COL holder.

DCD Tier 2, Revision 3, Section 11.4.6 “COL Information,” specifies 12 COL holder items, listed as Items 11.4.6.1 through 11.4.6.12. The following paragraphs summarize these COL action items.

The COL applicant is responsible for evaluating initial and future mobile systems, using the guidance and information in IE Bulletin 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 due to leakage, valving errors, or other operating conditions in radioactive systems). This is **COL Action Item 11.4.6-2.**

Under COL Items 11.4.6-3 through 11.4.6-9 and 11.4.6-11, the applicant identified requirements associated with (a) the operational interface with plant systems to avoid the contamination of nonradioactive systems and unmonitored and uncontrolled releases; (b) compliance 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 waste; and (3) requirements associated with operational programs and compliance with regulatory criteria addressing the design and operational features of each type of installed mobile waste processing systems. These items are identified as **COL Action Items 11.4.6-3 through 11.4.6-9 and 11.4.6-11.**

The COL applicant is responsible for ensuring that mobile systems comply with the guidance of RG 1.143, Revision 2. This is **COL Action Item 11.4.6-10.**

As mobile waste process systems are selected for use, during the design stage and before installation of final hookups and connection with the permanent plant SWMS systems, the COL applicant will evaluate the guidelines of IE Bulletin 80-10 to ensure that systems considered as nonradioactive but which could become radioactive through improper interfaces with a radioactive system remain nonradioactive. This is **COL Action Item 11.4-12.**

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 and GDCs 60, 61, and 63. 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.

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 mobile processing equipment integrated with the operation of permanently installed equipment. Section 11.4 of the DCD Tier 2 does not provide descriptions of the design nor performance specifications of each subsystem. Mobile waste processing systems are modular skid-mounted units that are designed to be easily connected to permanently installed equipment. The mobile systems are selected 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 types of mobile waste units initially described in DCD Tier 2, Section 11.4.2 are expected to change as new processing technologies are developed and proven effective over the operational life of the plant. The following paragraphs summarize the conceptual operation of the proposed mobile waste processing systems:

- For liquid and wet solid wastes, mobile processing systems 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 mobile waste processing units. The mobile system, in conjunction with 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, COL holder may erect temporary radiation shielding around mobile waste processing units to minimize exposures and doses to radiation workers.

- For dry solid wastes, the mobile processing system 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 Department of Transportation (DOT) shipping and disposal facility requirements or specifications of an offsite waste processor. The waste will be separated into specific categories, such as noncontaminated wastes, contaminated compressible wastes, and contaminated noncompressible wastes. Contaminated compressible wastes include such items as discarded anticontamination clothing, plastic, glass, paper, and HEPA filters. Contaminated noncompressible wastes include such items as discarded tools, wood, components, and debris. Depending on radioactivity and radiation levels, the applicant may erect temporary radiation shielding around specific containers to minimize exposures and doses to radiation workers.

Given that DCD Tier 2, Revision 3, Section 11.4 does not provide specific design features, piping and instrumentation diagrams, or operating characteristics, the COL applicant will be responsible for describing the initial type of mobile waste systems that will support the startup and initial operation of the plant. Once all mobile waste processing systems are installed, the applicant will subject them to preoperational and QA tests. The applicant has made provisions

for periodic inspections of system components to confirm the performance of the mobile unit and integrity of operational functions. The COL applicant and holder will be responsible for ensuring that the initial and future mobile waste processing systems comply with GDCs 60, 61, and 63; 10 CFR 20.1406; 10 CFR 50.34a; Appendix I to 10 CFR Part 50; design guidelines of SRP Section 11.4; and RGs 1.143, 8.8, and 8.10. The COL applicant and holder will be responsible for ensuring that the initial and future installations of mobile waste processing systems comply with the guidance of IE Bulletin 80-10 for the purpose of avoiding the cross-contamination of nonradioactive systems and unmonitored and uncontrolled radioactive releases into the environment. The staff finds the proposed conceptual approach of using mobile waste processing systems and their operational integration with permanently installed plant equipment acceptable.

DCD Tier 2, Revision 3, Sections 11.4.2.3 and 11.4.6 state that waste shipment and disposal containers will be selected from designs 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 49 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 applicant, referencing the ESBWR certified design, will develop a PCP, in compliance with 10 CFR Part 61, which identifies the operating procedures (i.e., boundary conditions for a set of process parameters, such as settling time, drain time, drying time, etc.) for processing wet solid wastes and parallel sets of conditions in processing and preparing 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 mobile system PCP should include a discussion of conformance to RG 1.143, and it should address the issues raised in GL 80-009, “Low Level Radioactive Waste Disposal,” dated January 29, 1980; GL 81-39, “NRC Volume Reduction Policy,” dated November 30, 1981; and GL 89-01, and the guidelines of SRP Section 11.4, including BTP 11-3 and Appendix 11.4-A. Also, it should include a discussion of equipment containing wet and liquid wastes located in the nonseismic-rated radwaste building. In DCD Tier 2, Revision 3, Section 11.4.6, the applicant identifies COL action items to meet the above requirements and guidance concerning the processing of wet and dry solid wastes. The staff finds the proposed approach and integration of operational requirements of the SWMS (described as permanently installed equipment used in conjunction with mobile processing equipment) in the PCP acceptable. The staff finds the COL action 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 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 should comply 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 3, Sections 3.2 and 3.8 provide discussions of 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. Also, the COL applicant is responsible for testing all mobile waste processing systems installed in the plant. Chapter 14 of the SER addresses the adequacy of the preoperational testing program for the SWMS.

Based on the applicant's projected waste generation rates, the staff finds that the ESBWR design has sufficient onsite storage capacity in the short term. The design of the radwaste building includes an onsite storage capacity of up to 6 months. The need for storage space capacity beyond 6 months is left to the determination of the COL applicant or holder. The design conforms with the guidelines of BTP 11-3 and Appendix 11.4-A to SRP Section 11.4. In GL 81-38, "Storage of Low-Level Radioactive Wastes 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 on site. The staff recognizes that the need for additional onsite storage capacity for low-level radioactive wastes is a plant-specific consideration, which depends, in part, on whether the State or a regional low-level waste compact has provided a facility for long-term storage and disposal. The availability of offsite low-level waste 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 low-level radioactive waste. The staff will review and evaluate such a proposed additional plant-specific facility against the guidelines in GL 81-38, 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 3, Section 11.4.6 to identify the need for low-level radioactive waste storage as part of an overall site management plan under the COL action item. The staff finds the proposed approach and revision to DCD Tier 2, Revision 3, Section 11.4.6 acceptable.

Under Appendix I to 10 CFR Part 50 dose objectives, 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 processing system 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 items noted in SER Section 11.2 for the LWMS and SER Section 11.3 for the GWMS.

In reviewing DCD Tier 2, Revision 1 the staff found that some information was not sufficient for it to determine the acceptability of the SWMS. The applicant responded to the staff's RAI, and the following paragraphs discuss the staff's evaluations of these responses.

In RAI 11.4-13, the staff requested additional information on how large system components will be handled and disposed of as radioactive wastes. In response, the applicant stated that large and high-specific-activity core internals or highly contaminated primary system components will be handled on a specialized basis using offsite waste processors, as needed. The applicant proposed a similar approach for the disposal of spent activated charcoals from the GWMS/OGS, if required. The preferred approach is described as one in which spent activated charcoal will be regenerated in place by 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 low-level compacts. In either case, the staff finds such considerations plausible and acceptable. Therefore, RAI 11.4-13 is closed.

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 off site to authorized processing facilities. In some instances, the plant may use other types of containers, such as high-integrity container (HICs), based on the radiological and chemical properties of specific mixed wastes. Regulations of the NRC and 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 NRC regulations. As with RAI 11.4-13, this matter is closed.

In RAI 11.4-15, the staff requested the addition of inspection, test, analysis, and acceptance criteria (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 nonsafety 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 Tier 1 of the DCD. Tier 1 of the DCD currently contains some design description without an ITAAC table and, therefore, already contains more information than is required. Consequently, Tier 1 of the DCD requires no additional information for the SWMS. The staff reviewed the above response to RAI 11.4-15 and finds the response not acceptable. The safety significance of the SWMS is at the same level as the LWMS and GWMS. The level of detail for the SWMS in ITAACs should be similar to the LWMS and GWMS, which include an ITAAC table to describe "design commitment," "inspection, tests, and analyses," and "acceptance criteria," and a process diagram. In response to a supplemental RAI, the applicant proposed, in a letter dated August 31, 2007, a response, which is being evaluated by the staff. Therefore, RAI 11.4-15 is not resolved and becomes **Open Item 11.4-15** until the staff completes its evaluation.

A review of the system components listed in DCD Revision 3, Table 11.4-1 and Figure 11.4-1, indicates that Figure 11.4-1 does not show the "HIC Return Pumps" and "Sorting Table." The staff asked the applicant, under RAI 11.4-6a, to update the table and figure to indicate where in the SWMS these components are located. In response to RAI 11.4-6a, the applicant proposed, in a letter dated August 31, 2007, to add in DCD Tier 2, Section 11.4 two new figures (Figures 11.4-2 and 11.4-3) describing the sorting table and HIC return pumping station, respectively. The staff finds the response acceptable as the applicant committed to placing this new information in DCD Tier 2, Revision 5. Therefore, this RAI becomes **Confirmatory Item 11.4-6a**.

A review of the estimated radwaste inventories listed in DCD Revision 3, Table 11.4-2, indicates that the amount of waste listed for the "Wet Solid Waste Total" is inconsistent with each of the listed waste streams comprising this total. The staff asked the applicant, under RAI 11.4-6b, to update the value of the total waste volume estimate. In response to RAI 11.4-6b, the applicant proposed, in a letter dated August 31, 2007, to revise the total amount of wet solid wastes listed in DCD Tier 2, Section 11.4, Table 11.4-2 to correctly reflect the amounts listed by each waste stream. The staff finds the response acceptable as the applicant committed to placing this information in DCD Tier 2, Revision 5. Therefore, this RAI becomes **Confirmatory Item 11.4-6b**.

A review of DCD Revision 3, Table 11.4-2, indicates that the last footnote refers to the use of evaporation as a means of achieving waste volume reduction for concentrated wet wastes. However, DCD Revision 3, Section 11.4.2, does not discuss the use of evaporators. The staff asked the applicant, under RAI 11.4-6c, to revise the footnote to either eliminate "evaporation" as a waste reduction method, or else add the use of this type of waste processing technology to DCD Section 11.4.2 and update the associated DCD tables and Figure 11.4-1. In response to RAI 11.4-6c, the applicant proposed, in a letter dated August 31, 2007, to revise the footnote in DCD Tier 2, Section 11.4, Table 11.4-2 by eliminating "evaporation" as a treatment method. The staff finds the response acceptable as the applicant committed to placing this information in DCD Tier 2, Revision 5. Therefore, this RAI becomes **Confirmatory Item 11.4-6c.**

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 mobile SWMS and its components in the plant in accordance with its overall QA program. However, DCD Tier 2, Revision 3, Section 11.4.6 does not commit the COL applicant to conform 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, Chapter 17, Table 17.0-1. As a result, the applicant is revising 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. Therefore, this RAI becomes **Confirmatory Item 11.5-44.**

In RAI 11.4-18, the staff requested 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 include a COL action 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's evaluation of the SWMS and use of mobile waste processing systems is that the design of the SWMS is conceptual and, therefore, not in the scope of design certification, 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 given the design features and specifications described in Tier I. In the

context of COL action items, a COL applicant referencing the ESBWR certified design is responsible for:

- ensuring that the design of the mobile SWMS and its components and operational features of each type of mobile waste processing subsystem initially installed by the COL applicant are consistent with the descriptions and characteristics given in DCD Revision 3, Section 11.4.2, Table 11.4-1 and Figure 11.4-1;

- providing details on system interface requirements between mobile waste processing equipment and permanently installed plant systems and components. The interface should address the integration of mobile equipment with sources wastes and process flows, describe key components, ensure that mobile systems can accommodate expected process flow rates and capacities, identify process and effluent sampling points, identify system interface features designed to prevent bypasses to non-radioactive systems, and describe instrumentation used to control and monitor system performance and prevent unmonitored and uncontrolled releases of radioactivity in the environment;

- compliance 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 arising out of the operation of the SWMS will not exceed dose criteria, as demonstrated in Section 12.2.2 of DCD Tier 2, as integrated with the operations of the LWMS and GWMS;

- the preparation of a plant-specific cost-benefit analysis in accordance with the guidance of 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 population doses arising from the operation of mobile waste processing systems to treat solid and wet wastes, as integrated with the operations of the LWMS and GWMS;

- describing the QA program for the specifications, procurement, installation, and testing of mobile systems in accordance with DCD Tier 2, Chapters 14 and 17 and its overall QA program; and

- compliance with the requirements of SRP Section 11.4, including the development of a PCP; the requirements of SRP Section 11.4, BTP 11-3 and Appendix 11.4-A, in establishing temporary radioactive waste storage; and the guidance of RGs 1.21, 1.33, 1.143, 4.15, 8.8, and 8.10, in implementing all related operational programs. The PCP should describe, given the proposed waste processing technologies and methods, a set of parameters that are used to process wastes. The PCP should identify surveillance requirements consistent with the plant's technical specifications, administrative procedures, operational procedures, QA and quality control program, radiological controls and monitoring program, information to be contained in annual radiological effluent release reports, reporting requirements to the NRC, instructions on using the NRC's uniform radioactive shipping waste manifest, and process for initiating and documenting changes to the PCP and its supporting procedures.

Pending the applicant's response and staff evaluation of the response, this RAI is identified as **Open Item 11.4-18**.

In Revision 3 of DCD Tier 2, Section 11.4.6 the applicant identified 12 COL action items, **COL Action Items 11.4.6-1 through 11.4.6-12.** The staff finds the inclusion of these COL action items acceptable, pending the resolution of all open RAI and confirmatory items.

The regulatory criteria requirements and guidance, as they relate to sufficient details to demonstrate that the SWMS equipment (as permanently installed equipment and mobile systems in conjunction with the operation of the LWMS and GWMS) will support the design objectives, are satisfied once the applicant adequately responds to all open RAI and confirmatory items, and COL actions items for a COL applicant referencing the ESBWR certified design.

11.4.4 Conclusions

Due to the open RAIs and confirmatory items, the staff was unable to finalize its conclusions regarding acceptability that the SWMS (as a permanently installed system and in combination with mobile 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, GDCs 60, 61, and 63, and 10 CFR 50.34a.

11.5 Process Radiation Monitoring System

11.5.1 Regulatory Criteria

The staff reviewed DCD Tier 2, Section 11.5 "Process Radiation Monitoring System" 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 liquid and gaseous effluent concentrations in unrestricted areas. These criteria apply to all effluent releases resulting from operation 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

- 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 the monitoring of 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 10 CFR 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 10 CFR 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 GDCs 63 and 64

- 10 CFR 50.34(f)(2)(viii), as it relates to providing the capabilities to obtain and analyze samples from the reactor coolant system and containment without exceeding occupational radiation exposure dose limits

- 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

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

- The design of systems should meet the provisions of the applicable regulatory positions given in RGs 1.21; 1.33; and 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.

- 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 of ANSI/Health Physics Society (HPS) ANSI/HPS N13.1-1999.

- The design of continuous RMS should follow the guidance of ANSI N42.18-2004 (as reaffirmation of N42.18-1980).

- 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 development of the plant’s SRECs, ODCM, and radiological environmental monitoring program (REMP), should be addressed in the description of the operational program, and should meet the provisions of GL 89-01 (Supplement No. 1), Radiological Assessment Branch Technical Position (Revision 1, November 1979) included as

Appendix A in NUREG 1302, the guidance of NUREG-1302 for BWR plants, and the guidance of NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” October 1978.

11.5.2 Summary of Technical Information

The primary purpose of the process radiation monitoring system (PRMS) is to provide information characterizing the types and amounts of radioactivity contained in process streams and liquid and gaseous effluents. Another objective is 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
- radiation instrumentation required for monitoring and 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 system 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 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 applicant will subject the PRMS to preoperational tests. Also, the COL applicant is responsible for testing all skid-mounted RMS installed in the plant. There are provisions for periodic inspection of major components to ensure capability and integrity of all PRMS subsystems.

DCD Tier 2, Revision 3, Sections 11.5.1 and 11.5.2, Table 11.5-3, and Figure 11.5-1 list the design bases and criteria and the locations of the PRMS in plant buildings. DCD Tier 2, Revision 3, 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 radionuclide on which initial instrumentation responses are based, expected activity levels, and types of trip and alarm functions. DCD Tier 2, Revision 3, Tables 11.5-5 through 11.5-8 describe provisions for the sampling and analysis of process and effluent streams. DCD Revision 3, Figure 11.5-2 presents the PRMS system’s interface with the plant’s instrumentation and control system, as described in DCD Revision 3, Sections 7.1 and 7.5. DCD Revision 3, Section 11.5.4 presents a regulatory evaluation of the PRMS addressing the basis of the selection for 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 3, Section 11.5.2.1 indicates that the PRMS subsystems required for safety incorporate the following major design requirements:

- capable of withstanding the effects of natural phenomena without the loss of operational function
- perform safety 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 and abnormal 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

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
- drywell sumps low-conductivity waste/high-conductivity waste (LCW/HCW) discharge 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 3, Section 11.5.2.2 states that the PRMS subsystems required for plant operation incorporate the following major functional requirements:

- exceed the operational range of each subsystem

- 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 and abnormal 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

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. The following PRMS subsystems provide signals and initiate automatic isolation functions and provide the means to collect process and effluent samples for radiological analysis:

- PRMS subsystems for gaseous effluents

  – plant stack RMS
  – reactor building HVAC exhaust 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
  – turbine 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
  – isolation condenser vent exhaust RMS
  – charcoal vault ventilation RMS
  – drywell fission product RMS

- PRMS subsystems for liquid process streams

  – reactor component cooling water intersystem leakage RMS

- PRMS subsystems for gaseous intake streams

– technical support center HVAC air intake RMS

DCD Tier 2, Revision 3, Sections 11.5.5, 7.5.2, and 9.3.2 describe the features of the process monitoring and sampling. DCD Revision 3, Tables 11.5-1, 11.5-2, 11.5-5 through 11.5-8, and 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 listing of process and effluent systems with operational features, the selection of locations for the placement of RMS monitors, 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
  - reactor water cleanup/shutdown cooling system
  - 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 and auxiliaries
- radwaste building
  - equipment and floor drain input
  - chemical waste drain
  - detergent waste drain
- auxiliary boiler (local grab sampling stations)
  - reactor component cooling water system
  - turbine component cooling water system

– plant service water system
– chilled water system
– circulating water system
– standby liquid control system
– storm and underdrain water system (COL applicant item)
– noncontaminated 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 plant vent. The system also provides the means for 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 3, Sections 7.5.2, 7.5.3, and 9.3.2 describe the features of the postaccident sampling system and process sampling system.

DCD Tier 2, Revision 3, Sections 11.5.3.1.3 and 11.5.3.2.13 describe the designs of the PRMS subsystems use 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 3, Section 11.5.6 describes the requirements for the calibration, inspection, testing, and maintenance of the PRMS. The PRMS system 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 system 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 lower limit of detection) are left to the COL applicant, based on site-specific conditions, type of RMS installed, and operating characteristics of each installed subsystem.

In DCD Tier 2, Revision 3, Section 11.5.7 "COL Information," the applicant listed five COL action items, which are summarized below.

Under COL Information Item 11.5.7.1, the COL applicant is required to derive the lower limit of detection for each PRMS subsystem installed, taking into consideration plant and site-specific conditions. This is **COL Action Item 11.5.7-1.**

Under COL Information Item 11.5.7.2, the COL applicant is required to develop a plant- and site-specific ODCM, or discuss the process in its description of the operational program for the ODCM. This is **COL Action Item 11.5.7-2.**

Under COL Information Item 11.5.7.3, the COL applicant is responsible for implementing the requirements of RG 1.21 and ANSI/HPS N13.1-1999 in developing a process to monitor and extract samples from all identified process and effluent streams. This is **COL Action Item 11.5.7-3.**

Under COL Information Item 11.5.7.4, 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 contain the requirements. The requirements define dose objectives for liquid and gaseous effluents, require a cost-benefit analysis in justifying installed processing and treatment systems for liquid and gaseous radioactive wastes, and require conformity with dose objectives demonstrated by calculations and use of local site-specific data. This is **COL Action Item 11.5.7-4.**

Under COL Information Item 11.5.7.5, the COL applicant is responsible for defining instrumentation and analytical sensitivities and sample collection and analysis frequencies for all listed liquid and gaseous samples extracted from process and effluent streams. This is **COL Action Item 11.5.7-5.**

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; GDCs 60, 63, and 64; and 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).

Under 10 CFR 50.34a and 10 CFR 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 GDCs 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 3, Sections 11.5.1 and 11.5.2, Table 11.5-3, and Figure 11.5-1 list the design bases and criteria and the locations of the PRMS in plant buildings. DCD Tier 2, Revision 3, 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 3, 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, expected activity levels, and types of trip and alarm functions. DCD Tier 2, Revision 3, Tables 11.5-5 through 11.5-8 describe provisions for the sampling and analysis of process and effluent streams. DCD Tier 2, Revision 3, Figure 11.5-2 presents the PRMS system's interface with the plant's instrumentation and control system, as described in DCD Tier 2, Revision 3, Sections 7.1 and 7.5. DCD Tier 2, Revision 3, Section 11.5.4 presents a regulatory evaluation of the PRMS addressing the basis of the selection for the locations of subsystem components, expected radiation or radioactivity levels, 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 whether those portions of the PRMS conform to the QA requirements of Appendix B to 10 CFR Part 50.

RG 1.21 addresses requirements associated with capabilities 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, and methods to measure effluent discharge flow and radioactivity release rates. In DCD Tier 2, Revision 3, Section 11.5.4.6 the applicant stated that the requirements of these two RGs are endorsed by reference and are the responsibility of the COL applicant under COL Action Item 11.5.7.3. Two other COL Action Items (11.5.7.1 and 11.5.7.5) require COL applicants to define appropriate PRMS instrumentation sensitivities and the frequencies and basis for each type of liquid and gaseous sample. DCD Tier 2, Revision 3, 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 of RG 1.21. 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 is required to provide the means to monitor radiation and radioactivity levels for routine operating and accident conditions, consistent with the requirements of GDCs 63 and 64. The staff finds the range provided in DCD Tier 2, Revision 3, Tables 11.5-1 and 11.5-9 for radiation measurement by the high-range containment radiation monitors inside the containment 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 Monitoring," dated November 1980. Therefore, the range complies with the applicable portions of 10 CFR 50.34(f)(2)(xvii). Also, the staff finds the ranges specified in DCD Tier 2, Table 11.5-1 for the main steam line and control building radiation monitors to be acceptable as they are consistent with applicable NRC guidance. RGs 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems," issued May 1973, and RG 1.97 present guidance for sampling and monitoring process and effluent streams and conducting analysis of samples, including the proposed analytical programs, during postulated accidents, in accordance with the requirements of 10 CFR 50.34(f)(2)(xvii) and 10 CFR 50.34(f)(2)(xxvii). On the basis of the above discussion, the staff finds that these special-purpose monitors comply with GDCs 60 and 64 in terms of their ability to control and monitor the release of radioactive materials into the environment. DCD Tier 2, Revision 3, 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, issued June 2006, to the ESBWR design. Section 7.5 of the SER presents the staff's evaluation of the provisions associated with the guidelines of Revision 4 of RG 1.97.

Under 10 CFR 50.34(f)(2)(xxviii), the applicant is required to 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 3, Sections 11.5.3.1.3 and 11.5.3.2.13 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 PRMS 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. 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. Section 6.4 of the SER discusses 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 3, 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 the SER addresses the adequacy of the preoperational testing program for the PRMS.

In DCD Tier 2, Revision 3, 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. 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 Action Item 11.5.7.3. The staff finds this approach acceptable.

DCD Tier 2, Revision 3, Section 11.5.5.9 states that provisions are in place to collect radioactive samples from radioactive process streams. The applicant states that the sample points are described in DCD Sections 7.5.2 and 9.3.2 and listed in DCD Tier 2, Revision 3, 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), 10 CFR 50.34(f)(2)(xvii), and 10 CFR 50.34(f)(2)(xxvii); GDCs 19, 60, 63, and 64; RGs 1.21, 1.33, 1.97, and 8.8; NUREG-0737 (Item II.B.3); and ANSI/HPS N13.1-1999. The systems identified in DCD Tier 2, Revision 3, Table 9.3-1 include the reactor water cleanup and shutdown cooling system, fuel and auxiliary pools cooling system, 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 due to corrosion and activation products, iodine-131, gaseous fission products (xenon and krypton), and principal radionuclides and alpha emitters. DCD Tier 2, Revision 3, Section 9.3.2.6 requires a COL Action Item (9.3.2.6) to develop a postaccident sampling and monitoring program based on the information presented in DCD Tier 2, Revision 3, Table 9.3-1 and the NRC guidance of SRP Section 9.3.2. 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 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 following paragraphs discuss the staff's evaluations of the applicant's responses to RAIs.

In RAI 16.2-9, as it relates to the submission of an ODCM under DCD Tier 2, Revision 3, Section 11.5.7.2 and the administrative requirements of DCD Revision 1, Section 16.5.5.1.c, the staff requested the applicant to address an internal inconsistency with its stated basis document (NUREG-1434, "Standard Technical Specifications General Electric Plants, BWR/6," Volume 1, "Specifications," Revision 3, issued June 2004). In DCD Revision 3,

Section 16.5.5.1.c, the applicant corrected the inconsistency. Therefore, this RAI is resolved. Regarding 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 of a plant- and site-specific ODCM, and its associated documents, is required to follow the NRC requirements and guidance. An 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 89-01 (Supplement No. 1); and Radiological Assessment Branch Technical Position (Revision 1).

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 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 for the purpose of demonstrating 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 in determining 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 3, 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 Action Items 11.5.7.2 and 11.5.7.4. The staff finds this approach acceptable.

In RAIs 11.5-5, 11.5-11, 11.5-12, 11.5-13, 11.5-16, 11.5-17, 11.5-20, 11.5-21, and 11.5-22, as they relate to DCD Tier 2, Revision 1, Sections 11.5.3 and 11.5.4 the staff requested that the applicant provide further elaborations and address the requirements of RGs 1.21 and 4.15 in its description of sampling requirements for batch and continuous releases, sampling and analyses frequencies, types of radionuclides or radionuclide groupings for which analyses are required, and PRMS subsystem calibration and maintenance. In DCD Tier 2, Revision 3, Sections 11.5.3 and 11.5.4 the applicant corrected these inconsistencies. Therefore, with the exception of RAI 11.5-5, these RAIs are resolved. In Revision 3 of DCD Tier 2, Sections 11.5.2, 11.5.4, and 11.5.5, the applicant does not indicate whether the design of the process and effluent sampling systems follows the guidance of IE Bulletin 80-10 and whether the design avoids interconnections with nonradioactive systems that could become radioactive through improper interfaces with radioactive systems. Similarly, the applicant does 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 Revision 3, Section 12.6, addresses some requirements associated with 10 CFR 20.1406, the discussions of DCD

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 in demonstrating compliance with the guidance of IE Bulletin 80-10 and implementation of 10 CFR Part 20.1406. The response acknowledges that there exist a potential for interconnections with non-radioactive systems and describe design features to prevent the contamination of non-radioactive systems and minimization of radioactive contamination during operation. The staff finds the response acceptable as the applicant committed to placing this information in DCD Tier 2, Revision 5. Therefore, this RAI becomes **Confirmatory Item 11.5-5.**

In RAI 11.5-6, as it relates to DCD Tier 2, Revision 1, Sections 11.5.3 and 11.5.4 the staff requested the applicant to describe how the reactor building HVAC exhaust system captures discharges from the isolation condenser vent exhaust. In Revision 3 of DCD Tier 2, Section 11.5.3.1.5, the discussion about 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 is not clear from this discussion and 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 by amplifying the operational description of the isolation condenser vent exhaust and related response of radiation monitors that initiate closure of the containment isolation valves for the affected condensers in the event of a leak. The staff finds the response acceptable as the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-6.**

In RAI 11.5-8, as it relates to DCD Tier 2, Revision 1, Sections 11.5.3 and 11.5.4 the staff requested the applicant to address 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 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 states 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 does not provide criteria for instrumentation variables as do Revisions 2 and 3 (issued December 1980 and May 1983, respectively) of the same guide. In Revision 4 of the guide, the basis and numerical values for instrumentation are to be established in the "licensing basis documentation," which is nonexistent at this time. The discussion in DCD Revision 3, Section 11.5.2.1, and basis for the chosen dynamic response ranges listed in DCD Revision 3, Table 15.5-9, reflect adoption of the design and qualification criteria and instrumentation variables of Tables 1 and 2 of RG 1.97, either as Revision 2 or 3. In addressing conformity with RG 1.97, DCD Revision 3, Section 7.5.1, states that "compliance cannot be specified at this time" and that "compliance to these requirements is [to be] addressed during the detailed design phase." However, DCD Tier 2, Revision 3, Sections 7.5.7 and 11.5.7 (COL Information) do not identify this issue as COL action items. Accordingly, the inconsistency in confirming compliance with either Revision 2/3 or Revision 4 of RG 1.97 for accident monitoring instrumentation described in DCD Revision 3, Sections 7.5.1 and 11.5.2, is left for the applicant to resolve. In response to a supplemental RAI, the applicant proposed, in

a letter dated August 9, 2007, to tie the response of this RAI to related topics addressed under RAI 11.5-46 and discussions of compliance with RG 1.97 for post-accident radiation monitoring instrumentation described in DCD Tier 2, Section 7.5.1.3.1.4. The staff finds the response acceptable. Therefore, this RAI becomes **Confirmatory Item 11.5-8 and is tied to the closure of Confirmatory Item 11.5-46.**

In RAI 11.5-9, as it relates to DCD Tier 2, Revision 1, Sections 11.5.3 and 11.5.4, the staff requested that the applicant address inconsistencies in describing the display RMS channel ranges, dynamic response ranges, and expected activity levels. The specific information is presented in DCD Revision 1, Tables 11.5-1, 11.5-2, 11.5-4, and 11.5-9. A review of these sections and tables of DCD Revision 3 revealed inconsistencies. DCD Tier 2, Revision 3, Table 11.5-1, describes the responses of PRMS subsystems using two radiological units, dose rates (mSv/hour) and concentrations (MBq/m^3). The subsystems with dynamic ranges described as radiation exposure rates include the reactor building HVAC exhaust, refuel handling area HVAC exhaust, control building air intake HVAC, LCW drywell dump discharge system, fuel building general area HVAC, isolation condenser vent exhaust, containment purge exhaust, fuel building fuel pool HVAC, turbine building normal ventilation system, turbine building compartment area air HVAC, off-gas pretreatment system, charcoal vault ventilation, and technical support center HVAC air intake. Since these subsystems are installed to measure radioactivity in process and effluent streams and air intakes, the units should be expressed in radiological units that are consistent when measuring liquid and gaseous concentrations. In DCD Tier 2, Revision 3, Table 11.5-9 the basis for the dynamic ranges of the same PRMS subsystems are expressed in units defined in terms of concentrations (MBq/m^3) and not in units of dose rates (mSv/hour). A review of the dynamic detection ranges listed in DCD Tier 2, Revision 3, Tables 11.5-2 and 11.5-4 revealed that they are also inconsistent with those listed in DCD Tier 2, Revision 3, Table 11.5-9. In response to a supplemental RAI, the applicant proposed, in a letter dated August 31, 2007, to revise DCD Tier 2, Table 11.5-1 of Section 11.5 by clarifying that instrumentation readings, expressed as dose rates (mSv/hour), would not be used to assess compliance with offsite effluent concentration limits (MBq/m^3) defined for unrestricted areas. Instrumentation readings expressed in terms of dose rates would be used to assess the radiological status of process systems and local radiological conditions. The staff finds the response acceptable as the applicant committed to placing this information in DCD Tier 2, Revision 5. Therefore, this RAI becomes **Confirmatory Item 11.5-9.**

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 indicates that there is 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 out 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." The staff requested the applicant to provide the following:

- description of turbine building features (such as placement of main steam pipes, shielding, and construction materials used for the turbine building walls and roof) that are designed to mitigate radiation fields and sky-shine in plant environs

- estimate of the dose to a postulated member of the public located at or beyond the EAB (800 meters (2625 feet)) in complying with 10 CFR 20.1302, 10 CFR 20.1301(e), and 40 CFR Part 190

- a description of how site-specific conditions will be considered in assessing radiation exposures and doses to members of the public and how such information and operational considerations will be addressed in the COL applicant's ODCM, or described in description of the Operational Program for the ODCM

In response to RAI 11.5-23, the applicant stated that the topics identified by the staff were addressed with the responses to RAIs 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 11.5.7.2 requiring a COL holder to consider in its ODCM site-specific conditions and requirements for the purpose of assessing 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 Section 11.5. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-23.**

In RAI 11.5-23 S01, the staff stated that one of the two computer codes used to calculate doses at and beyond the EAB was not included in DCD Tier 2, Revision 3, Section 12.2.1.3, Table 12.3-1. The staff asked the applicant to revise Table 12.3-1 to include the SKYIII-PC computer code along with the other listed codes. In response to this RAI, the applicant stated that DCD Tier 2, Section 12.2.1.3 and Table 12.3-1 is being revised to address this RAI. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-23 S01.**

In RAI 11.5-24, the staff's review of DCD Tier 2, Revision 1, 11.5 and Sections 9.3.2 and 11.5 indicated that there were 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 postaccident sampling system. The criteria include the following:

- GDC 1, "Quality Standards and Records"
- GDC 2, "Design Bases for Protection Against Natural Phenomena"
- GDC 13, "Instrumentation and Control"
- GDC 14, "Reactor Coolant Pressure Boundary"
- GDC 26, "Reactivity Control System Redundancy and Capability"
- GDC 41, "Containment Atmosphere Cleanup"
- GDC 60, "Control of Releases of Radioactive Materials to the Environment"
- GDCs 63 and 64
- 10 CFR 20.1101(b), 10 CFR 50.34(f)(2)(viii), and 10 CFR 50.34(f)(2)(xvii)

The guidance includes the following:

- RG 1.21

- RG 1.26, “Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants,” issued March 2007
- RG 1.29, “Seismic Design Classification,” issued March 2007
- RG 1.33
- RG 1.56, “Maintenance of Water Purity in Boiling Water Reactors,” issued July 1978
- RG 1.97
- RG 8.8
- ANSI/HPS N13.1-1999

The staff asked the applicant to take the following actions:

- 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 Section 9.3.2
- describe operational considerations that would be addressed by the COL applicant in DCD Tier 2, 11.5.7 and 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) is being created to address these issues and that it includes a cross-reference to DCD Tier 2, Revision 3, Section 9.3.2 where information can be found on the consideration of station layout and design criteria in selecting sampling locations from process and effluent streams against specific GDC, regulatory requirements, and regulatory guidance. Also, DCD Tier 2, Section 11.5.5.9 commits to maintaining radiation exposure to workers ALARA and reducing leakages and spills. The staff finds the applicant’s technical response to RAI 11.5-24 acceptable. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-24.**

In RAI 11.5-24 S01, the staff asked the applicant to revise its response by referring to the proper DCD Tier 2 section where information may be found on the postaccident sampling system and sections of NRC regulations under 10 CFR Part 20. Among the several citations noted, the response refers to a nonexistent section of DCD Tier 2, Revision 3 namely Section 7.9.2.5. Also, in the proposed revision of the text in DCD Tier 2, Section 9.3.2 the applicant refers to a nonexistent section of 10 CFR Part 20, namely Part 20.20. In a letter dated July 19, 2007, the applicant committed to placing this information in DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-24 S01.**

In RAI 11.5-37, the staff noted that in DCD Tier 2, Revision 3 the applicant had eliminated one of the design criteria from the lists in Sections 11.5.2.1 and 11.5.2.2. The deleted criterion, as a functional requirement of the PRMS, states that the instrumentation registers full-scale output if radiation detected exceeds full scale. The staff does not agree with the deletion of this criterion in either section of DCD Tier 2 and asked the applicant to update these sections. In a letter dated July 23, 2007, the applicant committed to placing this criterion in Sections 11.5.2.1 and 11.5.2.2 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-37.**

In RAI 11.5-38, the staff noted that in DCD Tier 2, Revision 3, Section 11.5.3.2.3 the discussion about the display ranges of the off-gas post-treatment RMS is inconsistent. The applicant should review the low end of the stated range to confirm whether the instrumentation can detect the stated levels of radioactivity. The staff requested the applicant to update this section of DCD Tier 2. In a letter dated July 23, 2007, the applicant committed to updating the stated ranges of instrumentation responses in Section 11.5.3.2.3 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-38.**

In RAI 11.5-39, the staff noted that in DCD Tier 2, Revision 3, Section 11.5.8 the applicant should combine the citations to ANSI N13.10-1974 and ANSI N42-18-1990 and refer to the source's current reaffirmation status as ANSI N42-18-2004. The staff asked the applicant to update the stated reference in DCD Tier 2. In a letter dated July 23, 2007, the applicant committed to updating these references in Section 11.5.8 and Section 1.9, Table 1.9-22 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-39.**

In RAI 11.5-40, the staff noted that in DCD Tier 2, Revision 3, Table 11.5-2 the stated operational response range for the off-gas pretreatment RMS is improperly characterized for cesium-137. The staff requested the applicant to update the entry in this table of DCD Tier 2. In a letter dated July 23, 2007, the applicant committed to updating the instrumentation response range for cesium-137 and correct related typographical errors in Table 11.5-2 of DCD Tier 2, Revision 4, Section 11.5. Therefore, this RAI becomes **Confirmatory Item 11.5-40.**

In RAI 11.5-41, the staff noted that in DCD Tier 2, Revision 3, Table 11.5-5 footnotes 3 and 4 commit the COL applicant to specific requirements. However, DCD Tier 2, Revision. 3, Section 11.5.7 "COL Information," does not identify these requirements. The staff asked the applicant to update that section of DCD Tier 2 to include these items. In a letter dated July 23, 2007, the applicant committed to updating Footnote No. 4 and leave Footnote No. 3 as is in Table 11.5-5 for the purpose of qualifying the responsibility of the COL applicant in Section 11.5 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-41.**

In RAI 11.5-42, the staff noted that in DCD Tier 2, Revision 3, Table 11.5-8 the third footnote lists a nonexistent radionuclide. The staff requested the applicant to update the footnote in this table of DCD Tier 2. In a letter dated July 23, 2007, the applicant committed to correcting the typographical error in Table 11.5-8, Section 11.5, of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-42.**

In RAI 11.5-43, the staff noted that in DCD Tier 2, Revision 3, Figure 11.5-1 a placeholder for footnote 3 is identified for "FB Building Exhaust," but the figure does not include the text for the footnote. The staff asked the applicant to provide the missing legend in that figure of DCD Tier 2. In a letter dated July 23, 2007, the applicant committed to inserting the appropriate

legend and text for the footnote in Figure 11.5-1, Section 11.5, of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-43.**

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. However, DCD Tier 2, Revision 3, Section 11.5.7 does not commit the COL applicant to conform 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, Chapter 17, Table 17.0-1. As a result, the applicant is revising 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 4. Therefore, this RAI becomes **Confirmatory Item Number 11.5-44.**

In RAI 11.5-45, the staff noted that in DCD Tier 2, Revision 3, Sections 11.5.3.1.3 and 11.5.3.2.13 describe the design 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 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. However, DCD Tier 2, Revision 3, Section 11.5.7 does not commit the COL applicant to establish operational set points of the associated RMS for control building air intake HVAC RMS and technical support center HVAC air intake RMS. The staff requested the applicant to update this section of DCD Tier 2 to include this COL information item. In a letter dated July 23, 2007, the applicant stated that because the PRMS subsystems for the control building and technical support center are addressed in plant technical specifications (TS 3.3.7.1 and 3.3.7.2) and in ITAAC Table 2.3.1-2, there is no need to identify separate COL action items for the purpose of establishing operational set points in activating the closure and isolation of HVAC systems servicing occupied spaces. The staff finds this explanation acceptable. Therefore, RAI 11.5-45 is closed.

In RAI 11.5-46, the staff noted that DCD Tier 2, Revision 3, Section 11.5.7 should commit the COL applicant to establish 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 operational range of each process radiation monitoring system 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, Attachments 1 and 2). However, DCD Revision 3, Section 11.5.7, does 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 clarify compliance with the guidance of RG 1.97 and TMI-related action items in Sections 11.5.2, 11.5.3, and 13.5.3.4 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-46.**

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, "Review of Operational Programs in a Combined License Application and Generic Emergency Planning Inspections, Tests, Analyses, and Acceptance Criteria," dated October 28, 2005, COL applicants should fully describe these operational programs in their COL applications and should propose implementation milestones (license conditions) for staff review. The staff requested 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 Sections 11.5.4.5, 11.5.4.6, 11.5.4.7, 11.5.4.8, and 11.5.7 of DCD Tier 2, Revision 4. Therefore, this RAI becomes **Confirmatory Item 11.5-47.**

In DCD Tier 2, Revision 3, Section 11.5.7 the applicant identified five COL action items, **COL Action Items 11.5.7.1 through 11.5.7.5.** The staff finds the inclusion of these COL action items acceptable, pending review of confirmatory items.

The regulatory requirements and guidance, as they relate to sufficient details provided to demonstrate that PRMS equipment (as permanently installed equipment and skid-mounted systems) will support the design objectives, are satisfied once the applicant adequately responds to all confirmatory items, and COL action items for a COL applicant referencing the ESBWR certified design.

11.5.4 Conclusions

Staff will verify the satisfactory inclusion of confirmatory items identified in this section in the applicant's DCD. Based on the information 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 GDCs 19, 60, 63, and 64; the requirements of 10 CFR 50.34a and 10 CFR 50.36a; Appendix I to 10 CFR Part 50; 10 CFR 20.1301 and 10 CFR 20.1302; 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 associated guidance of RGs 1.21, 1.45, 1.97 and 4.15. This conclusion is based on the following:

- The staff reviewed the provisions proposed in DCD Tier 2 to provide automatic termination of effluent releases and to ensure control over discharges, in accordance with GDCs 60 and 63. Sections 11.2 and 11.3 of the SER discuss systems used in controlling releases of radioactive materials from GWMS exhaust and LWMS discharge. The PRMS must monitor discharges or releases from the plant stack, 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 must 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, drywell sumps LCW/HCW discharge, 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 must provide signals and initiate automatic functions for the following plant systems—main steam line, off-gas pretreatment, off-gas posttreatment, charcoal vault ventilation, drywell fission product, reactor component cooling water intersystem leakage, and technical support center HVAC air intake.

- The staff reviewed the provisions proposed in DCD Tier 2 to sample and monitor all plant effluents in accordance with GDC 64. The process and effluent radiological monitoring and sampling systems must include instrumentation for monitoring and sampling 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 RG 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 the SER 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 10 CFR 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. Section 9.3.2 of DCD Tier 2, Revision 3 commits the COL applicant to develop a post-accident sampling program to monitor the parameters identified in Table 9.3-1. Section 7.5.1 of the SER addresses the design features of the postaccident monitoring instrumentation and compliance with RG 1.97.

- 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 TS/SREC, ODCM, and REMP as a COL action item. The operational programs include administrative programs. Operational procedures associated with their implementation by the COL applicant should be consistent with the guidance of GL 89-01 and NUREG-1302 for BWR plants; NUREG-0133; RGs 1.21, 1.33, 4.1, 4.8, and 4.15; and guidance from Radiological Assessment Branch Technical Position (Revision 1).

- The design of the PRMS, operating in conjunction with the LWMS, GWMS, and SWMS to control and monitor radioactive effluent releases in the environment, must meet 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. Section 12.2.2 of DCD Tier 2 presents this information and SER Section 12.3.3.2 presents the staff's evaluation.

- In conjunction with the operation of the LWMS, GWMS, and SWMS, the design of the PRMS must comply 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 10 CFR 50.36a. Section 12.2.2 of DCD Tier 2 presents this information and SER Section 12.3.3.2 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 structures housing these systems must meet the guidance of RG 1.143, as described in DCD Tier 2, Revision 3, Sections 3.2 and 3.8. SER Sections 3.2 and 3.8 present the staff's evaluation.