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12.0 RADIATION PROTECTION

This chapter of the U.S. EPR Final Safety Analysis Report (FSAR) is incorporated by reference with supplements as identified in the following sections.

12.1 ENSURING THAT OCCUPATIONAL RADIATION EXPOSURES ARE AS LOW AS IS REASONABLY ACHIEVABLE (ALARA)

This section of the U.S. EPR FSAR is incorporated by reference with the following departures and/or supplements.

12.1.1 POLICY CONSIDERATIONS

No departures or supplements.

12.1.2 DESIGN CONSIDERATIONS

No departures or supplements.

12.1.3 OPERATIONAL CONSIDERATIONS

The U.S. EPR FSAR includes the following COL Item in Section 12.1.3:

> A COL applicant that references the U.S. EPR design certification will fully describe, at the functional level, elements of the ALARA program for ensuring that occupational radiation exposures are ALARA. This program will comply with provisions of 10 CFR Part 20 and be consistent with the guidance in RGs 1.8, 8.2, 8.7, 8.8, 8.9, 8.10, 8.13, 8.15, 8.27, 8.28, 8.29, 8.34, 8.35, 8.36, 8.38, and the applicable portions of NUREG-1736.

This COL Item is addressed as follows:

This section incorporates by reference NEI 07-08, Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA)(NEI, 2007).

12.1.4 REFERENCES

{NEI, 2007. Generic FSAR Template Guidance for Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA), NEI 07-08, Revision 0, Nuclear Energy Institute, September 2007.}

12.2 RADIATION SOURCES

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

12.2.1 CONTAINED SOURCES

No departures or supplements.

12.2.1.1 Reactor Core

No departures or supplements.

12.2.1.2 Reactor Coolant System

No departures or supplements.

12.2.1.3 Chemical and Volume Control System

No departures or supplements.

12.2.1.4 Primary Coolant Purification System

No departures or supplements.

12.2.1.5 Primary Coolant Degasification System

No departures or supplements.

12.2.1.6 Secondary Coolant Cycle

No departures or supplements.

12.2.1.7 Component Cooling Water and Essential Service Water Systems

No departures or supplements.

12.2.1.8 Fuel Pool Cooling and Purification System

No departures or supplements.

12.2.1.9 Liquid Waste Management System

No departures or supplements.

12.2.1.10 Gaseous Waste Processing System

No departures or supplements.

12.2.1.11 Solid Waste Management System

No departures or supplements.

12.2.1.12 Post-LOCA ESF Filters

No departures or supplements.

12.2.1.13 Miscellaneous Sources

The U.S. EPR FSAR includes the following COL Item in Section 12.2.1.13:

> A COL applicant that references the U.S. EPR design certification will provide site-specific information for required radiation sources containing byproduct, source, and special nuclear material that may warrant shielding design considerations. This site-specific information will include a listing of isotope, quantity, form, and use of all sources in this latter category that exceed 100 millicuries.

This COL Item is addressed as follows:

The following radiation sources have been identified to be required.

Isotope	Quantity	Form	Use
Cf-252	0.5 Ci	Sealed Source	Primary Start-up Source
Sb-Be	3E+06 Ci	Sealed Source	Secondary Source
Cs-137	400 Ci	Sealed Source	Calibration
Cs-137	{200 Ci}	Sealed Source	Calibration
{AmBe	5 Ci	Sealed Source	Calibration}

12.2.2 AIRBORNE RADIOACTIVE MATERIAL SOURCES

No departures or supplements.

12.2.3 REFERENCES

No departures or supplements.

12.3 RADIATION PROTECTION DESIGN FEATURES

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

12.3.1 FACILITY DESIGN FEATURES

No departures or supplements.

12.3.2 SHIELDING

No departures or supplements.

12.3.3 VENTILATION

No departures or supplements.

12.3.4 AREA RADIATION AND AIRBORNE RADIOACTIVITY MONITORING INSTRUMENTATION

No departures or supplements.

12.3.4.1 Area Radiation Monitoring Instrumentation

No departures or supplements.

12.3.4.2 Airborne Radioactivity Monitoring Instrumentation

No departures or supplements.

12.3.4.3 Portable Airborne Monitoring Instrumentation

No departures or supplements.

12.3.4.4 Criticality Accident Monitoring

No departures or supplements.

12.3.4.5 Implementation of Regulatory Guidance

The U.S. EPR FSAR includes the following COL Items in Section 12.3.4.5:

A COL applicant that references the U.S. EPR design certification will describe the use of portable instruments, and the associated training and procedures, to accurately determine

the airborne iodine concentration within the facility where plant personnel may be present during an accident, in accordance with requirements of 10 CFR 50.34(f)(2)(xxvii) and the criteria in Item III.D.3.3 of NUREG-0737. The procedures for locating suspected high-activity areas will be described.

A COL applicant that references the U.S. EPR design certification will provide site-specific information on the extent to which the guidance provided by RG 1.21, 1.97, 8.2, 8.8, and ANSI/HPS-N13.1-1999 is employed in sampling, recording and reporting airborne releases of radioactivity.

These COL Items are addressed as follows:

Procedures detail the criteria and methods for obtaining representative measurement of radiological conditions, including in-plant airborne radioactivity concentrations in accordance with applicable portions of 10 CFR Part 20 (CFR, 2008) and consistent with the guidance in Regulatory Guides 1.21 Appendix A (NRC, 1974), 1.97 (NRC, 2006), 8.2 (NRC, 1973), 8.8 (NRC, 1978), and 8.10 (NRC,1977b) and ANSI/HPS-N13.1-1999 (ANSI, 1999). Additional discussion of radiological surveillance practices is included in the radiation protection program description referenced in Section 12.5.

Surveillance requirements are determined by the functional manager in charge of Radiation Protection based on actual or potential radiological conditions encountered by personnel and the need to identify and control radiation, contamination, and airborne radioactivity. These requirements are consistent with the operational philosophy in Regulatory Guide 8.10. Frequency of scheduled surveillances may be altered by permission of the functional manager in charge of Radiation Protection or their designee. Radiation Protection periodically provides cognizant personnel with survey data that identify radiation exposure gradients in areas resulting from identified components. These data include recent reports with survey data, location, and component information.

The following are typical criteria for frequencies and types of surveys:

Job Coverage Surveys

- Radiation, contamination, and/or airborne surveys are performed and documented to support job coverage.
- Radiation surveys are sufficient in detail for Radiation Protection to assess the radiological hazards associated with the work area and the intended/specified work scope.
- Surveys are performed commensurate with radiological hazard, nature and location of work being conducted.
- Job coverage activities may require surveys to be conducted on a daily basis where conditions are likely to change.

Radiation Surveys

- Radiation surveys are performed at least monthly in any radiological controlled area (RCA) where personnel may frequently work or enter. Survey frequencies may be modified by the functional manager in charge of Radiation Protection as previously noted.

- Radiation surveys are performed prior to or during entry into known or suspected high radiation areas for which up to date survey data do not exist.

- Radiation surveys are performed prior to work involving highly contaminated or activated materials or equipment.

- Radiation surveys are performed at least semiannually in areas outside the RCA. Areas to be considered include shops, offices, and storage areas.

- Radiation surveys are performed to support movement of highly radioactive material.

- Neutron radiation surveys are performed when personnel may be exposed to neutron emitting sources.

Contamination Surveys

- Contamination surveys are performed at least monthly in any RCA where personnel may frequently work or enter. Survey frequencies may be modified by the functional manager in charge of Radiation Protection as previously noted.

- Contamination surveys are performed during initial entry into known or suspected contamination area(s) for which up to date survey data do not exist.

- Contamination surveys are performed at least daily at access points, change areas, and high traffic walkways in RCAs that contain contaminated areas. Area access points to a High Radiation Area or Very High Radiation Area are surveyed prior to or upon access by plant personnel or if access has occurred.

- Contamination surveys are performed at least semiannually in areas outside the RCA. Areas to be considered include shops, offices, and storage areas.

- A routine surveillance is conducted in areas designated by the functional manager in charge of Radiation Protection or their designee likely to indicate alpha radioactivity. If alpha contamination is identified, frequency and scope of the routine surveillance is increased.

Airborne Radioactivity Surveys

- Airborne radioactivity surveys are performed during any work or operation in the RCA known or suspected to cause airborne radioactivity (e.g., grinding, welding, burning, cutting, hydrolazing, vacuuming, sweeping, use of compressed air, using volatiles on contaminated material, waste processing, or insulation).

- Airborne radioactivity surveys are performed during a breach of a radioactive system which contains or is suspected of containing significant levels of contamination.

- Airborne radioactivity surveys are performed during initial entry (and periodically thereafter) into any known or suspected airborne radioactivity area.

- Airborne radioactivity surveys are performed immediately following the discovery of a significant radioactive spill or spread of radioactive contamination, as determined by the functional manager in charge of Radiation Protection.

- Airborne radioactivity surveys are performed daily in occupied radiological controlled areas where the potential for airborne radioactivity exists, including containment.

- Airborne radioactivity surveys are performed any time respiratory protection devices, alternative tracking methods such as derived air concentration-hour (DAC-hr), and/or engineering controls are used to control internal exposure.

- Airborne radioactivity surveys are performed using continuous air monitors (CAMs) for situations in which airborne radioactivity levels can fluctuate and early detection of airborne radioactivity could prevent or minimize inhalation of radioactivity by workers. Determination of air flow patterns are considered for locating air samplers.

- Airborne radioactivity surveys are performed prior to use and monthly during use on plant service air systems used to supply air for respiratory protection to verify the air is free of radioactivity.

- Tritium sampling is performed near the spent fuel pit when irradiated fuel is in the pit and in other areas of the plant where primary system leaks occur and tritium is suspected.

Appropriate counting equipment is used based on the sample type and the suspected identity of the radionuclides for which the sample is being collected. Survey results are documented, retrievable, and processed per site document control and records requirements consistent with Regulatory Guide 8.2. Completion of survey documentation includes the update of room/area posting maps and revising area or room postings and barricades as needed.

Air samples indicating activity levels greater than a procedure specified percentage of DAC are forwarded to the radiochemistry laboratory for isotopic analysis. Samples which cannot be analyzed on-site are forwarded to a contractor for analysis; or, the DAC percentage may be hand calculated using appropriate values from 10 CFR Part 20, Appendix B.

The responsible Radiation Protection personnel review survey documentation to evaluate if surveys are appropriate and obtained when required, records are complete and accurate, and adverse trends are identified and addressed.

An in-plant radiation monitoring program maintains the capability to accurately determine the airborne iodine concentration in areas within the facility where personnel may be present under accident conditions. This program includes the training of personnel, procedures for monitoring, and provisions for maintenance of sampling and analysis equipment consistent with Regulatory Guides 1.21 (Appendix A) and 8.8. Training and personnel qualifications are discussed in Section 12.5.

A portable monitor system meeting the requirements of NUREG-0737 (NRC, 1980), Item III.D.3.3, is available. The system uses a silver zeolite or charcoal iodine sample cartridge and a single-channel analyzer. The use of this portable monitor is incorporated in the emergency plan implementing procedures. The portable monitor is part of the in-plant radiation monitoring program. It is used to determine the airborne iodine concentration in areas where plant personnel may be present during an accident. Accident monitoring instrumentation complies with applicable parts of 10 CFR Part 50, Appendix A.

Sampling cartridges are removed to a low background area for further analysis. These cartridge samples are purged of any entrapped noble gases, when necessary, prior to being analyzed.

12.3.5 DOSE ASSESSMENT

{No departures or supplements to introductory materials in this section.}

12.3.5.1 Overall Plant Doses

The U.S. EPR FSAR includes the following COL Item in Section 12.3.5.1:

> A COL applicant that references the U.S. EPR design certification will provide site-specific information on estimated annual doses to construction workers in a new unit construction area as a result of radiation from onsite radiation sources from the existing operating plant(s). This information will include bases, models, assumptions, and input parameters associated with these annual doses.

This COL Item is addressed as follows:

Radiation Exposure to Construction Workers

{This section discusses the exposure of construction workers building Callaway Plant Unit 2 to radiation from the normal operation of Callaway Plant Unit 1.

Site Layout

The physical location of Callaway Plant Unit 2 relative to the existing Callaway Plant Unit 1 on the Callaway site is presented on Figure 12.3-1. As shown, Callaway Plant Unit 2 would be located generally northwest geographically of the protected area of Callaway Plant Unit 1. Hence, the majority of construction activity would take place outside the protected area for the existing unit, but inside the Owner Controlled Area for the Callaway site.

Radiation Sources at Callaway Plant Unit 2

During the construction of Callaway Plant Unit 2, the construction workers will be exposed to radiation sources from the routine operation of Callaway Plant Unit 1. Potential sources are discussed in the Offsite Dose Calculation Manual (ODCM) (AmerenUE, 2005), the annual Radiological Effluent Release Report (AmerenUE, 2006), and the Radiological Environmental Operating Report (AmerenUE, 2006a) for Callaway Plant Unit 1. The potential sources of radiation to Callaway Plant Unit 2 construction workers are gaseous effluents, liquid effluents, and direct radiation from Callaway Plant Unit 1. These sources are discussed below.

All gaseous effluents flow out the Callaway Plant Unit 1 unit vent. The releases are reported annually to the NRC (AmerenUE, 2001, AmerenUE, 2002, AmerenUE, 2003, AmerenUE, 2004, AmerenUE, 2005a, AmerenUE, 2006). For example, over the past six years (2001 through 2006) the average annual gaseous releases from Callaway Plant Unit 1 were reported as 183 Ci (6.8E12 Bq) of fission and activation gases, 3.9E-4 Ci (1.4E+07 Bq) of Iodines, 2.0E-4 Ci (7.5E+06 Bq) of particulates with half-lives greater than eight days, and 46.0 Ci (1.7E+12 Bq) of Tritium. A summary by isotope for each of the six years is provided in Table 12.3-1. Doses to the general population are also computed in accordance with the ODCM (AmerenUE, 2005) and reported annually.

Effluents from the liquid waste disposal system produce small amounts of radioactivity in the discharge to the Missouri River and will not affect workers as discussed further in this section. A review of the annual Radioactive Effluent Release Reports issued for Callaway Plant Unit 1 indicate direct radiation for on-site areas of public access of less than 0.1 mrem (0.001 mSv). Direct radiation in the amount of 0.1 mrem (0.001 mSv) has been added to the dose estimates. It should be noted that AmerenUE does not have an on-site interim dry spent fuel storage

facility (often referred to as an ISFSI) at the Callaway site and has no plans to install such a facility until after the completion of construction of Callaway Plant Unit 2. The Old Steam Generator Storage Facility (OSGSF) represents a potential direct radiation source affecting construction workers. The OSGSF is located approximately 200 ft (60 m) geographically northeast of the Callaway Plant Unit 2 construction area. A survey conducted in November 2007 measured a dose rate of less than 0.5 mrem per hr (0.005 mSv per hr) from the OSGSF.}

Historical Dose Rates

The historical measured and calculated dose rates that were used to estimate worker dose are presented below.

Offsite Gaseous and Liquid Effluent Doses

{Each year the exposure to the maximally exposed member of the public due to the release of gaseous and liquid effluents from Callaway Plant Unit 1 are calculated in accordance with the existing units' ODCM (AmerenUE, 2005). These maximum individual doses are provided in historical Callaway Plant Unit 1 Annual Radiological Environmental Operating Reports (AmerenUE, 2001a, AmerenUE, 2002a, AmerenUE, 2003a, AmerenUE, 2004a, AmerenUE, 2005b, AmerenUE, 2006a). These reports show that the plant releases generally result in doses to the maximally exposed member of the public of less than 1 percent of the limits. Doses due to liquid releases are also very low and are not expected to be of any significance to construction workers since they will not be permitted to ingest food (edible plants or fish) grown in effluent streams during their working hours. Therefore, only external pathways will be considered.

Historical Measurements

Thermoluminescent dosimeter (TLD) measurements are reported each year in the Annual Radiological Environmental Operating Reports for Callaway Plant Unit 1. The closest TLDs to the location of Callaway Plant Unit 2 construction areas are located generally geographically WNW through N of Callaway Plant Unit 1 at about one mile (considerably beyond the construction areas). The most prevalent wind directions are also generally toward the NNW. Inspection of the TLD results for the six year period (2001 through 2006) show readings consistent with natural background activity. The REMP program will be modified to cover areas of construction closer to the existing plant.

Projected Dose Rates at Callaway Plant Unit 2

Dose rates from the gaseous releases from the plant vent were calculated for the general areas where construction activities will occur. No credit is taken for any shielding.

Gaseous Dose Rates

The annual dose rates from gaseous effluents to construction workers on the Callaway Plant Unit 2 construction site were computed using the XDCALC program with a semi-infinite gamma air dose plume model assuming a ground level release. Of the six-years of effluent release reports from Callaway Plant Unit 1, the releases in 2004 were highest and were used as the source term in the calculations. This source term is provided in Table 12.3-2. These isotopic release rates were used to compute dose for each hour of the three-year period of meteorological data (2004 through 2006). These doses were summed on a radial grid and averaged. The methodology found in NRC Regulatory Guide 1.109 (NRC, 1977a) was used to determine the appropriate doses for evaluation against limits. Results are presented in Table 12.3-3 for plant vent effluents only for 2200 hour exposure.

The calculations discussed in the previous paragraph follow the methodology in 10 CFR 50, Appendix I. Since the issuance of that document more recent methodology for determining

Total Effective Dose Equivalent (TEDE) has been issued by the EPA in Federal Guidance Reports 11 (EPA, 1988) and 12 (EPA, 1993). TEDE doses that result from the combined direct radiation from the plume and ground deposits as well as an effective dose due to inhalation are dominated by the plume contribution. A calculation was made using the 2004 source terms and the EPA methodology for TEDE where each of the pathways could be evaluated. This calculation showed the ground shine contribution to be very low and the inhalation of particulates and halogens to contribute about 13% more than the plume contribution. The Thyroid Committed Dose Equivalent (CDE) dose was lower than the inhalation component of the TEDE. Therefore, the whole body doses resulting from direct radiation from plant sources and from the plume are increased by a factor of 1.13 for comparison with standards involving TEDE doses as appropriate for routine operations. Results of the dose calculations for full time occupancy including the TEDE correction are provided in Table 12.3-4. This table also includes a direct radiation dose of 0.1 mrem/year (0.001 mSv). Table 12.3-5 provides the TEDE doses including the direct radiation for 2200 hour occupancy.

Liquid Dose Rates

There is no expected dose to construction workers from liquid effluents. A new discharge line was installed in 2007 and 2008 with sufficient capacity to accommodate the combined liquid effluents from Callaway Units 1 and 2. If necessary, dredging to deepen the approach to the existing barge dock will occur upstream of the discharge line. On-shore work to install the collector well system will also take place upstream of the outfall.

Collective Doses to Callaway Plant Unit 2 Workers

The collective dose is the sum of all doses received by all workers. It is a measure of population risk. The total worker collective dose for the combined years of construction is 1.8 person-rem (0.018 person-Sieverts). This is a best estimate and is based upon the worker census shown in Table 12.3-6 along with an estimated average dose rate from Table 12.3-5 in the zone of heaviest construction of Callaway Plant Unit 1 to be 0.209 mrem per yr (0.002mSv per yr).}

12.3.5.2 Post-Accident Access to Radiological Vital Areas

No departures or supplements.

12.3.5.3 Dose to the Public from Direct Radiation Exposure at the Exclusion Area Boundary

No departures or supplements.

12.3.6 MINIMIZATION OF CONTAMINATION

No departures or supplements.

12.3.7 REFERENCES

{**AMEREN, 2002a.** 2001 Callaway Plant Radioactive Effluent Release Report. April 25, 2002.

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NRC, 1977b. Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Reasonably Achievable, Regulatory Guide 8.10, Revision 1-R, U.S. Nuclear Regulatory Commission, May 1977.

NRC, 1978. Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be as Low As is Reasonably Achievable, Regulatory Guide 8.8, Revision 3, U.S. Nuclear Regulatory Commission, June 1978.

NRC,1980. Clarification of TMI Action Plan Requirements, NUREG-0737, U.S. Nuclear Regulatory Commission, November 1980.

NRC, 2006. Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants, Regulatory Guide 1.97, Revision 4, U.S. Nuclear Regulatory Commission, June 2006.}

Table 12.3-1—{Historical Gaseous Releases for Callaway Plant Unit 1 2001 through 2006}

(Page 1 of 2)

Nuclide	2001 Release Ci (Bq)	2002 Release Ci (Bq)	2003 Release Ci (Bq)	2004 Release Ci (Bq)	2005 Release Ci (Bq)	2006 Release Ci (Bq)
AR-41	5.33E-01 (1.97E+10)	3.71E-01 (1.37E+10)	1.14E+10 (4.21E+20)	2.89E-01 (1.07E+10)	4.44E-01 (1.64E+10)	2.27E-01 (8.40E+09)
XE-133	2.28E+02 (8.42E+12)	3.80E+00 (1.41E+11)	1.36E+12 (5.02E+22)	7.38E+02 (2.73E+13)	3.35E+00 (1.24E+11)	1.74E-01 (6.43E+09)
XE-135	1.02E+01 (3.79E+11)	5.94E-01 (2.20E+10)	1.61E+10 (5.96E+20)	1.62E+01 (5.98E+11)	1.13E+00 (4.17E+10)	5.93E-02 (2.19E+09)
KR-85	2.48E+00 (9.17E+10)	6.42E-01 (2.38E+10)	1.28E+10 (4.74E+20)	3.77E+00 (1.39E+11)	2.29E+01 (8.47E+11)	2.94E+00 (1.09E+11)
KR-85M	1.53E+00 (5.68E+10)	1.37E-02 (5.08E+08)	4.39E-03 (1.62E+08)	3.37E+00 (1.25E+11)	9.50E-02 (3.52E+09)	0.00E+00 (0.00E+00)
KR-87	7.79E-01 (2.88E+10)	2.06E-02 (7.62E+08)	3.72E-05 (1.38E+06)	1.01E+00 (3.73E+10)	2.02E-01 (7.48E+09)	0.00E+00 (0.00E+00)
KR-88	2.25E+00 (8.33E+10)	3.82E-02 (1.41E+09)	2.47E-02 (9.14E+08)	3.89E+00 (1.44E+11)	2.56E-01 (9.47E+09)	0.00E+00 (0.00E+00)
XE-135M	3.35E-01 (1.24E+10)	0.00E+00 (0.00E+00)	7.22E-03 (2.67E+08)	3.76E-01 (1.39E+10)	2.92E-01 (1.08E+10)	0.00E+00 (0.00E+00)
XE-138	1.71E+00 (6.33E+10)	1.20E-01 (4.45E+09)	1.59E-01 (5.90E+09)	2.63E-01 (9.71E+09)	1.96E+00 (7.25E+10)	0.00E+00 (0.00E+00)
XE-131M	2.93E+00 (1.09E+11)	1.62E-01 (6.00E+09)	9.81E+00 (3.63E+11)	3.43E+00 (1.27E+11)	3.90E+00 (1.44E+11)	1.02E-03 (3.77E+07)
XE-133M	8.74E-01 (3.23E+10)	2.52E-02 (9.32E+08)	5.28E-01 (1.95E+10)	7.84E+00 (2.90E+11)	9.37E-03 (3.47E+08)	7.94E-02 (2.94E+09)
I-133	3.42E-06 (1.27E+05)	2.08E-09 (7.70E+01)	6.59E-08 (2.44E+03)	5.04E-05 (1.87E+06)	2.23E-05 (8.26E+05)	0.00E+00 (0.00E+00)
I-131	4.98E-05 (1.84E+06)	3.34E-06 (1.23E+05)	2.08E-06 (7.69E+04)	2.36E-03 (8.75E+07)	1.43E-07 (5.29E+03)	0.00E+00 (0.00E+00)
I-132	3.23E-05 (1.19E+06)	1.47E-04 (5.45E+06)	1.65E-08 (6.11E+02)	1.37E-04 (5.07E+06)	2.06E-05 (7.61E+05)	0.00E+00 (0.00E+00)
I-135	5.21E-07 (1.93E+04)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	4.66E-06 (1.72E+05)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
CS-137	4.00E-05 (1.48E+06)	6.23E-05 (2.31E+06)	2.39E-06 (8.84E+04)	2.96E-05 (1.10E+06)	6.24E-06 (2.31E+05)	0.00E+00 (0.00E+00)
SB-125	2.09E-04 (7.75E+06)	9.51E-05 (3.52E+06)	9.42E-06 (3.49E+05)	4.29E-05 (1.59E+06)	1.22E-06 (4.53E+04)	2.53E-07 (9.36E+03)
BA-140	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	8.70E-07 (3.22E+04)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
CS-134	7.13E-06 (2.64E+05)	2.77E-05 (1.02E+06)	1.39E-08 (5.14E+02)	3.75E-05 (1.39E+06)	6.42E-06 (2.38E+05)	0.00E+00 (0.00E+00)
CS-136	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	4.47E-09 (1.65E+02)	3.17E-06 (1.17E+05)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
NA-24	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	4.30E-08 (1.59E+03)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
CO-58	2.15E-06 (7.96E+04)	9.72E-06 (3.60E+05)	2.02E-09 (7.47E+01)	9.63E-06 (3.56E+05)	2.35E-05 (8.71E+05)	0.00E+00 (0.00E+00)
CO-60	8.45E-05 (3.13E+06)	1.08E-04 (4.01E+06)	1.10E-04 (4.07E+06)	1.23E-04 (4.55E+06)	6.02E-05 (2.23E+06)	2.47E-05 (9.13E+05)
NB-95	0.00E+00 (0.00E+00)	8.31E-07 (3.07E+04)	5.34E-07 (1.98E+04)	4.25E-07 (1.57E+04)	1.93E-06 (7.13E+04)	0.00E+00 (0.00E+00)
CR-51	4.73E-06 (1.75E+05)	3.09E-06 (1.14E+05)	0.00E+00 (0.00E+00)	1.51E-06 (5.59E+04)	3.53E-06 (1.31E+05)	0.00E+00 (0.00E+00)

Table 12.3-1—{Historical Gaseous Releases for Callaway Plant Unit 1 2001 through 2006}

(Page 2 of 2)

Nuclide	2001 Release Ci (Bq)	2002 Release Ci (Bq)	2003 Release Ci (Bq)	2004 Release Ci (Bq)	2005 Release Ci (Bq)	2006 Release Ci (Bq)
MO-99	0.00E+00 (0.00E+00)	3.20E-08 (1.18E+03)	0.00E+00 (0.00E+00)	3.43E-10 (1.27E+01)	9.50E-07 (3.52E+04)	0.00E+00 (0.00E+00)
TC-99M	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	3.43E-10 (1.27E+01)	9.50E-07 (3.52E+04)	0.00E+00 (0.00E+00)
CE-144	0.00E+00 (0.00E+00)	5.67E-08 (2.10E+03)	1.00E-03 (3.70E+07)	4.73E-09 (1.75E+02)	5.86E-09 (2.17E+02)	0.00E+00 (0.00E+00)
CO-57	0.00E+00 (0.00E+00)	2.01E-08 (7.45E+02)	5.12E-08 (1.89E+03)	1.04E-07 (3.85E+03)	1.15E-08 (4.26E+02)	0.00E+00 (0.00E+00)
CE-141	0.00E+00 (0.00E+00)	2.39E-08 (8.84E+02)	0.00E+00 (0.00E+00)	1.07E-07 (3.96E+03)	1.79E-06 (6.60E+04)	0.00E+00 (0.00E+00)
CD-109	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	1.23E-05 (4.56E+05)	0.00E+00 (0.00E+00)
PR-144	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	5.86E-09 (2.17E+02)	0.00E+00 (0.00E+00)
TE- 132	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	1.06E-09 (3.92E+01)	0.00E+00 (0.00E+00)
SB- 124	7.19E-07 (2.66E+04)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	2.92E-09 (1.08E+02)	0.00E+00 (0.00E+00)
MN-54	0.00E+00 (0.00E+00)	6.88E+03 (2.55E+14)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	3.74E-07 (1.38E+04)	0.00E+00 (0.00E+00)
ZR-95	0.00E+00 (0.00E+00)	2.55E-07 (9.44E+03)	3.73E-07 (1.38E+04)	0.00E+00 (0.00E+00)	1.21E-06 (4.48E+04)	0.00E+00 (0.00E+00)
CS-138	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)	1.74E-07 (6.44E+03)	0.00E+00 (0.00E+00)	0.00E+00 (0.00E+00)
H-3	6.33E+01 (2.34E+12)	6.33E+01 (2.34E+12)	4.92E+01 (1.82E+12)	3.79E+01 (1.40E+12)	3.22E+01 (1.19E+12)	3.02E+01 (1.12E+12)

Table 12.3-2—{Average Unit 1 Effluent Release Rates in 2004 Used to Estimate Conservative Dose to Workers}

Nuclide	uCi/sec (Bq/sec)
AR-41	9.16E-03 (3.39E+08)
XE-133	2.34E+01 (8.65E+11)
XE-135	5.13E-01 (1.90E+10)
KR-85	1.19E-01 (4.42E+09)
KR-85M	1.07E-01 (3.96E+09)
KR-87	3.19E-02 (1.18E+09)
KR-88	1.23E-01 (4.56E+09)
XE-135M	1.19E-02 (4.41E+08)
XE-138	8.32E-03 (3.08E+08)
XE-131M	1.09E-01 (4.02E+09)
XE-133M	2.48E-01 (9.19E+09)
I-133	1.60E-06 (5.92E+04)
I-131	7.50E-05 (2.77E+06)
I-132	4.35E-06 (1.61E+05)
I-135	1.48E-07 (5.47E+03)
CS-137	9.40E-07 (3.48E+04)
SB-125	1.36E-06 (5.03E+04)
BA-140	2.76E-08 (1.02E+03)
CS-134	1.19E-06 (4.40E+04)
CS-136	1.01E-07 (3.72E+03)
NA-24	1.36E-09 (5.05E+01)
CO-58	3.05E-07 (1.13E+04)
CO-60	3.90E-06 (1.44E+05)
NB-95	1.35E-08 (4.99E+02)
CR-51	4.79E-08 (1.77E+03)
MO-99	1.09E-11 (4.02E-01)
TC-99M	1.09E-11 (4.02E-01)
CE-144	1.50E-10 (5.55E+00)
CO-57	3.30E-09 (1.22E+02)
CE-141	3.39E-09 (1.26E+02)
CS-138	5.52E-09 (2.04E+02)
H-3	1.24E+00 (4.57E+10)

Table 12.3-3—{Projected Gamma Air Dose Rates from Plant Vent Effluent for all Areas Around Callaway Plant Unit 1 (mrem per 2200 hours per year)}

Period of Meteorological Record 12/31/2003 24:00 through 12/31/2006 23:00

Source Term Based on 2004 Release Rates (See Table 12.3-2)

Distance (meters) from Unit 1 Containment

Direction (Toward)	200	250	300	350	400	500	700	800	1000	2000
S	8.62E-02	5.99E-02	4.42E-02	3.40E-02	2.70E-02	1.85E-02	1.08E-02	8.71E-03	6.14E-03	2.09E-03
SSW	8.07E-02	5.60E-02	4.13E-02	3.17E-02	2.52E-02	1.72E-02	1.01E-02	8.10E-03	5.72E-03	1.96E-03
SW	8.79E-02	6.12E-02	4.51E-02	3.47E-02	2.75E-02	1.88E-02	1.10E-02	8.79E-03	6.22E-03	2.13E-03
WSW	5.82E-02	4.01E-02	2.95E-02	2.25E-02	1.78E-02	1.22E-02	7.11E-03	5.71E-03	4.04E-03	1.41E-03
W	5.32E-02	3.67E-02	2.70E-02	2.06E-02	1.63E-02	1.11E-02	6.48E-03	5.20E-03	3.68E-03	1.28E-03
WNW	7.02E-02	4.84E-02	3.55E-02	2.72E-02	2.15E-02	1.46E-02	8.46E-03	6.76E-03	4.78E-03	1.67E-03
NW	1.36E-01	9.38E-02	6.91E-02	5.29E-02	4.19E-02	2.84E-02	1.63E-02	1.30E-02	9.12E-03	3.16E-03
NNW	1.77E-01	1.23E-01	9.04E-02	6.97E-02	5.53E-02	3.76E-02	2.16E-02	1.72E-02	1.20E-02	4.09E-03
N	1.21E-01	8.27E-02	6.05E-02	4.63E-02	3.66E-02	2.47E-02	1.41E-02	1.13E-02	7.97E-03	2.77E-03
NNE	8.96E-02	6.19E-02	4.55E-02	3.49E-02	2.76E-02	1.88E-02	1.07E-02	8.54E-03	5.96E-03	2.03E-03
NE	8.07E-02	5.54E-02	4.05E-02	3.10E-02	2.44E-02	1.65E-02	9.46E-03	7.53E-03	5.29E-03	1.84E-03
ENE	5.37E-02	3.68E-02	2.69E-02	2.04E-02	1.62E-02	1.09E-02	6.24E-03	4.99E-03	3.53E-03	1.25E-03
E	7.98E-02	5.46E-02	3.98E-02	3.04E-02	2.39E-02	1.62E-02	9.29E-03	7.45E-03	5.29E-03	1.88E-03
ESE	8.54E-02	5.89E-02	4.32E-02	3.31E-02	2.61E-02	1.77E-02	1.03E-02	8.20E-03	5.79E-03	2.01E-03
SE	9.04E-02	6.22E-02	4.55E-02	3.48E-02	2.75E-02	1.88E-02	1.09E-02	8.79E-03	6.22E-03	2.18E-03
SSE	8.17E-02	5.65E-02	4.15E-02	3.19E-02	2.53E-02	1.73E-02	1.02E-02	8.18E-03	5.81E-03	2.00E-03

	Construction Areas are Shaded

Table 12.3-4—{Projected TEDE Dose Rates from All Sources in Construction Areas (Maximum Dose Rate mrem/year (mSv/year) Assuming Full Time Occupancy}

Period of Meteorological Record 12/31/2003 24:00 through 12/31/2006 23:00

Source Term Based on 2004 Release Rates (See Table 12.3-2)

Distance (meters) from Unit 1 Containment

Direction (Toward)	200	250	300	350	400	500	700	800	1000	2000
S	4.21E-01	3.03E-01	2.32E-01	1.86E-01	1.55E-01	1.17E-01	8.19E-02	7.25E-02	6.09E-02	4.28E-02
SSW	3.96E-01	2.85E-01	2.19E-01	1.76E-01	1.47E-01	1.11E-01	7.89E-02	6.98E-02	5.91E-02	4.21E-02
SW	4.29E-01	3.09E-01	2.36E-01	1.89E-01	1.57E-01	1.18E-01	8.27E-02	7.29E-02	6.13E-02	4.29E-02
WSW	2.95E-01	2.14E-01	1.66E-01	1.35E-01	1.14E-01	8.83E-02	6.53E-02	5.90E-02	5.15E-02	3.97E-02
W	2.73E-01	1.98E-01	1.55E-01	1.26E-01	1.07E-01	8.34E-02	6.25E-02	5.67E-02	4.99E-02	3.91E-02
WNW	3.49E-01	2.51E-01	1.93E-01	1.56E-01	1.30E-01	9.89E-02	7.14E-02	6.38E-02	5.48E-02	4.08E-02
NW	6.47E-01	4.55E-01	3.44E-01	2.71E-01	2.22E-01	1.61E-01	1.07E-01	9.17E-02	7.44E-02	4.76E-02
NNW	8.32E-01	5.87E-01	4.40E-01	3.47E-01	2.82E-01	2.02E-01	1.31E-01	1.11E-01	8.72E-02	5.17E-02
N	5.76E-01	4.05E-01	3.06E-01	2.42E-01	1.98E-01	1.44E-01	9.70E-02	8.42E-02	6.92E-02	4.58E-02
NNE	4.36E-01	3.12E-01	2.38E-01	1.90E-01	1.58E-01	1.18E-01	8.15E-02	7.18E-02	6.02E-02	4.25E-02
NE	3.96E-01	2.83E-01	2.16E-01	1.73E-01	1.43E-01	1.08E-01	7.59E-02	6.72E-02	5.71E-02	4.16E-02
ENE	2.75E-01	1.99E-01	1.54E-01	1.25E-01	1.06E-01	8.23E-02	6.14E-02	5.58E-02	4.92E-02	3.89E-02
E	3.92E-01	2.79E-01	2.13E-01	1.70E-01	1.41E-01	1.06E-01	7.51E-02	6.69E-02	5.71E-02	4.18E-02
ESE	4.18E-01	2.98E-01	2.28E-01	1.82E-01	1.51E-01	1.13E-01	7.97E-02	7.02E-02	5.94E-02	4.24E-02
SE	4.40E-01	3.13E-01	2.38E-01	1.90E-01	1.57E-01	1.18E-01	8.23E-02	7.29E-02	6.13E-02	4.31E-02
SSE	4.01E-01	2.88E-01	2.20E-01	1.77E-01	1.47E-01	1.11E-01	7.93E-02	7.01E-02	5.95E-02	4.23E-02

	Construction Areas are Shaded

Table 12.3-5— {Annual Average TEDE Dose Rates for 2200 Hour Per Year Occupation Includes Direct Dose of 0.1 mrem/year}

Period of Meteorological Record 12/31/2003 24:00 through 12/31/2006 23:00

Source Term Based on 2004 Release Rates (See Table 12.3-2)

Distance (meters) from Unit 1 Containment

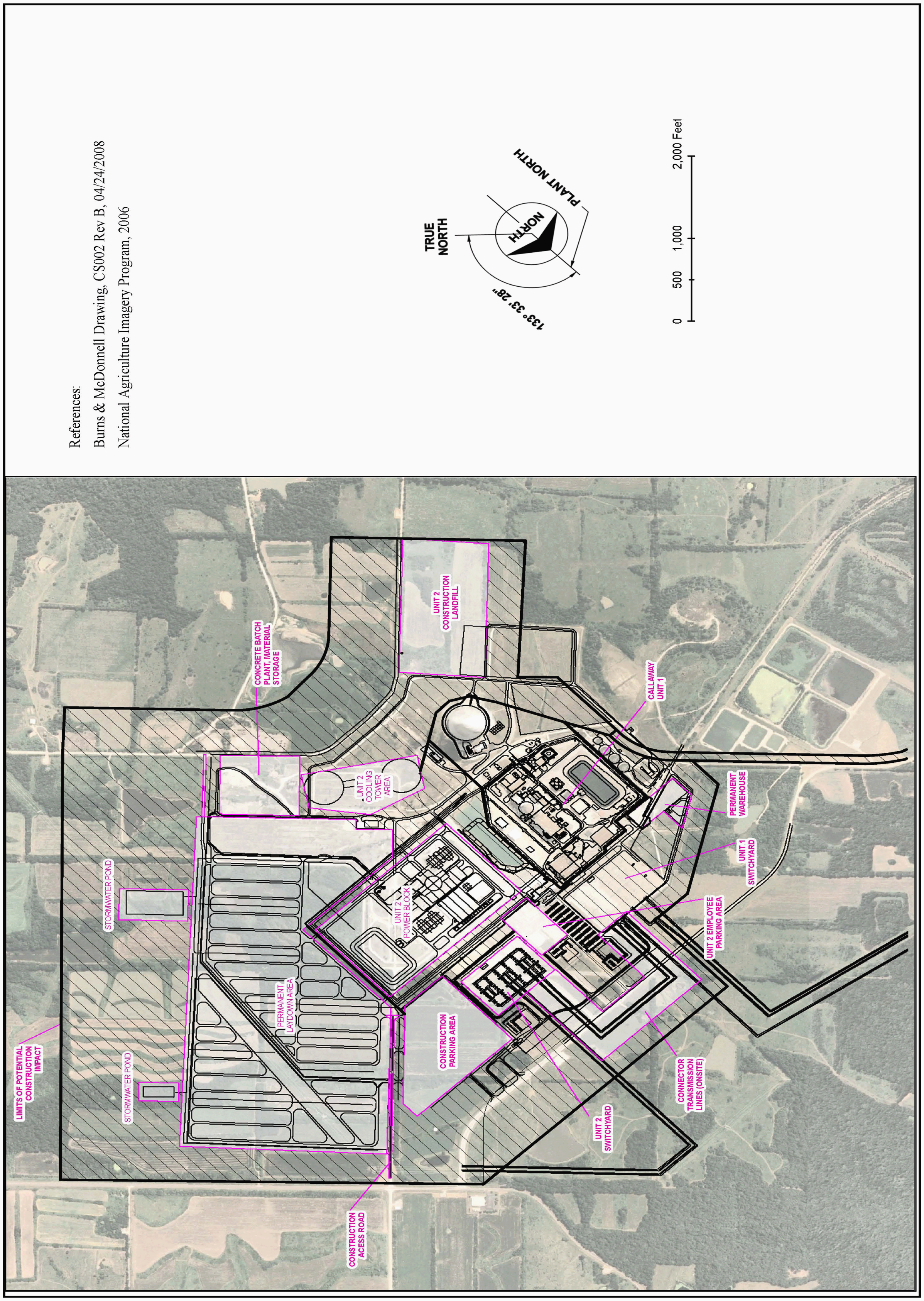
Direction (Toward)	200	250	300	350	400	500	700	800	1000	2000
S	1.06E-01	7.60E-02	5.83E-02	4.68E-02	3.88E-02	2.93E-02	2.06E-02	1.82E-02	1.53E-02	1.07E-02
SSW	9.96E-02	7.17E-02	5.50E-02	4.42E-02	3.68E-02	2.79E-02	1.98E-02	1.75E-02	1.48E-02	1.06E-02
SW	1.08E-01	7.75E-02	5.94E-02	4.75E-02	3.95E-02	2.97E-02	2.08E-02	1.83E-02	1.54E-02	1.08E-02
WSW	7.41E-02	5.37E-02	4.17E-02	3.38E-02	2.85E-02	2.22E-02	1.64E-02	1.48E-02	1.29E-02	9.96E-03
W	6.85E-02	4.98E-02	3.88E-02	3.16E-02	2.68E-02	2.10E-02	1.57E-02	1.42E-02	1.25E-02	9.82E-03
WNW	8.76E-02	6.30E-02	4.85E-02	3.91E-02	3.27E-02	2.48E-02	1.79E-02	1.60E-02	1.38E-02	1.03E-02
NW	1.63E-01	1.14E-01	8.64E-02	6.82E-02	5.57E-02	4.04E-02	2.68E-02	2.30E-02	1.87E-02	1.19E-02
NNW	2.09E-01	1.47E-01	1.11E-01	8.72E-02	7.09E-02	5.08E-02	3.28E-02	2.78E-02	2.19E-02	1.30E-02
N	1.45E-01	1.02E-01	7.68E-02	6.07E-02	4.97E-02	3.63E-02	2.44E-02	2.11E-02	1.74E-02	1.15E-02
NNE	1.10E-01	7.84E-02	5.97E-02	4.78E-02	3.96E-02	2.96E-02	2.05E-02	1.80E-02	1.51E-02	1.07E-02
NE	9.96E-02	7.10E-02	5.42E-02	4.34E-02	3.60E-02	2.70E-02	1.91E-02	1.69E-02	1.43E-02	1.05E-02
ENE	6.91E-02	4.99E-02	3.87E-02	3.15E-02	2.66E-02	2.07E-02	1.54E-02	1.40E-02	1.24E-02	9.78E-03
E	9.85E-02	7.00E-02	5.34E-02	4.27E-02	3.54E-02	2.66E-02	1.89E-02	1.68E-02	1.43E-02	1.05E-02
ESE	1.05E-01	7.49E-02	5.72E-02	4.57E-02	3.79E-02	2.84E-02	2.00E-02	1.76E-02	1.49E-02	1.06E-02
SE	1.11E-01	7.87E-02	5.98E-02	4.77E-02	3.95E-02	2.96E-02	2.07E-02	1.83E-02	1.54E-02	1.08E-02
SSE	1.01E-01	7.22E-02	5.53E-02	4.44E-02	3.69E-02	2.80E-02	1.99E-02	1.76E-02	1.49E-02	1.06E-02

	Construction Areas are Shaded

Table 12.3-6—{Projected Construction Worker Census 2012 to 2017 and Estimated Collective Dose}

Year	Construction Workers on Site	Collective Dose (person-rem) (person-sievert) Based on Average TEDE Dose of 0.1mrem (0.001mSv) in NW Direction 2200 Hrs/year (See Table 12.3-5)
2012	531	0.053 (0.000531)
2013	2,281	0.228 (0.00228)
2014	4,000	0.400 (0.004)
2015	4,000	0.400 (0.004)
2016	4,000	0.400 (0.004)
2017	3,215	0.321 (0.00321)
	Totals	1.800 (0.018)

Figure 12.3-1—{Site Layout of Callaway Plant Unit 2}



12.4 DOSE ASSESSMENT

This section of the U.S. EPR FSAR is incorporated by reference.

12.5 OPERATIONAL RADIATION PROTECTION PROGRAM

This section of the U.S. EPR FSAR is incorporated by reference with the following supplements.

The U.S. EPR FSAR includes the following COL Item in Section 12.5:

> A COL applicant that references the U.S. EPR design certification will fully describe, at the functional level, elements of the Radiation Protection Program. The purpose of this Radiation Protection Program is to maintain occupational and public doses ALARA. The program description will identify how the program is developed, documented, and implemented through plant procedures that address quality requirements commensurate with the scope and extent of licensed activities. This program will comply with the provisions of 10 CFR Parts 19, 20, 50, 52, and 72 and be consistent with the guidance in RGs 1.8, 8.2, 8.4, 8.5, 8.6, 8.8, 8.9, 8.10, 8.13, 8.15, 8.20, 8.26, 8.27, 8.28, 8.29, 8.32, 8.34, 8.35, 8.36, 8.38, and the consolidated guidance in NUREG-1736.

This COL Item is addressed as follows:

This section incorporates by reference NEI 07-03, Generic FSAR Template Guidance for Radiation Protection Description (NEI, 2007).

12.5.1 REFERENCES

{**NEI, 2007**. Generic FSAR Template Guidance for Radiation Protection Program Description, NEI 07-03, Revision 3, Nuclear Energy Institute, October 2007.}