5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).[a] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) Single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

Two classes of accidents are evaluated in the GEIS. These are design-basis accidents (DBAs) and severe accidents, as discussed below.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the “GEIS” include the GEIS and Addendum 1.

5.1.1 Design-Basis Accidents

In order to receive NRC approval to operate a nuclear power facility, an applicant must submit a safety analysis report (SAR) as part of the application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in 10 CFR Part 50 and 10 CFR Part 100.

The environmental impacts of DBAs are evaluated during the initial licensing process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license (OL). The results of these evaluations are found in license documentation such as the staff's safety evaluation report (SER), the final environmental statement (FES), the licensee's updated final safety analysis report (UFSAR), and Section 5.1 of this supplemental environmental impact statement (SEIS). The licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant, including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment will not affect these evaluations. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the license renewal period. Accordingly, the design of the plant relative to DBAs during the extended period is considered to remain acceptable, and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, design-basis events are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of the DBAs make them a part of the current licensing basis of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue, applicable to Fort Calhoun Station, Unit 1, is listed in Table 5-1.

Table 5-1. Category 1 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
POSTULATED ACCIDENTS	
Design-basis accidents	5.3.2; 5.5.1

Based on information in the GEIS, the Commission found that

> The NRC staff has concluded that the environmental impacts of design basis accidents are of small significance for all plants.

The Omaha Public Power District (OPPD) stated in its Environmental Report (ER; OPPD 2002) that it is not aware of any new and significant information associated with the renewal of the Fort Calhoun Station, Unit 1 OL. The staff has not identified any significant new information during its independent review of the OPPD ER, the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts related to this issue beyond those discussed in the GEIS.

5.1.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. The GEIS assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Based on information in the GEIS, the Commission found that

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

Therefore, the Commission has designated mitigation of severe accidents as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue, applicable to Fort Calhoun Station, Unit 1, is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
POSTULATED ACCIDENTS			
Severe Accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	L	5.2

The staff has not identified any significant new information with regard to the consequences from severe accidents during its independent review of the OPPD ER (OPPD 2002), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMAs) for Fort Calhoun Station, Unit 1. The results of the staff's review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe-accident safety performance are identified and evaluated. SAMAs have not been previously considered for Fort Calhoun Station, Unit 1; therefore, the remainder of Chapter 5 addresses those alternatives.

5.2.1 Introduction

The OPPD submitted an assessment of SAMAs for Fort Calhoun Station, Unit 1 as part of the ER (OPPD 2002). This assessment was based on the current Fort Calhoun Station, Unit 1 probabilistic risk assessment (PRA), a plant-specific offsite consequence analysis performed using the MELCOR Accident Consequence Code System 2 (MACCS2) and insights from the Fort Calhoun Station, Unit 1 individual plant examination of external events (IPEEE; Patterson 1995). In identifying and evaluating potential SAMAs, the OPPD considered several

SAMA analyses for other plants and advanced light-water reactor designs, including Watts Bar, Calvert Cliffs, Oconee, Turkey Point, and Combustion Engineering (CE) System 80+, and other documents that discuss potential plant improvements, such as NUREG-1560 (NRC 1997a) and NUREG-1462 (NRC 1994). The OPPD identified and evaluated 190 potential SAMA candidates. This list was reduced to 20 unique SAMA candidates by eliminating SAMAs that either were not applicable to Fort Calhoun Station, Unit 1, were already implemented, were similar to other SAMAs being considered, were prohibitively expensive, or provided minimal risk reduction. Further cost-benefit analysis, including sensitivity studies, showed that 7 of the 20 candidate SAMAs are potentially cost-beneficial. Although the OPPD does not consider it a regulatory commitment, the OPPD is planning to implement these seven SAMAs by the end of 2005.

Based on a review of the SAMA assessment, the NRC issued a request for additional information (RAI) to the OPPD by letter dated July 16, 2002 (Kenyon 2002a). Key questions concerned differences between the PRA used for the SAMA analysis and earlier risk assessments for Fort Calhoun Station, Unit 1, the potential impact of uncertainties and external-event initiators on the study results, the use of importance measures, and detailed information on several candidate SAMAs. The OPPD submitted additional information on September 18, 2002, in response to the RAIs (Ridenoure 2002). This supplemental information was responsive to the staff's concerns and reaffirmed that none of the SAMAs (other than the seven planned for implementation) would be cost-beneficial.

An assessment of the SAMAs for Fort Calhoun Station, Unit 1 is presented below.

5.2.2 Estimate of Risk for Fort Calhoun Station, Unit 1

The OPPD's estimates of offsite risk at Fort Calhoun Station, Unit 1 are summarized in Section 5.2.2.1 of this SEIS. The summary is followed by a review of the OPPD's risk estimates in Section 5.2.2.2 of this SEIS.

5.2.2.1 The OPPD's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the Fort Calhoun Station, Unit 1 Level 1 and 2 PRA performed by the OPPD and documented as the Fort Calhoun Station, Unit 1 PRA, Revision 3 and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis. The Fort Calhoun Station, Unit 1 PRA is a November 2000 update to the Fort Calhoun Station, Unit 1 individual plant examination (IPE) (for internal events) (Gates 1993) and is considered to be a living PRA in that it tracks the changes in the plant design, procedures, and operating changes as they impact the PRA. The scope of the Fort Calhoun Station, Unit 1 PRA does not include full consideration of seismic or fire initiators. However, the dominant seismic sequences are included in the PRA.

The Fort Calhoun Station, Unit 1 IPEEE (Patterson 1995) addresses seismic, fire, tornado, external flooding, transportation, nearby facility accidents, and other external events. The contribution from seismic events was assessed using the seismic margin approach, and the fire risk was assessed using the fire-induced vulnerability evaluation (FIVE) approach. The estimated core damage frequency (CDF) in the Fort Calhoun Station, Unit 1 IPEEE was 3.13×10^{-5} per year. The OPPD notes that the results from the seismic margins approach were not part of the IPEEE CDF, but as noted above, the dominant seismic sequences were subsequently added to the PRA. About 88 percent of the IPEEE CDF is dominated by fires. However, the OPPD's position is that the FIVE methodology results in a fire-induced CDF that is much greater than the actual plant fire CDF.

Although the OPPD did not include the contribution of risk from external events within the Fort Calhoun Station, Unit 1 risk estimates (except for the dominant seismic initiators), the OPPD did account for the potential risk-reduction benefits associated with external events by applying a factor of 2 multiplier to the benefits estimates for internal events. This is discussed further in Sections 5.2.2.2 and 5.2.6.2 of this SEIS.

The total CDF for internal events (including internal flooding), as calculated in the original IPE, was 1.36×10^{-5} per year. The current baseline CDF for internal events (including internal flooding) is approximately 2.4×10^{-5} per year. The breakdown of the CDF is provided in Table 5-3. As shown in this table, loss of offsite power (LOOP), station blackout (SBO), and transients are major contributors to the CDF, accounting for 46 percent of the CDF. Loss-of-coolant accidents (LOCAs), internal flooding, and other internal-events initiators contribute to about 40 percent of the CDF. The containment bypass initiators (interfacing systems LOCA [ISLOCA] and steam-generator tube rupture [SGTR] events) contribute to about 14 percent of the CDF.

In the ER, the OPPD uses 2.48×10^{-5} per year as the baseline CDF. This includes a contribution from seismic events, which, according to the OPPD's response to an RAI, is 1.1×10^{-6} per year (Ridenoure 2002). The sum of internal and seismic yields 2.52×10^{-5} per year, a slight (<2 percent) discrepancy from the 2.48×10^{-5} per year baseline value. In response to a staff question, the OPPD stated that the difference between the two numbers was due to a combination of roundoff and truncation errors (Kenyon 2002b).

Table 5-3. Fort Calhoun Station, Unit 1 CDF for Internal Events

Initiating Event	Frequency (per year)	Percent Contribution to the CDF
Loss of offsite power (LOOP)	3.8×10^{-6}	16
Station blackout (SBO)	4.2×10^{-6}	17
Transients	3.0×10^{-6}	13
Anticipated transient without scram (ATWS)	Negligible	Negligible
Loss-of-coolant accident (LOCA)	6.3×10^{-6}	26
Interfacing systems LOCA (ISLOCA)	9.6×10^{-7}	4
Steam-generator tube rupture (SGTR)	2.3×10^{-6}	10
Internal flooding	1.3×10^{-6}	5
Others	2.3×10^{-6}	9
Total CDF (from internal events)	2.41×10^{-5}	100

The Level 2 PRA model is based on the containment event tree and source terms from the IPE (Gates 1993). A description of the plant damage states (PDSs) input to the Level 2 analysis was provided in the OPPD's response to staff RAIs (Ridenoure 2002). Of the 520 potential PDSs, 12 listed in the response have contributions greater than 1 percent of the CDF. The PDSs are propagated into release classes with corresponding source terms. A summary of the mapping of the initiating events into the release categories was also provided in the RAI responses (Ridenoure 2002). The fission-product release fractions and characteristics (source terms) for each release category are provided in Table 4.8.2.6 of the Fort Calhoun Station, Unit 1 IPE (Gates 1993).

The offsite-consequences and economic-impact analyses use the MACCS2 code, Version 1.12, to determine the offsite risk impacts on the surrounding environment and public. Inputs for this analysis include plant- and site-specific input values for core radionuclide inventory, source term and release fractions, meteorological data, projected population (within an 80-km [50-mi] radius) for the year 2030, emergency response evacuation modeling, and economic data.

The OPPD estimated the dose to the population within 80 km (50 mi) of Fort Calhoun Station to be approximately 0.1 person-Sv (10.2 person-rem) per year. The breakdown of the total population dose by containment release mode is summarized in Table 5-4. Releases due to containment bypass (i.e., SGTR and ISLOCAs) account for most (71 percent) of the population dose risk at Fort Calhoun Station, Unit 1. Early and late containment failures contribute about 16 percent and 11 percent of the population dose, respectively. Events in which the containment remains intact account for the remaining 2 percent of the population dose.

Table 5-4. Breakdown of Population Dose by Containment Release Mode

Containment Release Mode	Population Dose [person-rem[a] per year]
SGTR (Late and Early)	4.7
ISLOCAs	2.5
Early containment failure	1.6
Late containment failure	1.1
No vessel breach, no containment failure	0.2
No containment failure	<0.05
Total	10.2

[a]1 person-Sv = 100 person-rem

5.2.2.2 Review of the OPPD's Risk Estimates

The OPPD's estimate of offsite risk at Fort Calhoun Station, Unit 1 is based on the following major elements of the analysis:

- the Level 1 and 2 risk models that form the bases for the 1993 IPE and 1995 IPEEE submittals (Gates 1993; Patterson 1995),
- the major modifications to the IPE model that have been incorporated in the Fort Calhoun Station, Unit 1 PRA, as provided by the licensee in response to RAIs (Ridenoure 2002), and
- the MACCS2 analyses performed to translate fission-product release frequencies from the Level 2 PRA model into offsite consequence measures.

Each of these analyses was reviewed to determine the acceptability of the OPPD's risk estimates for the SAMA analysis, as summarized below.

The staff's review of the Fort Calhoun Station, Unit 1 IPE is described in an NRC report dated December 9, 1996 (Wharton 1996b). In that review, the staff evaluated the methodology, models, data, and assumptions used to estimate the CDF and characterize containment performance and fission-product releases. The staff concluded that the OPPD's analysis met the intent of Generic Letter 88-20 (NRC 1988); that is, the IPE was of adequate quality to be used to look for design or operational vulnerabilities. The staff's review primarily focused on the licensee's ability to examine Fort Calhoun Station, Unit 1 for severe-accident vulnerabilities and not specifically on the detailed findings or quantification estimates. Overall, the staff concluded that the Fort Calhoun Station, Unit 1 IPE was of adequate quality to be used as a tool in searching for areas with high potential for risk reduction and to assess such risk reductions, especially when the risk models are used in conjunction with insights, such as those from risk importance, sensitivity, and uncertainty analyses.

The Fort Calhoun Station, Unit 1 PRA has been updated several times since the IPE to reflect changes in data on equipment performance, plant configuration, and PRA model refinements. In response to an RAI, the OPPD provided a description of plant and PRA model changes implemented since the IPE (Ridenoure 2002). The specific changes to the plant and PRA include the following:

- adding two 161-kV lines, two 345/161-kV auto-transformers, and interconnection capabilities to improve alternating current (ac) power reliability;

- modifying the condensate-storage-tank dump valve and installing a protective trip-override switch to improve the availability of the diesel-driven auxiliary feedwater pump;

- making potable water and raw water available for makeup to the emergency feedwater storage tank and modifying the roof hatch to allow makeup following a turbine-building fire;

- reconfiguring a component cooling-water isolation valve to provide improved closure capabilities in ISLOCA-type events;

- procuring and prestaging portable pumps for feeding steam generators (SGs) in external-flooding events;

- updating initiating event frequencies based upon the CE Owners Group (CEOG) standard;

- improving the human reliability analysis (HRA) dependency analysis;

- adding common-cause basic events for emergency-core-cooling-system (ECCS) sump strainer blockage and for common-cause battery demand failure; and

- revising the model to account for possible loss of air to air-operated ECCS recirculation actuation switches and valves.

The changes from the IPE version to the current PRA appear to be reasonable and have a relatively small effect on the PRA results. A comparison of risk profiles between the IPE and the PRA used in the SAMA analysis indicates a slight (1×10^{-5} per year) increase in the total CDF.

In an RAI, the staff questioned whether the current Fort Calhoun Station, Unit 1 PRA had been subjected to peer review (Kenyon 2002a). In response, the OPPD noted that the PRA was peer-reviewed by a team of PRA engineers from Westinghouse, four other utilities, and a PRA consultant (Ridenoure 2002). This peer review was conducted in accordance with the CEOG implementation of the nuclear-industry, peer-review process documented in NEI 00-02 (NEI 2000). The peer review resulted in a total of 89 specific peer-review comments and observations, seven of which were identified by the OPPD for expedited resolution and were included in the plant's PRA configuration-control program. In response to a further staff inquiry, the OPPD stated that two of the seven items were already resolved in the Revision 3 PRA model used in the initial SAMA evaluation. The other five items, mainly related to human-reliability dependencies and methodologies, were not specifically addressed in the PRA, but these items were qualitatively reviewed by the OPPD and were judged to have no significant impact on the SAMA analysis (Kenyon 2002b).

The IPE and updated CDF values for Fort Calhoun Station, Unit 1 are lower than most of the original IPE values estimated for other pressurized-water reactors (PWRs) with a large, dry containment. Figure 11.6 of NUREG-1560 shows that the IPE-based total internal-events CDF for CE plants ranges from 1×10^{-5} to 3×10^{-4} per year (NRC 1997a). While it is recognized that other plants have reduced the values for CDF since the IPE submittals, due to modeling and hardware changes, the CDF results for Fort Calhoun Station, Unit 1 confirm that the overall risks are lower than or comparable to other plants of similar vintage and characteristics.

The OPPD submitted an IPEEE by letter dated June 30, 1995 (Patterson 1995), in response to Supplement 4 of Generic Letter 88-20. The OPPD did not identify any fundamental weaknesses or vulnerabilities to severe-accident risk in regard to the external events related to seismic, fire, or other external events. The Fort Calhoun Station, Unit 1 high-winds and tornado analyses show that Fort Calhoun Station, Unit 1 is adequately designed or that procedures exist to cope against the effects of these natural events. Additionally, the Fort Calhoun Station, Unit 1 IPEEE demonstrated that transportation and nearby facility accidents were not considered to be significant vulnerabilities at Fort Calhoun Station, Unit 1. However, a number of areas were identified for improvement in both the seismic and fire areas. In a letter dated May 6, 1996 (Wharton 1996a), the staff concluded that the submittal met the intent of Supplement 4 to Generic Letter 88-20 and that the licensee's IPEEE process is capable of identifying the most likely severe accidents and severe-accident vulnerabilities.

The ER (OPPD 2002) acknowledges that the methods used for the Fort Calhoun Station, Unit 1 IPEEE do not provide the means to determine the numerical estimates of the CDF contributions from seismic initiators (i.e., the seismic IPEEE uses a reduced-scope margins method emphasizing plant walkdowns) and fire initiators (i.e., the fire IPEEE uses the FIVE method). The IPEEE fire CDF estimates are considered by the OPPD to be conservative and overestimate the fire risk for screening purposes (OPPD 2002). The OPPD performed several procedural and hardware modifications in the areas of seismic, external flooding, and fire. As a result, the seismic and external flooding CDF was reduced by almost 2 orders of magnitude, and the fire CDF was reduced by a factor of 3 (Patterson 1995).

Because of the small expected contribution of external events to the overall risk profile for Fort Calhoun Station, Unit 1, the risk-reduction estimates for the SAMAs were evaluated based on a consideration of the internal-events risk profile. However, in the SAMA screening process described in Section 5.3 of Appendix 5 of the ER, the OPPD screened out SAMAs from further consideration only if a SAMA's implementation cost would be greater than twice its estimated benefit (based on internal events). The staff notes that the contribution of external events to total risk would be bounded by this factor of 2 if (1) the total contribution from external events is a small fraction of the contribution from internal events and (2) there are no external-event vulnerabilities that can be eliminated or mitigated by cost-effective SAMAs. As noted above, the external-event contribution to total CDF at Fort Calhoun Station, Unit 1 is small, and the OPPD has previously made modifications specifically addressing external-event vulnerabilities. Also, the use of a factor of 2 multiplier results in a CDF that exceeds the 95^{th} percentile CDF for internal events (see Table 5-6). Finally, as discussed in Section 5.2.6.2 of this SEIS, the OPPD assessed the impact that the use of a factor of 3 would have on the SAMA process and concluded that the results would not be altered. Based on the above considerations, the staff finds the OPPD's treatment of external events within the SAMA analysis to be acceptable.

The staff reviewed the process used by the OPPD to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (a Level 3 PRA). This included consideration of the source terms used to characterize fission-product releases for each containment-release category and the major input assumptions used in the offsite consequence analyses. The MACCS2 code was used to estimate offsite consequences. Plant-specific input to the code includes the Fort Calhoun Station, Unit 1 reactor core radionuclide inventory (obtained from Fort Calhoun Station, Unit 1-specific ORIGEN-S computer code calculations performed as part of the OPPD alternative source-term application submittal of February 2001), emergency evacuation modeling, release category source terms from the Fort Calhoun Station, Unit 1 IPE, site-specific meteorological data, and projected population distribution within an 80-km (50-mi) radius for the year 2030. This information is provided in Section 5.2 of the ER (OPPD 2002).

The applicant used source-term release fractions for 27 different release classes defined for Fort Calhoun Station. The staff reviewed the OPPD's source-term estimates for the major release categories and found the release fractions to be consistent with those of similarly designed plants and of expected magnitudes when considering early versus late containment failures and rupture versus leak-type failures. A sensitivity analysis was performed for a 10-percent increase in the fission-product release. The increase in fission-product release results in approximately a 6-percent increase in population dose risk. The staff concludes that the assignment of source terms is acceptable for use in the SAMA analysis.

The applicant used site-specific meteorological data (wind speed, wind direction, stability class, and precipitation) processed from hourly measurements for the 1998 calendar year as input to the MACCS2 code. As a sensitivity study, the applicant also considered the meteorological data from 1994 to 1998 to verify that the 1998 data set is representative for Fort Calhoun Station.

A detailed discussion of the methodology for estimating population is provided in Section 5.2.1.4 of the ER (OPPD 2002). Briefly summarized, 1990 census data were used to prepare population estimates for the region surrounding the plant. The 1990 population distribution by sector for the 80-km (50-mi) region was prepared using population data extracted from the STF3A files released by the U.S. Bureau of the Census in 1992 (USBC 1992). A commercially available geographic-information tool was used to estimate the population within each of 16 sectors. The total 1990 population residing in the 80-km (50-mi) radius region was estimated to be 770,000 persons.

County-level data extracted from the year 2000 census data were used to estimate the year 2000 population distribution. Changes in population between 1990 and 2000 were calculated under the assumption that an increase or decrease in the population for each census block group within a given county was the same as that of the county as a whole. The total year 2000 80-km (50-mi) radius population estimate is 853,000 persons.

County-specific population estimates were used to extrapolate the year 2000 population estimate to year 2030. County-population projections for the year 2030 were not available for the states of Iowa and Nebraska; therefore, straight-line projections to the year 2030 were made using available population projections for 2020 and 2025 (Iowa) or 2015 and 2020 (Nebraska). The county-population change factors were then applied to the respective block groups. The year 2030 80-km (50-mi) radius population total for the Fort Calhoun Station, Unit 1 region was estimated to be 1,056,000 persons. The staff considers the methods and assumptions for estimating population reasonable and acceptable for purposes of the SAMA analysis.

The emergency evacuation model was modeled as a single evacuation zone extending out 16 km (10 mi) from the plant. It was assumed that 95 percent of the population would move at an average speed of approximately 2 m/s with a 45-minute delay time. This assumption is conservative relative to the NUREG-1150 study (NRC 1990), which assumed an evacuation of 99.5 percent of the population within the emergency planning zone. In addition, a sensitivity analysis was performed that assumed both 100-percent evacuation and no evacuation of the surrounding population. The difference between the two evacuation assumptions (zero and 100 percent) correlates to approximately a 10-percent variation in population dose. The evacuation assumptions and analysis are deemed reasonable and acceptable for the purposes of the SAMA evaluation.

The staff concludes that the methodology used by the OPPD to estimate the CDF and offsite consequences for Fort Calhoun Station, Unit 1 provides an acceptable basis from which to proceed with an assessment of risk-reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDF and offsite doses reported by the OPPD.

5.2.3 Potential Plant Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by the OPPD are discussed in this section.

5.2.3.1 Process for Identifying Potential Plant Improvements

The OPPD’s process for identifying potential plant improvements (SAMAs) consisted of the following elements:

- review of plant-specific improvements identified in the Fort Calhoun Station, Unit 1 IPE and IPEEE,
- review of SAMA analyses submitted in support of original licensing and license renewal activities for other operating nuclear power plants,
- review of other NRC and industry documentation discussing potential plant improvements (e.g., NUREG-1560 and NUREG-1462),
- a review of the top 100 cut sets and risk achievement worth (RAW) and Fussel–Vesely (F–V) importance measures from Revision 3 of the PRA, and
- insights provided by Fort Calhoun Station, Unit 1 staff.

Based on this process, an initial list of 190 candidate SAMAs was identified, as reported in Table 5.3-1 of the ER (OPPD 2002). The OPPD performed a qualitative screening of the initial list of SAMAs and screened SAMAs from further consideration using the following criteria:

- the SAMA has already been implemented at Fort Calhoun Station, Unit 1, or the plant design meets the intent of the SAMA;

- the SAMA modifies features not applicable to Fort Calhoun Station, Unit 1;
- the SAMA will involve major plant design and/or structural changes that will clearly be well in excess of the maximum attainable benefit (MAB);
- the SAMA will provide only minimal risk reduction based on a review of system risk-reduction worth (RRW) values and other plant metrics, or previous system review results; or
- the SAMA duplicates or can be consolidated with one or more other SAMA being considered.

Based on the qualitative screening, 170 SAMAs were eliminated, leaving 20 for further evaluation. Of the 170 SAMAs eliminated, 50 were eliminated because they already had been implemented at Fort Calhoun Station, Unit 1 (or the design met the intent of the SAMA), 57 were eliminated because they were not applicable to Fort Calhoun Station, Unit 1, 31 were prohibitively expensive, 24 resulted in minimal risk reduction, and 8 were duplicates or were combined with other SAMAs. The 20 remaining SAMAs are discussed in Section 5.4 of the ER (OPPD 2002) and were subjected to further evaluation and final screening.

The final screening process was conducted in two steps: (1) identifying and eliminating those SAMAs whose cost exceeded the MAB ($784,000, as discussed in Section 5.2.6.1 of this SEIS) and (2) performing a more detailed cost-benefit analysis on the remaining SAMAs and eliminating those SAMAs whose costs exceeded twice their calculated benefit. Of the 20 SAMAs surviving the initial screening, 6 were identified as cost-beneficial. Two additional SAMAs were determined to be potentially cost-beneficial based on sensitivity analyses. These SAMAs are discussed further in Section 5.2.6 of this SEIS.

5.2.3.2 Staff Evaluation

The OPPD's efforts to identify potential SAMAs focused primarily on areas associated with internal initiating events. The initial list of SAMAs generally addressed the accident categories that are dominant CDF contributors or issues that tend to have a large impact on a number of accident sequences at Fort Calhoun Station, Unit 1.

The staff requested more information on how the OPPD used cut sets and importance measures to identify candidate SAMAs. A review of the importance ranking of basic events in the PRA has the potential to identify SAMAs that may not be apparent from a review of the top cut sets. In response to the RAI, the OPPD explained that the lists of components and actions with high RRW values (greater than 1.1) or F–V values (greater than 0.005) were assembled and reviewed to establish a potential means of improving the component's or action's reliability or of using alternate systems or components to meet the intent of the component. In addition, the OPPD examined the top 100 cut sets, which account for about 64 percent of the CDF, to identify potential SAMAs (Ridenoure 2002).

The potential SAMA candidates included both hardware and procedural alternatives. The set of SAMAs considered also includes low-cost alternatives, which have the greatest potential for being cost-beneficial.

The OPPD's efforts to identify potential SAMAs focused primarily on areas associated with internal initiating events. This is reasonable, since external events contribute a small amount to the total CDF and the containment response to external events was found to be similar to that from internal events in the IPE. The list of 20 candidate SAMAs generally addressed (1) the accident categories that are dominant CDF contributors or (2) issues that tend to have a large impact on a number of accident sequences at Fort Calhoun Station, Unit 1.

The staff notes that the set of SAMAs submitted is not all inclusive since additional, possibly even less expensive, design alternatives can always be postulated. However, the staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least-expensive alternatives evaluated when the subsidiary costs associated with maintenance, procedures, and training are considered.

It should be noted that the OPPD has previously implemented processes to identify and voluntarily implement cost-beneficial enhancements to further reduce risk at Fort Calhoun Station, Unit 1. This has resulted in the implementation of numerous plant enhancements, as described in Section 5.2.2.2 of this SEIS, and reduction of the risk at Fort Calhoun Station, Unit 1 from both internally and externally initiated events. The staff concludes that the OPPD used a systematic process for identifying further plant improvements for Fort Calhoun Station, Unit 1 and that the set of potential plant improvements identified by the OPPD is reasonably comprehensive and therefore acceptable. This search included using the knowledge and experience of its PRA personnel; reviewing insights from the IPE, IPEEE, and other plant-specific studies; and reviewing plant improvements in previous SAMA analyses. While the explicit treatment of external events in the SAMA identification process was limited, it is recognized that the prior implementation of plant modifications for external events and fires, and the absence of external-event vulnerabilities reasonably justifies examining primarily the internal-events risk results for this purpose.

5.2.4 Risk-Reduction Potential of Plant Improvements

The OPPD evaluated the risk-reduction potential of the 20 SAMA candidates surviving the initial screening. Each SAMA evaluation was performed in a bounding fashion in that the SAMA was assumed to eliminate the core damage events the SAMA is intended to address or substantially reduce the frequency of these events. Such bounding calculations overestimate the benefit of each SAMA and are conservative.

The OPPD used two types of evaluations, model and cut set requantification, to determine the benefit of the SAMAs. Requantified PRA results were used to establish both the CDF change and its impact on the change in the fission-product classes. These results were combined with MACCS2 release class impacts to determine the change in offsite exposure risk. Some of the SAMAs were more quickly evaluated by examining the contribution of specific components or human actions to the CDF.

Table 5-5 lists the assumptions used to estimate the risk reduction for each of the 20 SAMAs, the estimated risk reduction in terms of percent reduction in CDF and population dose, and the estimated total benefit (present value) of the averted risk. The determination of the benefits for the various SAMAs is discussed in Section 5.2.6 of this SEIS.

In response to an RAI, the OPPD considered the uncertainties associated with the calculated CDF. This matter is considered further in Section 5.2.6.2 of this SEIS.

The staff has reviewed the OPPD's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the staff based its estimates of averted risk for the various SAMAs on the OPPD's risk-reduction estimates.

5.2.5 Cost Impacts of Candidate Plant Improvements

The OPPD estimated the costs of implementing the 20 SAMAs, which were not initially screened out, through the application of engineering judgment, estimates from other licensees' submittals, and site-specific cost estimates. The cost estimates conservatively did not include the cost of replacement power during extended outages that would be required to implement the modifications, nor did the estimates include contingency costs associated with unforeseen implementation obstacles. Estimates based on modifications implemented or estimated in the past were presented in terms of dollar values at the time of implementation and were not adjusted to present-day dollars. The depth of analysis performed varied depending on the magnitude of the expected benefit. For most of the SAMAs considered, the cost estimates were sufficiently greater than the benefits calculated such that no detailed evaluation was required. Detailed cost-estimating was only applied in those situations in which the benefit is significant and the application of judgement would be questioned.

Table 5-5. SAMA Cost/Benefit Screening Analysis

SAMA #	SAMA[(a)]	Assumptions	Percent Risk Reduction: CDF	Percent Risk Reduction: Population Dose	Total Benefit (2001 dollars)	Cost (2001 dollars)
Improvements Related to the Mitigation of the Reactor Coolant Pump (RCP) Seal LOCA						
4	**Implement procedure and operator-training enhancements for support-system failure sequences, with an emphasis on anticipating problems and coping with events that could lead to loss of cooling to RCP seals.**	**All core damage events associated with loss-of-component, cooling-water (LOCCW) initiators and those associated with SBOs with induced RCP seal failures are eliminated.**	**5**	**2.4**	**$27,000**	**>$30,000**
9	Install an additional service water pump	All core damage events associated with a LOCCW are eliminated.	3	1.4	$17,000	>2 × benefit
10	Install the improved N 9000 RCP seals	Same as SAMA 4.	5	2.4	$27,000	>$2M
41	Use the fire-protection system (FPS) as a backup source for the containment spray system	All late containment failures are eliminated.	0	8.5	$23,000	>2 × benefit
Improvements in Identifying or Coping with Containment Bypass						
52	Install additional batteries to extend 125-V direct current (dc) battery life to 24 hours	All late SBOs core damage sequences are eliminated.	16	12	$111,000	$3.5M
54	Incorporate an alternate battery-charging capability by adding an independent power supply (20-kW dc source) to charge batteries	All late SBOs core damage sequences are eliminated.	16	12	$111,000	>$150,000

[(a)]SAMAs in bold were judged to be cost-beneficial.

Table 5-5 (contd)

SAMA #	SAMA[a]	Assumptions	Percent Risk Reduction: CDF	Percent Risk Reduction: Population Dose	Total Benefit (2001 dollars)	Cost (2001 dollars)
56	Improve 125-V dc busload management to allow the 125-V dc batteries to last for 24 hours	All late SBOs core damage sequences are eliminated.	16	12	$111,000	>$160,000
60	Develop procedures to repair or replace failed 4-kV breakers	Basic events ECBD1A11, ECBD1A31, ECBD1A22, and ECBD1A42 were set to zero.	0	0	0	NA
88	Develop procedures and install systems such that every possible ISLOCA path would undergo scrubbing	All ISLOCA sequences are scrubbed, reducing the associated releases by a factor of 5.	0	12.8	$35,000	>2 × benefit
92	**Modify procedures to conserve or prolong the inventory in the borated-water storage tank (safety injection refueling water storage tank [SIRWT]) during SGTRs**	**Failures associated with the depletion of the SIRWT inventory during ISLOCAs and SGTRs are eliminated.**	**25**	**16.4**	**$165,000**	**<$30,000**
Fort Calhoun Station, Unit 1-Specific SAMAs						
181	**Add accumulators or implement training on SIRWT bubblers and recirculation valves**	**The air supply to the bubblers will always be available.**	**17.2**	**3.6**	**$78,000**	**<$30,000**
182	**Add capability for SG-level indication during SBO**	**All SBOs that were not predicted to have induced RCP seal failure are eliminated.**	**17.2**	**3.6**	**$76,000**	**<$30,000**

[a] SAMAs in bold were judged to be cost-beneficial.

Table 5-5 (contd)

SAMA #	SAMA[(a)]	Assumptions	Percent Risk Reduction: CDF	Percent Risk Reduction: Population Dose	Total Benefit (2001 dollars)	Cost (2001 dollars)
183	**Add 480-V ac power supply to open the power-operated relief valve (PORV)**	**No credit was taken for the use of the PORV in averting core damage. For post-core damage, all SGTRs that result in direct releases to the environment are assumed to go to zero.**	**0**	**7.8**	**$32,000**	**<$25,000**
184	**Add capability to flash the field on the emergency diesel generator (EDG) to enhance SBO recovery**	**Twenty percent of the mechanical failures of the EDGs and 15 percent of the battery-related failures are recoverable.**	**27**	**5.4**	**$118,000**	**<$30,000**
185	Remove SI-2C from auto-start	The recirculation actuation signal (RAS) dependency on SI-2C is eliminated.	10	2	$44,000	>2 × benefit
186	**Add manual steam-relief capability and associated procedures**	**Twenty percent of SGTR CDF and all CDF for small LOCA sequences are eliminated.**	**3**	**12.6**	**$62,000**	**<$40,000**
187	Enhance operation of FW-54	FW-54 (diesel-driven auxiliary feedwater pump) will never fail.	3	0.5	$14,000	>2 × benefit
188	Enhance external-flooding procedures	CDF for external flooding is reduced by 50 percent.	17 percent of flooding CDF	<<1	$16,000	>2 × benefit
189	Add trisodium phosphate into the auxiliary-building sumps	ISLOCA releases from small LOCA events are reduced by a factor of 5.	0	6.4	$17,000	>2 × benefit
190	Enhance emergency operating procedures to provide guidance to operators to better avert thermally induced SGTRs	All SGTR event loss-of-isolation releases are eliminated.	0	2.4	$20,000	>$30,000

[(a)]SAMAs in bold were judged to be cost-beneficial.

The staff reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared the cost estimates (presented in Table 4.16-2 of the ER [OPPD 2002]) to estimates developed elsewhere for similar improvements, including estimates developed as part of other licensees' analyses of SAMAs for operating reactors and advanced light-water reactors. Most of the SAMAs were screened from further consideration on the basis that the expected implementation cost would be much greater than twice the estimated risk-reduction benefit. This is reasonable for the SAMAs considered, given the relatively small estimated benefit for the SAMAs (a maximum benefit of about $165,000) and the large implementation costs typically associated with major hardware changes and hardware changes that impact safety-related systems. In previous SAMA evaluations, the implementation costs for such hardware changes were generally estimated to be $1 million or more. Where specific cost estimates were provided in the ER (OPPD 2002), these were typically obtained from previous licensees' ERs or from other industry submittals, most of which have been previously reviewed by the NRC. Accordingly, the cost estimates were found to be consistent with previous estimates. The staff concludes that the cost estimates are sufficient and appropriate for use in the SAMA evaluation.

5.2.6 Cost-Benefit Comparison

The OPPD's cost-benefit analysis and the staff's review are described in the following sections.

5.2.6.1 The OPPD Evaluation

The methodology used by the OPPD was based primarily on the NRC's guidance for performing cost-benefit analysis in the *Regulatory Analysis Technical Evaluation Handbook*, NUREG/BR-0184 (NRC 1997b). The guidance involves determining the net value for each SAMA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) – COE,

where

APE = present value of averted public exposure ($),

AOC = present value of averted offsite property damage costs ($),

AOE = present value of averted occupational exposure costs ($),

AOSC = present value of averted onsite costs ($), and

COE = cost of enhancement ($).

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA, and it is not considered cost-beneficial. The OPPD's derivation of each of the associated costs is summarized below.

<u>Averted Public Exposure Costs</u>

The averted public exposure (APE) costs were calculated using the following formula:

APE = annual reduction in public exposure (person-rem/year)
× monetary equivalent of unit dose ($2000 per person-rem)
× present-value conversion factor (10.76 based on a 20-year period with a 7-percent discount rate).

As stated in NUREG/BR-0184 (NRC 1997b), it is important to note that the monetary value of the public-health risk after discounting does not represent the expected reduction in public-health risk due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss due to a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these potential future losses to present value. For the purposes of initial screening, the OPPD calculated an APE of approximately $218,000 for the 20-year license renewal period, which assumes the elimination of all severe accidents.

<u>Averted Offsite Property Damage Costs</u>

The averted offsite property damage costs (AOCs) were calculated using the following formula:

AOC = annual CDF reduction
× offsite economic costs associated with a severe accident (on a per-event basis)
× present-value conversion factor.

For the purposes of initial screening, which assumes all severe accidents are eliminated, the OPPD calculated an annual offsite economic risk of $15,427 based on the Level 3 risk analysis. This results in a discounted value of approximately $166,000 for the 20-year license renewal period.

Postulated Accidents

Averted Occupational Exposure Costs

The averted occupational exposure (AOE) costs were calculated using the following formula:

AOE = annual CDF reduction
× occupational exposure per core damage event
× monetary equivalent of unit dose
× present-value conversion factor.

The OPPD derived the values for AOE from information provided in Section 5.7.3 of the regulatory analysis handbook (NRC 1997b). Best-estimate values provided for immediate occupational dose (3300 person-rem) and long-term occupational dose (20,000 person-rem over a 10-year cleanup period) were used. The present value of these doses was calculated using the equations provided in the handbook in conjunction with a monetary equivalent of unit dose of $2000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. For the purposes of initial screening, which assumes all severe accidents are eliminated, the OPPD calculated an AOE of approximately $9000.

Averted Onsite Costs

Averted onsite costs (AOSCs) include averted cleanup and decontamination costs and averted replacement-power costs (RPCs). Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. The OPPD derived the values for the AOSCs based on information provided in Section 5.7.6 of the regulatory analysis handbook (NRC 1997b).

The OPPD divided this cost element into two parts, the onsite cleanup and decontamination cost (also commonly referred to as averted cleanup and decontamination costs [ACCs]) and the RPC.

ACCs were calculated using the following formula:

ACC = annual CDF reduction
× present value of cleanup costs per core damage event
× present-value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in the regulatory analysis handbook (NRC 1997b) to be $\$1.5 \times 10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension.

Long-term RPCs were calculated using the following formula:

RPC = annual CDF reduction
× present value of replacement power for a single event
× factor to account for remaining service years for which replacement power is required
× reactor power scaling factor

Fort Calhoun Station, Unit 1 has a gross electrical rating of 478 MW(e), which is much lower than the reference rating in NUREG/BR-0184 (NRC 1997b). Thus, a reactor power scaling factor (478/910) of 0.53 was applied to the corresponding formula. For the purposes of initial screening, which assumes all severe accidents are eliminated, the OPPD calculated the AOSC to be approximately $391,000.

Using the above equations, the OPPD estimated the total present dollar-value equivalent associated with completely eliminating all severe accident risk at Fort Calhoun Station, Unit 1 to be $784,000.

<u>The OPPD's Results</u>

If the implementation costs of a SAMA were greater than the MAB of $784,000, then the SAMA was screened from further consideration. A more refined look at the costs and benefits was performed for the remaining SAMAs. If the expected cost for those SAMAs exceeded twice the calculated benefit, the SAMA was considered not to be cost-beneficial. The cost-benefit results for the individual analysis of the 20 SAMA candidates are presented in Table 5-5. As a result, the following six SAMAs were considered to be cost-beneficial:

- SAMA 92 – Conserve/make up borated-water storage tank inventory post-accident. This SAMA candidate would modify procedures to conserve or prolong the inventory in the borated-water storage tank (SIRWT) during SGTRs.

- SAMA 181 – Add accumulators or implement training on SIRWT bubblers and recirculation valves. This SAMA candidate would involve adding the capability to prevent an early RAS following the loss of instrument air by revising procedures to support operator actions to avert and/or recover from the premature RAS.

- SAMA 182 – Add capability for SG-level indication during an SBO. This SAMA candidate would use a portable 120-V ac generator with manual clamps to provide power supply to the SG-level instrumentation.

- SAMA 183 – Add a 480-V ac power supply to open the PORV. This SAMA candidate would use a portable power source, inverter, cables, and necessary guidance for use as a backup power supply for opening the PORVs during ISLOCAs and some SGTRs.

- SAMA 184 – Add capability to flash the field on the EDG to enhance SBO recovery. This SAMA candidate is intended to increase the capability to cope with an SBO event by using a power supply to flash the field (i.e., start an EDG if one or more EDGs fail to start or if an EDG fails and restart is required after battery depletion).

- SAMA 186 – Add manual steam-relief capability and associated procedures. This SAMA candidate involves performing specific procedural and/or hardware changes to give the plant the alternate capability to increase heat removal from the reactor coolant system (RCS) and accelerate RCS cooldown. Hardware changes may include nitrogen backup to open the main steam valves.

The OPPD performed sensitivity analyses to evaluate the impact of parameter choices on the analysis results (OPPD 2002). The sensitivity analyses included the calculation of candidate SAMA benefits using a 3-percent discount rate, as recommended in NUREG/BR-0184 (NRC 1997b). As a result, two additional SAMA candidates were determined to be potentially cost-beneficial:

- SAMA 4 – Implement procedure and operator-training enhancements to anticipate problems and cope with events that lead to loss of cooling to RCP seals

- SAMA 54 – Add independent power supply to charge batteries.

As stated in the ER (OPPD 2002), the OPPD plans to implement the first seven of the SAMAs listed above. The implementation of these SAMAs reduces the benefit of the last SAMA (SAMA 54) such that it is not cost-beneficial. The OPPD expects the SAMA implementations to be completed by the end of 2005.

5.2.6.2 Staff Evaluation

The cost-benefit analysis performed by the OPPD was based primarily on NUREG/BR-0184 (NRC 1997b) and was executed appropriately. The analysis included a 3-percent discount rate sensitivity study, as recommended in the regulatory analysis handbook (NRC 1997b), which led to the reconsideration of some SAMAs.

The OPPD's assessment of SAMAs (OPPD 2002) indicated that an upper-bound CDF for fires plus internal events (including the dominant seismic contributors) could be about a factor of 3 higher than the mean value. However, in the final screening and cost-benefit analysis, the

OPPD used a factor of 2 to account for the potential contribution to risk from external events. The staff questioned whether this factor of 2 might not be sufficiently conservative if other uncertainties (in addition to contributions from external events) are considered. In response to the RAIs, the OPPD provided the uncertainty range associated with the calculated CDF (see Table 5-6 below) and also reassessed the impact on results if a multiplication factor of 3 rather than 2 were used in the final screening (Ridenoure 2002). The OPPD found that four SAMAs (SAMAs 54, 185, 187, and 190) would become cost-beneficial using a factor of 3. However, a more detailed examination by the OPPD concluded that these SAMAs either would have little to no impact on fire risk or would continue to have a negative net value after implementation of the seven SAMAs identified in Section 5.2.6.1 of this SEIS (Ridenoure 2002). Accordingly, the initial conclusions are considered justifiable.

Table 5-6. Uncertainty in the Calculated CDF for Fort Calhoun Station, Unit 1

Percentile	CDF (per year)
Mean	2.52×10^{-5}
5th	1.22×10^{-5}
50th	1.97×10^{-5}
95th	4.68×10^{-5}

The staff concludes that, except for the seven SAMAs that were determined to be cost-beneficial, the costs of the candidate SAMAs assessed would be higher than the associated benefits. This conclusion is upheld despite a number of uncertainties and nonquantifiable factors in the calculations, which are summarized as follows:

- Uncertainty in the internal-events CDF was not explicitly included in the calculations, which employed best-estimate values to determine the benefits. The 95th percent confidence level for internal-events CDF is approximately 2 times the mean CDF. The results of the cost-benefit analysis show that all of the SAMAs evaluated (except the seven SAMAs that were determined to be cost-beneficial) would cost more than twice the associated benefit. However, since the OPPD's use of a factor of 2 in the SAMA screening was intended to account for external events, consideration of internal-event uncertainties could potentially increase that factor. The OPPD addressed the implications of an overall uncertainty factor of 3 and found that although the screening made several additional SAMA candidates worthy of further scrutiny, no new SAMAs were justified. Therefore, further consideration of internal-event uncertainty is not expected to alter the conclusions of the analysis.

- External events were similarly not explicitly included in the Fort Calhoun Station, Unit 1 risk profile. However, given that external events were accounted for by using a factor-of-2 increase in the benefits and the observation that there are no particular vulnerabilities in the external-event risk profile at Fort Calhoun Station, Unit 1, any additional benefits that might accrue due to external events would be relatively small.

- Risk-reduction and cost estimates were generally found to be conservative. As such, uncertainty in the costs of any of the contemplated SAMAs would not likely have the effect of making them cost-beneficial.

- Sensitivity calculations were performed with respect to the discount rate (as low as 3 percent) and various MACCS2 parameters, including evacuation speed, meteorological data, and fission-product release. Using the 3-percent discount rate, two additional SAMA candidates, SAMAs 4 and 54, were introduced as cost-beneficial. SAMA 4 was added to the list of SAMA improvements, while SAMA 54 was dismissed on other sound technical grounds. The results of the MACCS2 parameter sensitivity studies showed that none of the risk benefits were increased by more than about 10 percent. Since this is less than the margin between cost and benefit for the SAMAs considered, the uncertainties in these parameters would not alter the conclusions.

5.2.7 Conclusions

The OPPD compiled a list of 190 SAMA candidates using the SAMA analyses, as submitted in support of licensing activities for other nuclear power plants; NRC and industry documents discussing potential plant improvements; and the plant-specific insights from the OPPD IPE, IPEEE, and current PRA model. A qualitative screening removed SAMA candidates that (1) had already been implemented at Fort Calhoun Station, Unit 1, (2) modified features not applicable to Fort Calhoun Station, Unit 1, (3) would involve major plant design and/or structural changes that would clearly be well in excess of the MAB, (4) would provide only minimal risk reduction, or (5) duplicated other SAMAs or could be consolidated with one or more other SAMAs being considered. A total of 170 SAMA candidates was eliminated based on the above criteria, leaving 20 SAMA candidates for further evaluation.

Using guidance in NUREG/BR-0184 (NRC 1997b), the current PRA model, and a Level 3 analysis developed specifically for SAMA evaluation, an MAB of about $784,000 was calculated, representing the total present-dollar-value equivalent associated with completely eliminating severe accidents at Fort Calhoun Station, Unit 1. Of the 20 SAMAs, 14 were screened from further evaluation because the implementation costs were greater than this MAB or exceeded twice the estimated benefit for that specific SAMA. The factor of 2 was used to account for uncertainties in the analysis and the potential impact of external events on the results of the SAMA evaluations. The end result was that six SAMA candidates were determined to be cost-beneficial. Upon completion of a 3-percent discount rate sensitivity study, one additional SAMA candidate was determined to be sufficiently cost-beneficial to be added to the list. The OPPD plans to implement these seven cost-beneficial SAMAs by 2005.

However, these SAMAs do not relate to adequately managing the effects of aging during the period of extended operation; therefore, they are not required as part of license renewal pursuant to 10 CFR Part 54.

The staff reviewed the OPPD analysis and concluded that the methods used and the implementation of those methods were sound. The treatment of SAMA benefits and costs; the generally large, negative net benefits; and the inherently small baseline risks support the general conclusion that the SAMA evaluations performed by the OPPD are reasonable and sufficient for the license renewal submittal. The unavailability of an external-event PRA model precluded a quantitative evaluation of SAMAs specifically aimed at reducing the risk of external-event initiators; however, significant improvements have been realized as a result of the IPEEE process at Fort Calhoun Station, Unit 1 that would minimize the likelihood of identifying cost-beneficial enhancements in this area.

Based on its review of the OPPD SAMA analyses, the staff concurs that, with the exception of the seven candidate SAMAs identified for implementation, none of the remaining candidate SAMAs are cost-beneficial. This is based on a conservative treatment of costs and benefits. This conclusion is consistent with the low residual level of risk indicated in the Fort Calhoun Station, Unit 1 PRA and the fact that Fort Calhoun Station, Unit 1 has already implemented plant improvements identified from the IPE and IPEEE process to reduce plant risk.

5.3 References

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