**FENOC**

*FirstEnergy Nuclear Operating Company*

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*724-682-7773*

May 2, 2008
L-08-148

10 CFR 54

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Beaver Valley Power Station, Unit Nos. 1 and 2
BV-1 Docket No. 50-334, License No. DPR-66
BV-2 Docket No. 50-412, License No. NPF-73
Reply to Follow-up Questions Pertaining to Request for Additional Information Regarding Severe Accident Mitigation Alternatives for Beaver Valley Power Station, Units 1 and 2, License Renewal (TAC Nos. MD6595 and MD6596)

Reference 1 provided the FirstEnergy Nuclear Operating Company (FENOC) License Renewal Application for the Beaver Valley Power Station (BVPS). The U.S. Nuclear Regulatory Commission (NRC) held a telephone conference call with FENOC on April 10, 2008, to present follow-up questions concerning the FENOC reply (Reference 2) to a NRC request for additional information (RAI) pertaining to the BVPS Severe Accident Mitigation Alternatives (SAMAs).

The Attachment provides the FENOC reply to the NRC follow-up questions.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Clifford I. Custer, Fleet License Renewal Project Manager, at 724-682-7139.

I declare under penalty of perjury that the foregoing is true and correct. Executed on May 2, 2008.

Sincerely,

Kevin L. Ostrowski

Kevin L. Ostrowski

A108
NRR

References:
1. FENOC Letter L-07-113, "License Renewal Application," August 27, 2007.
2. FENOC Letter L-08-081, "License Renewal Application Amendment 2: Reply to Request for Additional Information Regarding Severe Accident Mitigation Alternatives for Beaver Valley Power Station Units 1 and 2 License Renewal," March 7, 2008.

Attachment:
Reply to Follow-up Questions Pertaining to Request for Additional Information Regarding the Analysis of Severe Accident Mitigation Alternatives (SAMAs) for Beaver Valley Power Station, Units 1 and 2, License Renewal

cc: Mr. K. L. Howard, NRC DLR Project Manager
Mr. S. J. Collins, NRC Region I Administrator

cc: w/o Attachment
Dr. S. S. Lee, NRC DLR Acting Director
Mr. D. L. Werkheiser, NRC Senior Resident Inspector
Ms. N. S. Morgan, NRC DORL Project Manager
Mr. D. J. Allard, PA BRP/DEP Director
Mr. L. E. Ryan, PA BRP/DEP

**Follow-up Question RAI 2.b:**

1. **Provide the reason for the large difference in the SrO releases predicted by MAAP-DBA and MAAP 4.0.4 for RCs BV1, BV5, and BV9.**
2. **Describe the significance of the SrO release fractions on the estimated population dose.**

FOLLOW-UP RESPONSE RAI 2.b.1

**Provide the reason for the large difference in the SrO releases predicted by MAAP-DBA and MAAP 4.0.4 for RCs BV1, BV5, and BV9.**

FENOC concludes that the difference in the Beaver Valley Power Station (BVPS) SrO releases predicted by MAAP-DBA and MAAP 4.0.4 for release categories BV1, BV5, and BV9 is due to the model differences for the two MAAP code versions related to differences in vessel failure timing, direct containment heating (DCH), and containment enhancements associated with MAAP-DBA (discussed in the initial FENOC reply to NRC RAI 2.b—see FENOC Letter L-08-081, dated March 7, 2008).

In addition to the differences in the slope of the CsOH release fractions for BV9, there are also some noteworthy differences in the SrO release fractions for release categories BV1, BV5, and BV9. These differences, as shown in FENOC Letter L-08-081, Figures 2.B-1b, 2.B-3b, and 2.B-4b, are in the range of 3 to10 times lower for MAAP 4.0.4 results versus the MAAP-DBA results, which were always higher. The SrO release fractions for release category BV3 were in agreement (as shown in FENOC Letter L-08-081, Figure 2.B-2b) between the two versions of MAAP.

A review of the output files for the four release categories revealed that the vessel failure timing differences affect the SrO release fractions, as does the Reactor Coolant System (RCS) pressure at the time of vessel failure (i.e., high vs. low). For release category BV3, vessel failure occurs early in the sequence and the RCS pressure is low; in this sequence the two code versions were in excellent agreement with each other. For release categories BV1, BV5, and BV9, which are all high RCS pressure vessel failure sequences, there are substantive differences in the timing for vessel failure between the code models. For release categories BV1 and BV9, the vessel failure times differ by about 40 minutes, with MAAP-DBA failing sooner than MAAP 4.0.4.

For release category BV5 the MAAP-DBA vessel failure occurred later than MAAP 4.0.4, but only by about 15 minutes.

MAAP model changes described in Section 3.5 of the MAAP 4.0.5 Transition Guidance Document identify another SrO release mechanism:

> *"...a generic improvement was made to mechanistically model metal oxidation during the DCH event. In addition to the energy added to the containment atmosphere, this process can liberate a non-trivial amount of non-volatile fission products, such as Group 4 (SrO), from the entrained debris to the containment atmosphere. Most of the subsequent aerosol generated will settle out and be deposited on containment surfaces prior to containment failure, so environmental release will not be substantially influenced."*

As noted above, the improvements in the MAAP code can yield results that show a non-trivial amount of SrO during DCH events, which are only possible for high RCS pressures at the time of vessel failure due to high pressure melt ejections (represented by release categories BV1, BV5, and BV9). Investigation of the MAAP tabular data concluded that, immediately following vessel failure, MAAP-DBA produced more debris available for DCH in release categories BV1, BV5, and BV9, as compared with the MAAP 4.0.4 runs.

However, for release categories BV1 and BV5, the last statement in the above excerpt is not true, as these are defined as EARLY containment failures based on the assumed Individual Plant Examination (IPE) release timings. The BV1 release category was modeled with a containment failure 5 seconds after the vessel failure to mimic a DCH-induced containment failure. Release category BV5 was modeled with a containment failure 1.5 hours after the vessel failure to model a small containment failure as assumed in the IPE. Release category BV9 is a LATE containment failure, modeled 10 hours after the vessel failure, so there is time for the SrO to settle out and be deposited on containment surfaces prior to containment failure. This SrO settling is demonstrated by the significantly lower SrO release fractions (on the order of E-05) for BV9 verses the other release categories.

The early containment failure timings relative to when vessel failure occurred will not provide ample time for aerosol generated to settle out and be deposited on containment surfaces. In addition, these containment failure times associated with the DCH-induced containment failure are very conservative, such that given some longer period of time between the vessel failure and containment failure, the SrO release fraction magnitudes could be more in line with those for BV9.

Subsequently, FENOC concludes that it is the differences in vessel failure timings, the DCH model differences and the significant differences in the containment enhancements associated with MAAP-DBA (discussed in FENOC Letter L-08-081) that are causing these differences in the SrO release fractions. Based on the higher SrO release fractions that MAAP-DBA is producing compared to those using MAAP 4.0.4, and that the MACCS2 results discussed in the following response reveal that the estimated population dose is relatively insensitive to the SrO release fractions, it is concluded that the BVPS SAMA submittal SrO results are conservative, and not a significant contributor to population dose.

FOLLOW-UP RESPONSE RAI 2.b.2

**Describe the significance of the SrO release fractions on the estimated population dose.**

The estimated population dose is relatively insensitive to the release fractions of SrO as shown in Table 2.B-2, below. For a two order of magnitude decrease in the release fractions from the base case, there was no observed decrease in the mean long term total dose. Even for an order of magnitude increase in the release fractions, the mean dose increased by only 6.4 percent.

**Table 2.B-2**
**BVPS Release Category BV5 SrO Group Sensitivity Results**

| MAACS2 Release Category BV5 | | Base | x 0.01 | x 0.10 | x 10.0 |
|---|---|---|---|---|---|
| SrO Release Fraction | Plume 1 | 1.4E-07 | 1.4E-09 | 1.4E-08 | 1.4E-06 |
| | Plume 2 | 3.4E-03 | 3.4E-05 | 3.4E-04 | 3.4E-02 |
| Mean Total Long-Term Pathway Dose | Sv | 43,800 | 43,800 | 43,800 | 46,600 |
| | % Change | | 0.0 | 0.0 | 6.4 |
| Mean Population Exceeding Early Dose of 0.05 Sv | | 86,700 | 86,300 | 86,300 | 93,600 |
| | % Change | | -0.5 | -0.5 | 8.0 |
| Mean Total Economic Costs | Million $ | $11,300E+06 | $11,000E+06 | $11,000E+06 | $11,500E+06 |
| | % Change | | -2.7 | -2.7 | 1.8 |

Table 2.B-2 provides the results of a sensitivity analysis performed for the MACCS2 Release Category BV5 (corresponding to Level 2 Release Category BV5, as shown in FENOC Letter L-08-081, Table 2.A-1) to examine the sensitivity of population dose from SrO. Release category BV5, which represents a small early containment failure with a high RCS pressure at vessel failure, was used for the sensitivity analysis, and is

modeled with two plumes. For release category BV5, the SrO release fractions are 1.4E-07 for the first plume, and 3.4E-03 for the second. The other two MACCS2 release categories shown in FENOC Letter L-08-081, Table 2.A-1, DCH (corresponding to Level 2 release category BV1/BV3) and $H_2$ Burn (corresponding to Level 2 release category BV9), were also considered candidates for the conduct of this sensitivity analysis. However, release category BV5 was selected because its SrO release fractions lie between the DCH and $H_2$ Burn release categories values.

Three sensitivity runs were made for release category BV5 using the MACCS2 computer code. All runs were made using 2001 meteorological data and the estimated population for 2047. Runs of 0.01, 0.10, and 10.0 times the SrO base case release fraction were made. The MACCS2 output variables of interest for the runs were the Mean Total Long-Term Pathway Dose, the Mean Population Exceeding an early dose of 0.05 Sv, and the Mean Total Economic Costs. Table 2.B-2 provides the results of the MACCS2 sensitivity runs for SrO.

**Follow-up Question RAI 3.a:**

1. **For Unit 1, PA-1E and NS-1 were listed as significant contributors to the CDF (in ER Table 3.1.2.1-2) apparently based on the IPEEE; SAMAs 182 and 184 were identified to address these contributors. For Unit 2, SB-4, CV-1, and CV-3 were listed as significant contributors to the CDF, and SAMAs 181, 182 and 183 were identified to address these contributors. These fire risk contributors and SAMAs are not mentioned in the response to RAI 3.a. Explain the model or plant changes that reduced the importance of these contributors identified in the IPEEE.**
2. **The descriptions of Unit 2 SAMAs 179 through 185 provided in ER Table 6-1 do not explain the proposed changes associated with these SAMAs. Additional information is provided for SAMAs 179 and 180 as part of response to RAI 8b, however the changes associated with the other SAMAs is unclear. Describe the proposed changes associated with each of these SAMAs that are the basis for the $100K to >$1,000K cost variation.**

FOLLOW-UP RESPONSE RAI 3.a.1

**For Unit 1, PA-1E and NS-1 were listed as significant contributors to the CDF (in ER Table 3.1.2.1-2) apparently based on the IPEEE; SAMAs 182 and 184 were identified to address these contributors. For Unit 2, SB-4, CV-1, and CV-3 were listed as significant contributors to the CDF, and SAMAs 181, 182 and 183 were identified to address these contributors. These fire risk contributors and SAMAs**

**are not mentioned in the response to RAI 3.a. Explain the model or plant changes that reduced the importance of these contributors identified in the IPEEE.**

The BVPS Environmental Report (ER), Attachments C-1, "Beaver Valley Unit 1 SAMA Analysis," and C-2, "Beaver Valley Unit 2 SAMA Analysis," Tables 3.1.2.1-2, "BVPS-1 (BVPS-2) IPEEE Model/Design Enhancements," provided the significant fire area contributors identified in the BVPS Individual Plant Examination of External Events (IPEEE). The percent of core damage frequency (CDF) values listed in these tables were based on the summation of the individual detailed fire scenarios developed in the IPEEE for the particular areas identified. This method of presenting the CDF results was different than that provided in the FENOC reply (FENOC Letter L-08-081 dated March 7, 2008) to NRC RAI 3.a, which provided the percent of CDF values for only the top 10 individual dominant fire scenarios. If the fire scenarios for each of the fire areas are summed for the current BVPS Probabilistic Risk Assessment (PRA) models, a better comparison to the IPEEE results can be made, as shown in Tables 3.A-5 and 3.A-6, below. These tables present the fire area's CDF and percent contributions to the fire CDF and total CDF for the Unit 1 (PA-1E and NS-1) and Unit 2 (SB-4, CV-1, and CV-3) fire areas, based on the summation of all fire scenarios within the fire area.

**Table 3.A-5**
**Unit 1 Fire CDF Comparison Between IPEEE and BV1REV4 PRA Models**

| FIRE AREA | IPEEE | | | BV1REV4 | | |
|---|---|---|---|---|---|---|
| | CDF | Percent of Fire CDF | Percent of Total CDF | CDF | Percent of Fire CDF | Percent of Total CDF |
| PA-1E | 2.44E-06 | 13.7% | 1.7% | 1.72E-09 | 0.0% | 0.0% |
| NS-1 | 1.42E-06 | 7.9% | 1.0% | 2.78E-07 | 7.6% | 1.4% |

**Table 3.A-6**
**Unit 2 Fire CDF Comparison Between IPEEE and BV2REV4 PRA Models**

| FIRE AREA | IPEEE | | | BV2REV4 | | |
|---|---|---|---|---|---|---|
| | CDF | Percent of Fire CDF | Percent of Total CDF | CDF | Percent of Fire CDF | Percent of Total CDF |
| SB-4 | 1.10E-06 | 10.5% | 1.4% | 1.12E-07 | 2.3% | 0.5% |
| CV-1 | 6.54E-07 | 6.2% | 0.9% | 4.86E-09 | 0.1% | 0.0% |
| CV-3 | 6.12E-07 | 5.8% | 0.8% | 3.49E-07 | 7.3% | 1.5% |

As stated in the BVPS ER, Attachments C-1 and C-2, Sections 3.1.2.1, the BVPS Fire PRAs have not been explicitly updated since the IPEEE. However, as the fire sequences are dependent on the internal events modeling, the fire sequences have implicitly been partially updated as the internal events models are updated. The major Level 1 PRA model changes incorporated into each revision of the BVPS PRA models since the IPEEE are discussed in ER Attachments C-1 and C-2, Sections 3.1.1.2.

Specific PRA model changes that contributed to the reduction in the CDF contribution from the Unit 1 PA-1E and NS-1 fire areas, and the Unit 2 SB-4, CV-1, and CV-3 fire areas (as shown in Tables 3.A-5, and 3.A-6, above) are provided in the following discussions.

**Unit 1:**

For the Unit 1 PA-1E and NS-1 fire areas, the current BV1REV4 PRA model uses probabilistic reactor coolant pump (RCP) seal failures based on WCAP-15603, Revision 1-A, "WOG 2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs," while the IPEEE assumed a probability of 1.0. In the BV1REV4 PRA model, the dominant CDF sequences for the PA-1E and NS-1 fire scenarios consist of 182 gallons/minute (gpm) RCP seal loss of coolant accidents (LOCAs) (failure of the #2 and #3 seals with the #1 seal remaining intact), with a failure probability of 1.97E-01. Therefore, a reduction factor of 0.197 exists in the core damage sequence frequency for these fire areas, due to the probability of having a 182 gpm RCP seal LOCA.

**PA-1E**

Fire area PA-1E involves fires in emergency motor control centers (MCCs) 3 and 4 that impact high head safety injection and reactor plant component cooling water leading to an RCP seal LOCA without makeup.

For the IPEEE PA-1E fire area, the RCP seal LOCA failure probability reduction factor would apply, which would reduce the corresponding CDF by 0.197. In addition to the RCP Seal LOCA, these PA-1E fire sequences also result in the loss of the high head safety injection capability. Therefore, in the IPEEE PRA model (BV1REV1) these sequences were assumed to go directly to core damage, since no credit was given to depressurize the RCS and inject with the low head safety injection pumps. As a result, the conditional core damage probability for the IPEEE PA-1E fire area was set to 1.0.

However, as stated in the ER, Attachment C-1, Section 3.1.1.2, during the BV1REV2 PRA model update, credit was given for the operators to depressurize the RCS during small break (e.g., RCP Seal) LOCAs, so that a low head safety injection pump could be used to provide makeup and core cooling given the failure of the high head safety injection system. This operator action was reevaluated in the current PRA model using the Electric Power Research Institute (EPRI) HRA Calculator, resulting in a human error probability (HEP) of 2.60E-03. If the IPEEE PA-1E fire area CDF is reduced by the 0.197 RCP seal LOCA failure probability and by the 2.60E-03 HEP to depressurize the RCS, then the corresponding CDF would be reduced to 1.25E-09 (or 2.44E-06 * 1.97E-01 * 2.60E-03), which is comparable to the current BV1REV4 value of 1.72E-09 shown in Table 3.A-5.

**NS-1**

Fire area NS-1 involves normal switchgear fires that result in the loss of all river water leading to an RCP seal LOCA without makeup.

The differences in the fire area frequencies between the IPEEE and the current PRA model is attributed to the RCP seal LOCA probabilities. If the IPEEE NS-1 fire area CDF is reduced by the 0.197 RCP seal LOCA failure probability, then the corresponding CDF would be reduced to 2.80E-07 (or 1.42E-06 * 1.97E-01), which is comparable to the current BV1REV4 value of 2.78E-07 shown in Table 3.A-5.

**Unit 2:**

For the Unit 2 SB-4, CV-1 and CV-3 fire areas, the current BV2REV4 PRA model uses probabilistic RCP seal failures based on WCAP-15603, Revision 1-A, "WOG 2000 Reactor Coolant Pump Seal Leakage Model for Westinghouse PWRs," while the IPEEE assumed a probability of 1.0. In the BV2REV4 PRA model, the dominant CDF sequences for the SB-4, CV-1 and CV-3 fire scenarios consist of 21 gpm RCP seal LOCAs (all seals intact), with a failure probability of 7.90E-01. Therefore, a reduction factor of 0.79 exists in the core damage sequence frequency for these fire areas, due to the probability of having a 21 gpm RCP seal LOCA.

**SB-4**

Fire area SB-4 involves normal switchgear fires that result in a station blackout (SBO), leading to an RCP seal LOCA without makeup. For fire area SB-4, the dominant sequences involve fires that impact both trains of normal AC power located within the room, leading to subsequent failures of both trains of emergency AC power (SBO condition).

In the IPEEE, these SBO sequences were represented by the guaranteed failure of offsite power followed by the probabilistic failures of the emergency AC power top events, which had an associated string (OGF*AO2*BP6) probability of 1.64E-02. The resultant SBO then leads to an RCP seal LOCA with an assumed probability of 1.0.

In the current PRA model, the normal AC buses are modeled separately from the offsite power supplies. Therefore, similar types of SBO accident sequence progressions involve the guaranteed failures of each of the normal buses followed by the probabilistic failures of the emergency AC power top events. Furthermore, the current BV2REV4 PRA model uses probabilistic RCP seal failures. As such, the most likely RCP seal LOCA now has a probability of 0.79. Altogether, these failures have an associated string (NAF*NDF*AO2*BPB*RL1) probability of 1.85E-03.

The differences in these SBO string probabilities can be associated with the way the emergency AC power systems are modeled. In the IPEEE, the emergency MCCs were modeled as part of the associated emergency AC power train top events. Consequently, the failure of a single MCC could result in the failure of the whole train of associated emergency AC power. During the BV2REV3 PRA model update, these MCCs were broken out into separate top events, so the emergency AC power trains were unaffected by the failure of the MCCs.

If the IPEEE SB-4 fire CDF is adjusted based on these dominant sequences, the resultant CDF would be 1.24E-07 (or 1.10E-06 * 1.85E-03 / 1.64E-02), which is comparable to the current BV2REV4 value of 1.12E-07 shown in Table 3.A-6.

**CV-1**

For fire area CV-1, the postulated fires impact the Orange train MCCs located within the room that impacts the emergency AC Orange train of power with subsequent failures of all seal cooling leading to an RCP seal LOCA without makeup.

In the IPEEE, these MCCs were modeled in the Emergency AC Power Orange Train Top Event (AO), so the top event was set to a guaranteed failure, thereby failing one whole train of emergency AC power. In the BV2REV3A PRA model update, these MCCs were broken out into a separate top event (M3), so the emergency AC power Orange train (Top Event AO) is unaffected.

The dominant IPEEE core damage sequences for fire area CV-1 involved the failure of emergency AC Orange train power and the subsequent unconditional probabilistic failure of the opposite train (Purple) of emergency AC power (failure probability of 7.20E-04), thereby leading to an SBO condition and resultant RCP seal LOCA without makeup.

In the current PRA model, since emergency AC Orange power is not a guaranteed failure, similar types of accident sequence progressions require the probabilistic failures of the offsite and onsite AC power systems. Furthermore, the current BV2REV4 PRA model uses probabilistic RCP seal failures. As such, the most likely RCP seal LOCA now has a probability of 0.79. These probabilistic failures of the AC power systems are represented by the loss of offsite power followed by the failures of the emergency AC power top events and a 21 gpm RCP seal LOCA, with an associated string (OG1*AO3*BP3*RL1) probability of 1.64E-06.

If the IPEEE CV-1 fire CDF is adjusted based on these dominant sequences, the resultant CDF would be 1.49E-09 (or 6.54E-07 * 1.64E-06 / 7.20E-04), which is comparable to the current BV2REV4 value of 4.86E-09 shown in Table 3.A-6.

**CV-3**

For fire area CV-3, the postulated fires impact the Purple train MCCs or electrical panels located within the room. These fires are assumed to fail the emergency AC Purple train (Top Event BP) of power in both the IPEEE and current fire PRA models.

The dominant IPEEE core damage sequences for fire area CV-3 involved the failure of emergency AC Purple train power and the subsequent probabilistic failure of the opposite train (Orange) of emergency AC power (failure probability of 7.60E-04), thereby leading to an SBO condition and resultant RCP seal LOCA without makeup. In the IPEEE, the Orange train MCCs were modeled in the Emergency AC Power Orange Train Top Event (AO). In the BV2REV3A PRA model update, these MCCs were broken out into a separate top event, so the probability of the emergency AC power Orange train (Top Event AO) failing is now lower by about a factor of 10. As such, the most probable failures of the emergency AC Orange train of power are now as a result of the probabilistic failure of the normal 4KV bus placing a demand on the emergency diesel generator to start, load, and run. Furthermore, the current BV2REV4 PRA model uses probabilistic RCP seal failures, so the most likely RCP seal LOCA now has a probability of 0.79. These probabilistic failures of the AC power systems are represented by the loss of normal 4KV power followed by the failure of the emergency AC Orange train of power and a 21 gpm RCP seal LOCA, with an associated string (NA1*AO2*BPF*RL1) probability of 1.74E-04.

Additionally, for the current PRA model there are some sequences for this fire area in which the opposite Orange train of emergency AC power does not fail, so there is no resultant RCP seal LOCA. Instead a power-operated relief valve LOCA develops with a subsequent failure of the recirculation spray function, thereby leading to a core damage sequence. These sequences account for about 7.87E-08 of the current CV-3 fire area CDF.

When the IPEEE CV-3 fire CDF is adjusted based on the dominant sequences, the resultant CDF would be 1.40E-07 (or 6.12E-07 * 1.74E-04 / 7.60E-04). If the additional power-operated relief valve LOCA CDF is also included in with this adjusted total, the resultant CDF is 2.19E-07 (or 1.40E-07 + 7.87E-08), which is comparable to the current BV2REV4 value of 3.49E-07 shown in Table 3.A-6.

FOLLOW-UP RESPONSE RAI 3.a.2

**The descriptions of Unit 2 SAMAs 179 through 185 provided in ER Table 6-1 do not explain the proposed changes associated with these SAMAs. Additional information is provided for SAMAs 179 and 180 as part of response to RAI 8b, however the changes associated with the other SAMAs is unclear. Describe the proposed changes associated with each of these SAMAs that are the basis for the $100K to >$1,000K cost variation.**

Additional information on Unit 2 SAMAs 179 thru 183 (fire in CB-3, CT-1, SB-4, CV-1, CV-3, respectively) can be found in Table 3.1.2.1-2, "BVPS-2 IPEEE Model/Design Enhancements" (ER Attachment C-2, page C.2-20; reproduced on page 12, below). The ER, Attachment C-2, Table 5.6-1, "List of SAMA Candidates," identifies these five (5) SAMAs as having originated with IPEEE, although there is no direct reference made to Table 3.1.2.1-2.

SAMA 184 and 185 involve eliminating all risk of fire in the Emergency Diesel Generator Building. A review of meeting notes of SAMA cost evaluation by the SAMA Expert Panel identified no details of proposed change specifics (e.g., material types, quantities). However, modifications were envisioned as entailing fireproofing both the fuel and electrical systems to eliminate any chance of fire, in addition to the redundant enhancement of the existing $CO_2$ system, in order to assure the prompt extinguishment of any fire that should occur. Change packages for these systems would each cost a minimum of $100K to produce – exclusive of material, installation and testing costs. Additionally, since the Emergency Diesel Generator Building is seismically designed, any modification would require analysis or testing for either functionality or seismic structural integrity to avoid adverse interaction with safety-related systems, structures or components (SSCs) that share the interior space. The total costs for performing these modifications for both Unit 2 diesel generator sets, were estimated at greater than $1,000K, and substantially exceeded the estimated benefit value of $164/$163K for SAMAs 184 and 185, respectively. Partial implementation was not considered for these SAMAs, since all fires would not then be eliminated.

The estimate of costs for the subject SAMAs followed the process described in the FENOC reply (FENOC Letter L-08-081 dated March 7, 2008) to NRC RAI 6a. The SAMA Expert Panel considered the nature of the proposed modification(s) and "conceptually estimated" relevant costs. The Expert Panel included reasonable pricing of activities needed to bring about the SAMA-suggested improvements. In some instances, generic BVPS costs were assigned (minimum costs; e.g., design modification—$100K, procedure change—$15K). The estimated costs were occasionally influenced by consideration of a SAMA's benefit to the extent that, when minimal costs (e.g., design modification—$100K) substantially exceeded a low value estimated benefit (e.g., SAMA 181—$10.7K), additional costs were not added in, since the cost-benefit decision was already evident. Also, for some SAMAs, the Expert Panel concluded that stated estimated costs could significantly be exceeded, and indicated this possibility with a greater than (">") symbol.

**Table 3.1.2.1-2**
**BVPS-2 IPEEE Model/Design Enhancements**

| CDF Key Contributor | Model or Design Enhancement | IPEEE CDF Importance | | Percent of Total CDF ** | Status |
|---|---|---|---|---|---|
| | | Percent of CDF | Risk Reduction Worth * | | |
| Emergency AC Power | Reevaluate diesel generator building fragility. | 58.3 (Seismic) | 0.7110 (Seismic) | 4.1 | The diesel generator building HCLPF is 0.28g, more than twice the SSE level. This along with a low contribution to total CDF warrants no further action. |
| CB-3 Fire | Provide operator credit for recovery of auxiliary feedwater from outside of control room. | 17.8 (Fire) | 0.79062 (Fire) | 2.5 | The low contribution to total CDF warrants no further action. This evaluation is consistent with the BVPS-1 analysis. However, the operator recovery credit could change if deemed necessary. |
| CT-1 Fire | Install qualified fire barriers between fire areas CB-1, CB-2 and CT-1. | 12.6 (Fire) | 0.9941 (Fire) | 1.8 | The low contribution to total CDF warrants no further action. |
| SB-4 Fire | Install an automatic CO2 fire suppression system. | 10.5 (Fire) | 0.9380 (Fire) | 1.4 | The low contribution to total CDF warrants no further action. |
| CV-1 Fire | Reroute Purple train service water pump/MOV power and control cables. | 6.2 (Fire) | 0.9941 (Fire) | 0.9 | The low contribution to total CDF warrants no further action. |
| CV-3 Fire | Reroute Orange train CCP/thermal barrier cooling MOV and service water power and control cables. | 5.8 (Fire) | 0.9986 (Fire) | 0.8 | The low contribution to total CDF warrants no further action. |

Notes: * The Risk Reduction Worth is the factor decrease in CDF that would be realized if the failure probability of the affected contributor was decreased to 0.0 (i.e., guaranteed success). ** Total CDF includes both internal and external events.

**Follow-up Question RAI 3.b and 5.b:**

1. **As shown in Tables 3.B-1 and 3.B-2, total CDF is dominated by seismic events with PGAs in the ranges of 0.25g to 0.35g (SEIS 2 events), 0.35g to 0.5g (SEIS 3 events), and 0.5g to 1.0g (SEIS 4 events). Tables 5.B-1 through 5.B-4 indicate that seismic SAMAs were considered for each of the initiating event groups including SEIS 1 through SEIS 4 events for Unit 1 and SEIS 2 through SEIS 4 events for Unit 2. However, as described in the response to RAI 3.b, in identifying potential SAMAs for seismic events, FENOC considered only the risk associated with PGAs ranging from 0.01g to 0.25g (i.e., SEIS 1 events). SEIS 1 events account for only about 2 to 4 percent of the seismic CDF as shown in Tables 3.B-1 and 3.B-2. The response to RAI 3.b states that designing against higher PGAs would require modifications to structures housing the components and would result in excessive costs. In view of the significantly larger CDF and risk reduction potential associated with events with higher PGA (e.g., about 20% and 40% of the seismic CDF from SEIS 2 and SEIS 3 events, respectively), provide additional justification for: (a) limiting the consideration of seismic SAMAs to events with PGA less than 0.25g, and (b) the statement that designing against PGAs higher than 0.25g would require modifications to structures housing the components. In addition, explicitly describe the approach used to calculate the benefits for SAMAs 167 and 187 including the split fraction changes used for Top Events ZB and ZD. If only the low PGA split fraction for these top events was improved, demonstrate that additional hardening is not cost effective.**

FOLLOW-UP RESPONSE RAI 3.b and 5.b

In the FENOC reply (FENOC Letter L-08-081 dated March 7, 2008) to NRC RAI 3.b, the SEIS1 Initiating Event Seismic Scenario Descriptions in Tables 3.B-1 and 3.B-2 were erroneously reported with a range of 0.01g to 0.25g. The actual range for the SEIS1 initiating event is from 0.10g to 0.25g, as stated in the BVPS Unit 1 and Unit 2 IPEEEs. This range description error was also carried over into the four paragraphs of text provided on page 59 of 106 of the FENOC RAI response, where 0.01g should be changed to 0.10g. The description provided in FENOC Letter L-08-081, Table 5.B-1 for the 6th ranked initiating event is correct as written (0.10 to 0.25g).

In addition to these corrections, an alternate approach to determine possible seismic SAMAs was developed to check the validity of the original methodology and assumptions. Since Tables 3.B-5 and 3.B-6 in FENOC Letter L-08-081 only represented the top 10 seismic split fractions, the alternate approach was developed based on the top 100 seismic core damage sequences. This alternate methodology, which is applicable to both BVPS Units, and conclusions are described below.

**Alternate Methodology used to Determine Seismic SAMAs**

**Step 1:** To assess the dominant seismic risk contributors, the top 100 seismic core damage sequences were examined to determine what combination of seismic top events were failed in the sequence. A listing of the top 100 seismic core damage sequences is presented in Table 3.B-7 (this Attachment, starting on page 20) and Table 3.B-8 (this Attachment, starting on page 25), for Unit 1 and Unit 2 respectively. These tables provide the seismic initiating event, CDF, percentage of seismic CDF, percentage of total CDF, and the combination of seismic top event failures in the core damage sequence. As shown in Table 3.B-9, below, these top 100 sequences at Unit 1 represent 71.6 percent of all seismic CDF and 43.6 percent of the total CDF. At Unit 2, the top 100 sequences represent 55.7 percent of all seismic CDF and 22.5 percent of the total CDF.

**Table 3.B-9**

**Summary of BVPS Top 100 Seismic Sequences Core Damage Frequency**

| | Total Seismic Events CDF | Top 100 Seismic Sequences CDF | Top 100 Percentage of Seismic CDF | Top 100 Percentage of Total CDF |
|---|---|---|---|---|
| Unit 1 | 1.19E-05 | 8.51E-06 | 71.6% | 43.6% |
| Unit 2 | 9.70E-06 | 5.40E-06 | 55.7% | 22.5% |

**Step 2:** If the top 100 sequences were triggered by seismic events with peak ground accelerations (PGAs) greater than 0.5g (i.e., initiating events SEIS4 and SEIS5) they were screened out based on the judgment that substantial analyses and modifications would have to be performed on the SSCs in order to increase the seismic capacity enough to withstand such PGAs. The cost of these analyses and modifications was judged to be in excess of the maximum attainable benefit value of $5.1 million. The results of this screening retained 70 seismic sequences at Unit 1, and 61 seismic sequences at Unit 2.

**Step 3:** If the sequences contained a seismic failure of the Primary Auxiliary Building (Top Event ZP) or the seismic failure of the River/Service Water System (Top Event ZG), they were screened out. The seismic failure of the Primary Auxiliary Buildings was modeled explicitly in Top Event ZP at each Unit, while the dominant SSC seismic failure contributing to the failure of the River/Service Water System (Top Event ZG) at each Unit is from the shear failure of both the Main and Alternate Intake Structures.

At BVPS, these structures house safety-related SSCs and are only designed for PGAs of 0.125g. Therefore, any attempts to reduce the seismic split fractions for these SSCs would require substantial design analyses, major design modifications, and revised fragility analyses for the structures to increase the seismic capacity beyond that credited in the seismic PRA model, as well as replacement power costs. It was judged that together these revised analyses and structural modifications would exceed the maximum cost benefit value of $5.1 million, and would not warrant any SAMA evaluations.

**Step 4:** The first three steps of this process eliminated all but a few seismic sequences. The remaining seismic sequences retained were then reviewed to determine if any potentially cost beneficial design modification could be performed on the weakest link component in the seismic top event, which could increase the seismic capacity and therefore reduce the seismic split fraction failure probability and CDF. At Unit 1, 20 such sequences were retained, and at Unit 2 there were only 8 sequences. A listing of the retained seismic core damage sequences is presented in Table 3.B-10 (this Attachment, page 30) and Table 3.B-11 (this Attachment, page 31), for Unit 1 and Unit 2 respectively.

**Conclusions of Alternate Methodology used to Determine Seismic SAMAs**

In identifying potential SAMAs for seismic events, only those scenarios whose summed CDF have a greater than 1 percent contribution to the total CDF were considered. It was judged that the risk associated with seismic scenarios having a 1 percent or less contribution to the total CDF does not significantly impact the CDF, and, as such, does not warrant any SAMA evaluation considerations.

**Unit 1 (see Table 3.B-10, page 30):**

1. The retained seismic sequences contribute to 24.1 percent of the seismic CDF and 14.7 percent to the total CDF.
2. Top Event ZB is present in all but one of the retained seismic core damage sequences. Therefore, this top event was judged to have a significant impact on the CDF. **SAMA 187** was developed to determine the cost benefit of reducing this weakness.
3. Top Event ZC is present in 80 percent of the retained seismic core damage sequences. This Top Event was judged to have a significant impact on the CDF; however, no practical modifications can be performed to reduce the weakness, since it is due to the low seismic capacity of the offsite power ceramic insulators. Therefore, no SAMA was developed to evaluate the cost benefit of potential modifications.
4. Top Event ZD is present in 70 percent of the retained seismic core damage sequences. This Top Event was judged to have a significant impact on the CDF.

**SAMA 167** was developed to determine the cost benefit of reducing this weakness.

5. Top Event ZE is present in 25 percent of the retained seismic core damage sequences. The summation of the ZE sequences CDF contributes to less than 1.6 percent of the seismic CDF and less than 1 percent to the total CDF. Therefore, no SAMA was developed to evaluate the cost benefit of potential modifications to the Emergency AC Power system. However, all of these sequences are also in combination with ZB failures, so the CDF associated with these sequences would be reduced by implementation of **SAMA 187**.
6. Top Event ZF is present in two (10 percent) of the retained seismic core damage sequences. The summation of the ZF sequences CDF contributes to less than 1 percent of the seismic CDF and total CDF. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.
7. Top Event ZH is present in one (5 percent) of the retained seismic core damage sequences. This sequence contributes to less than 1 percent of the seismic CDF and total CDF. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.
8. The remainders of the seismic top events (ZS, ZI, ZA, ZW, & ZN) do not contribute to any of the retained seismic core damage sequences. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.

**Unit 2 (see Table 3.B-11, page 31):**

1. The retained seismic sequences contribute to 3.7 percent of the seismic CDF and 1.5 percent to the total CDF.
2. Top Event ZB is present in all of the retained seismic core damage sequences. However, **SAMA 186** was already developed to determine the cost benefit of reducing this weakness. Although **SAMA 186** was determined not to be cost beneficial, it would benefit by any modifications performed for Unit 1 SAMA 187, which was determined to be potentially cost beneficial.
3. Top Event ZC is also present in all of the retained seismic core damage sequences. This Top Event was judged to have a significant impact on the CDF; however, no practical modifications can be performed to reduce the weakness, since it is due to the low seismic capacity of the offsite power ceramic insulators. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.
4. Top Event ZM is present in 88 percent of the retained seismic core damage sequences. The summation of the ZM sequences CDF contributes to 3.5 percent of the seismic CDF and 1.4 percent to the total CDF. However, all of the retained sequences are also in combination with ZB failures, so the CDF associated with

these sequences would be reduced by implementation of **SAMA 186** (or by Unit 1 **SAMA 187**). Additionally, the risk reduction worth for Top Event ZM is only 1.0021, which indicates that even if all the risk was eliminated there would only be a 0.21 percent reduction in CDF. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.

5. Top Event ZE is present in 88 percent of the retained seismic core damage sequences. The summation of the ZE sequences CDF contributes to 3.3 percent of the seismic CDF and 1.3 percent to the total CDF. However, the dominant seismic failure of the Emergency AC Power System at Unit 2 is due to the interaction of the emergency diesel generator with the building. As such, any modifications to increase the seismic capacity would entail significant modifications to the emergency diesel generator and/or building. These modifications were judged to exceed the maximum cost benefit value of $5.1 million, when considering the analyses, modifications, and replacement power costs since they could not be performed on-line. Moreover, all of these sequences are also in combination with ZB failures, so the CDF associated with these sequences would be reduced by implementation of **SAMA 186** (or by Unit 1 **SAMA 187**). Therefore, no SAMA was developed to evaluate the cost benefit of potential modifications to the Emergency AC Power System.

6. Top Event ZW is present in 75 percent of the retained seismic core damage sequences. The summation of the ZW sequences CDF contributes to 3 percent of the seismic CDF and 1.2 percent to the total CDF. This Top Event was judged to have some impact on the CDF; however, since it is dependent on offsite power being available, and since no practical modifications can be performed on the offsite power ceramic insulators, this event does not warrant any SAMA development.

7. Top Event ZD is present in one (13 percent) of the retained seismic core damage sequences. This sequence contributes to less than 0.5 percent of the seismic CDF and less than 0.2 percent of the total CDF. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.

8. The remainders of the seismic top events (ZQ, ZR, ZI, & ZF) do not contribute to any of the retained seismic core damage sequences. Therefore, no SAMA was developed to evaluate the cost benefit of modifications.

Based on the results of this alternate approach to identify any potential seismic SAMAs, it was concluded that there were no additional SAMAs beyond those originally identified in the BVPS Environmental Report (i.e., Unit 1 SAMAs 167 & 187) that could be potentially cost beneficial.

An explicit description of the approach used to calculate the benefits for Unit 1 SAMAs 167 and 187, including the split fraction changes used for Top Events ZB and ZD, are provided below.

**SAMA 167:**

The SAMA 167 analysis (Sensitivity Case DC2) assumed that the Unit 1 emergency DC battery room block walls would not fail for any seismic event modeled in the PRA (up to 1.33g). As can be seen from the modified split fraction values for Top Event ZD in Table 3.B-12 below, all seismic split fraction failure probabilities were reduced, not just the low PGA split fractions. Therefore, the SAMA benefits are based on the reduction in CDF from all seismic events.

**Sensitivity Case DC2**

**Description:** Assume a seismic event does not cause the block wall to fail which in turn would have failed the batteries. This case is used to determine the benefit of eliminating the seismic failure of the 125VDC battery room block walls.

**Method:** A new master frequency file (MFF) is created in RISKMAN by merging the baseline PEBDD MFF into a new MFF named DC2. The DC2 MFF is then edited by setting the split fractions ZD1, ZD2, ZD3, ZD4 and ZD5 accordingly to the modified split fraction probability values listed in Table 3.B-12, below. These values are the corresponding seismic point estimate split fraction values for the DC Power System considering only the emergency DC switchboards without the block walls. The PRA model is then quantified using the DC2 MFF and the SAMA batch file and a report is generated for the DC2 MFF bin totals for the CDF group.

**Table 3.B-12**
**Modified Split Fractions for Case DC2**

| Split Fraction | PGA Range (g) | Base Case Value | Modified Value |
|---|---|---|---|
| ZD1 | 0.10 to 0.25 | 4.94E-03 | 1.02E-05 |
| ZD2 | 0.25 to 0.35 | 9.55E-02 | 7.51E-04 |
| ZD3 | 0.35 to 0.50 | 2.94E-01 | 7.31E-03 |
| ZD4 | 0.50 to 1.00 | 6.51E-01 | 6.42E-02 |
| ZD5 | 1.00 to 1.33 | 9.75E-01 | 3.97E-01 |

**SAMA 187:**

The SAMA 187 analysis (Sensitivity Case SEISMIC1) assumed that the Unit 1 Emergency Response Facility (ERF) batteries would have the same seismic capacity as the Unit 2 Emergency DC batteries. As can be seen from the modified split fraction values for Top Event ZB in Table 3.B-13, below, all seismic split fraction failure probabilities were reduced, not just the low PGA split fractions. Therefore, the SAMA benefits are based on the reduction in CDF from all seismic events.

**Sensitivity Case SEISMIC1**

**Description:** This case reduces the failure of the ERF Substation batteries due to seismic events by setting the ERF Substation battery seismic capacity equivalent to the Unit 2 125V DC Emergency battery capacity (i.e., median acceleration = 1.38g, beta r = 0.42, beta u = 0.37, HCLPF = 0.375). This case is used to evaluate improvements that would strengthen the ERF Substation battery racks.

**Method:** A new MFF is created in RISKMAN by merging the baseline PEBDD MFF into a new MFF named SEISMIC1. The SEISMIC1 MFF is then edited setting the split fractions ZB1, ZB2, ZB3, ZB4 and ZB5 accordingly to the modified split fraction probability values presented in Table 3.B-13, below. These values are the corresponding seismic point estimate split fraction values for the ERF Substation Power considering the ERF Diesel Generator Building, ERF DG Substation Building, ERF Substation MCCs, and the increased seismic capacity for the modified 125V DC ERF Substation batteries. The PRA model is then quantified using the SEISMIC1 MFF and the SAMA batch file. These same methodology and modified ZB split fractions were used in the Unit 2 SAMA 186 analysis.

**Table 3.B-13**
**Modified Seismic Split Fractions for Case SEISMIC1**

| Split Fraction | PGA Range (g) | Base Case Value | Modified Value |
|---|---|---|---|
| ZB1 | 0.10 to 0.25 | 4.61E-01 | 2.97E-03 |
| ZB2 | 0.25 to 0.35 | 9.63E-01 | 8.79E-02 |
| ZB3 | 0.35 to 0.50 | 9.97E-01 | 3.47E-01 |
| ZB4 | 0.50 to 1.00 | 1.00E+00 | 8.07E-01 |
| ZB5 | 1.00 to 1.33 | 1.00E+00 | 9.99E-01 |

# Table 3.B-7
# Unit 1 Top 100 Seismic Core Damage Sequences

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ZB | ZC | ZD | ZP | ZG | ZE | ZH | ZF | ZS | ZI | ZA | ZW | ZN |
| 1 | SEIS3 | 5.67E-07 | 4.77% | 2.90% | ZB | ZC | ZD | | | | | | | | | | |
| 2 | SEIS2 | 5.03E-07 | 4.23% | 2.57% | ZB | ZC | ZD | | | | | | | | | | |
| 3 | SEIS3 | 4.96E-07 | 4.17% | 2.54% | ZB | ZC | | | ZG | | | | | | | | |
| 4 | SEIS3 | 4.90E-07 | 4.12% | 2.51% | ZB | ZC | | ZP | | | | | | | | | |
| 5 | SEIS2 | 3.91E-07 | 3.29% | 2.00% | ZB | | ZD | | | | | | | | | | |
| 6 | SEIS2 | 3.17E-07 | 2.66% | 1.62% | ZB | ZC | | ZP | | | | | | | | | |
| 7 | SEIS2 | 2.82E-07 | 2.37% | 1.44% | ZB | ZC | | | ZG | | | | | | | | |
| 8 | SEIS4 | 2.71E-07 | 2.28% | 1.39% | ZB | ZC | ZD | ZP | ZG | | | | | | | | |
| 9 | SEIS1 | 2.63E-07 | 2.22% | 1.35% | ZB | | ZD | | | | | | | | | | |
| 10 | SEIS3 | 2.20E-07 | 1.85% | 1.12% | ZB | ZC | ZD | | | | | | | | | | |
| 11 | SEIS3 | 2.11E-07 | 1.78% | 1.08% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 12 | SEIS3 | 2.09E-07 | 1.76% | 1.07% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 13 | SEIS2 | 1.95E-07 | 1.64% | 1.00% | ZB | ZC | ZD | | | | | | | | | | |
| 14 | SEIS3 | 1.82E-07 | 1.53% | 0.93% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 15 | SEIS3 | 1.42E-07 | 1.19% | 0.73% | ZB | ZC | ZD | | | | | | | | | | |
| 16 | SEIS4 | 1.35E-07 | 1.14% | 0.69% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 17 | SEIS2 | 1.26E-07 | 1.06% | 0.64% | ZB | ZC | ZD | | | | | | | | | | |
| 18 | SEIS4 | 1.25E-07 | 1.05% | 0.64% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 19 | SEIS3 | 1.24E-07 | 1.04% | 0.63% | ZB | ZC | | | ZG | | | | | | | | |
| 20 | SEIS3 | 1.22E-07 | 1.03% | 0.63% | ZB | ZC | | ZP | | | | | | | | | |
| 21 | SEIS4 | 1.04E-07 | 0.87% | 0.53% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 22 | SEIS3 | 9.03E-08 | 0.76% | 0.46% | ZB | ZC | | | ZG | | | | | | | | |
| 23 | SEIS4 | 8.93E-08 | 0.75% | 0.46% | ZB | ZC | ZD | ZP | ZG | | ZH | | | | | | |
| 24 | SEIS3 | 8.93E-08 | 0.75% | 0.46% | ZB | ZC | | ZP | | | | | | | | | |

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ZB | ZC | ZD | ZP | ZG | ZE | ZH | ZF | ZS | ZI | ZA | ZW | ZN |
| 25 | SEIS4 | 8.83E-08 | 0.74% | 0.45% | ZB | ZC | ZD | ZP | ZG | ZE | | | | | | | |
| 26 | SEIS3 | 8.18E-08 | 0.69% | 0.42% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 27 | SEIS3 | 8.08E-08 | 0.68% | 0.41% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 28 | SEIS2 | 7.92E-08 | 0.67% | 0.41% | ZB | ZC | | ZP | | | | | | | | | |
| 29 | SEIS3 | 7.78E-08 | 0.65% | 0.40% | ZB | ZC | ZD | ZP | ZG | | | | | | | | |
| 30 | SEIS3 | 7.72E-08 | 0.65% | 0.40% | ZB | ZC | | | | ZE | | | | | | | |
| 31 | SEIS3 | 7.29E-08 | 0.61% | 0.37% | ZB | | ZD | | | | | | | | | | |
| 32 | SEIS2 | 7.04E-08 | 0.59% | 0.36% | ZB | ZC | | | ZG | | | | | | | | |
| 33 | SEIS4 | 6.77E-08 | 0.57% | 0.35% | ZB | ZC | ZD | ZP | ZG | | | | | | | | |
| 34 | SEIS4 | 6.23E-08 | 0.52% | 0.32% | ZB | ZC | | | ZG | | | | | | | | |
| 35 | SEIS2 | 5.77E-08 | 0.49% | 0.30% | ZB | ZC | | ZP | | | | | | | | | |
| 36 | SEIS3 | 5.49E-08 | 0.46% | 0.28% | ZB | ZC | ZD | | | | | | | | | | |
| 37 | SEIS3 | 5.28E-08 | 0.44% | 0.27% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 38 | SEIS3 | 5.22E-08 | 0.44% | 0.27% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 39 | SEIS4 | 5.17E-08 | 0.43% | 0.26% | ZB | ZC | ZD | | | | | | | | | | |
| 40 | SEIS2 | 5.13E-08 | 0.43% | 0.26% | ZB | ZC | | | ZG | | | | | | | | |
| 41 | SEIS2 | 5.08E-08 | 0.43% | 0.26% | ZB | | | ZP | | | | | | | | | |
| 42 | SEIS2 | 4.86E-08 | 0.41% | 0.25% | ZB | ZC | ZD | | | | | | | | | | |
| 43 | SEIS4 | 4.77E-08 | 0.40% | 0.24% | ZB | ZC | | ZP | | | | | | | | | |
| 44 | SEIS4 | 4.58E-08 | 0.39% | 0.23% | ZB | ZC | | ZP | ZG | ZE | | | | | | | |
| 45 | SEIS3 | 4.56E-08 | 0.38% | 0.23% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 46 | SEIS2 | 4.52E-08 | 0.38% | 0.23% | ZB | | | | ZG | | | | | | | | |
| 47 | SEIS4 | 4.46E-08 | 0.37% | 0.23% | ZB | ZC | ZD | | ZG | | ZH | | | | | | |
| 48 | SEIS4 | 4.41E-08 | 0.37% | 0.23% | ZB | ZC | ZD | | ZG | ZE | | | | | | | |
| 49 | SEIS2 | 4.20E-08 | 0.35% | 0.22% | ZB | ZC | | | | ZE | | | | | | | |
| 50 | SEIS4 | 4.12E-08 | 0.35% | 0.21% | ZB | ZC | | ZP | ZG | | ZH | | | | | | |
| 51 | SEIS2 | 3.42E-08 | 0.29% | 0.18% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 52 | SEIS4 | 3.42E-08 | 0.29% | 0.17% | ZB | ZC | ZD | ZP | | | ZH | | | | | | |

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ZB | ZC | ZD | ZP | ZG | ZE | ZH | ZF | ZS | ZI | ZA | ZW | ZN |
| 53 | SEIS4 | 3.38E-08 | 0.28% | 0.17% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 54 | SEIS4 | 3.38E-08 | 0.28% | 0.17% | ZB | ZC | ZD | ZP | | ZE | | | | | | | |
| 55 | SEIS3 | 3.32E-08 | 0.28% | 0.17% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 56 | SEIS4 | 3.28E-08 | 0.28% | 0.17% | ZB | ZC | ZD | ZP | ZG | | | ZF | | | | | |
| 57 | SEIS4 | 3.12E-08 | 0.26% | 0.16% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 58 | SEIS2 | 3.04E-08 | 0.26% | 0.16% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 59 | SEIS3 | 3.01E-08 | 0.25% | 0.15% | ZB | ZC | ZD | ZP | ZG | | | | | | | | |
| 60 | SEIS3 | 3.00E-08 | 0.25% | 0.15% | ZB | ZC | | | ZG | | | | | | | | |
| 61 | SEIS3 | 2.97E-08 | 0.25% | 0.15% | ZB | ZC | | ZP | | | | | | | | | |
| 62 | SEIS3 | 2.96E-08 | 0.25% | 0.15% | ZB | ZC | | | ZG | | | | | | | | |
| 63 | SEIS3 | 2.92E-08 | 0.25% | 0.15% | ZB | ZC | ZD | | | ZE | | | | | | | |
| 64 | SEIS3 | 2.92E-08 | 0.25% | 0.15% | ZB | ZC | | ZP | | | | | | | | | |
| 65 | SEIS4 | 2.91E-08 | 0.24% | 0.15% | ZB | ZC | ZD | ZP | ZG | ZE | ZH | | | | | | |
| 66 | SEIS3 | 2.91E-08 | 0.24% | 0.15% | ZB | ZC | ZD | | | | ZH | | | | | | |
| 67 | SEIS3 | 2.87E-08 | 0.24% | 0.15% | ZB | ZC | | | ZG | ZE | | | | | | | |
| 68 | SEIS3 | 2.84E-08 | 0.24% | 0.15% | ZB | ZC | | ZP | | ZE | | | | | | | |
| 69 | SEIS3 | 2.83E-08 | 0.24% | 0.15% | ZB | ZC | | | | | | ZF | | | | | |
| 70 | SEIS4 | 2.59E-08 | 0.22% | 0.13% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 71 | SEIS4 | 2.58E-08 | 0.22% | 0.13% | ZB | ZC | ZD | ZP | ZG | | | | | ZI | | | |
| 72 | SEIS3 | 2.54E-08 | 0.21% | 0.13% | ZB | ZC | | | ZG | | ZH | | | | | | |
| 73 | SEIS4 | 2.52E-08 | 0.21% | 0.13% | ZB | ZC | ZD | ZP | ZG | | | | ZS | | | | |
| 74 | SEIS3 | 2.51E-08 | 0.21% | 0.13% | ZB | ZC | | ZP | | | ZH | | | | | | |
| 75 | SEIS4 | 2.38E-08 | 0.20% | 0.12% | ZB | ZC | | | | | | | | | | | |
| 76 | SEIS4 | 2.29E-08 | 0.19% | 0.12% | ZB | ZC | | | ZG | ZE | | | | | | | |
| 77 | SEIS3 | 2.26E-08 | 0.19% | 0.12% | ZB | ZC | | | ZG | | | | | | | | |
| 78 | SEIS4 | 2.23E-08 | 0.19% | 0.11% | ZB | ZC | ZD | ZP | ZG | | ZH | | | | | | |
| 79 | SEIS3 | 2.23E-08 | 0.19% | 0.11% | ZB | ZC | | ZP | | | | | | | | | |
| 80 | SEIS4 | 2.21E-08 | 0.19% | 0.11% | ZB | ZC | ZD | ZP | ZG | ZE | | | | | | | |

| *Rank* | *Seismic Initiating Event* | *Core Damage Frequency* | *Percent of Seismic CDF* | *Percent of Total CDF* | *Combination of Seismic Top Event Failures in the Core Damage Sequence* | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *ZB* | *ZC* | *ZD* | *ZP* | *ZG* | *ZE* | *ZH* | *ZF* | *ZS* | *ZI* | *ZA* | *ZW* | *ZN* |
| 81 | SEIS3 | 2.16E-08 | 0.18% | 0.11% | ZB | | ZD | | ZG | | | | | | | | |
| 82 | SEIS3 | 2.13E-08 | 0.18% | 0.11% | ZB | | ZD | ZP | | | | | | | | | |
| 83 | SEIS2 | 2.12E-08 | 0.18% | 0.11% | ZB | | ZD | ZP | | | | | | | | | |
| 84 | SEIS1 | 2.07E-08 | 0.17% | 0.11% | | | | ZP | | | | | | | | | |
| 85 | SEIS4 | 2.05E-08 | 0.17% | 0.11% | ZB | ZC | | | ZG | | ZH | | | | | | |
| 86 | SEIS3 | 2.05E-08 | 0.17% | 0.10% | ZB | ZC | ZD | | ZG | | | | | | | | |
| 87 | SEIS2 | 2.02E-08 | 0.17% | 0.10% | ZB | | | | | ZE | | | | | | | |
| 88 | SEIS3 | 2.02E-08 | 0.17% | 0.10% | ZB | ZC | ZD | ZP | | | | | | | | | |
| 89 | SEIS3 | 1.94E-08 | 0.16% | 0.10% | ZB | ZC | ZD | ZP | ZG | | | | | | | | |
| 90 | SEIS3 | 1.93E-08 | 0.16% | 0.10% | ZB | ZC | | | | ZE | | | | | | | |
| 91 | SEIS2 | 1.92E-08 | 0.16% | 0.10% | ZB | ZC | | ZP | | | | | | | | | |
| 92 | SEIS4 | 1.92E-08 | 0.16% | 0.10% | ZB | ZC | ZD | ZP | ZG | | | | | | ZA | | |
| 93 | SEIS2 | 1.92E-08 | 0.16% | 0.10% | ZB | ZC | | ZP | ZG | | | | | | | | |
| 94 | SEIS2 | 1.89E-08 | 0.16% | 0.10% | ZB | ZC | | ZP | | | | | | | | | |
| 95 | SEIS2 | 1.89E-08 | 0.16% | 0.10% | ZB | ZC | | | | | | ZF | | | | | |
| 96 | SEIS2 | 1.88E-08 | 0.16% | 0.10% | ZB | | ZD | | ZG | | | | | | | | |
| 97 | SEIS1 | 1.77E-08 | 0.15% | 0.09% | ZB | | | ZP | | | | | | | | | |
| 98 | SEIS4 | 1.75E-08 | 0.15% | 0.09% | ZB | ZC | | ZP | | ZE | | | | | | | |
| 99 | SEIS2 | 1.74E-08 | 0.15% | 0.09% | | ZC | ZD | | | | | | | | | | |
| 100 | SEIS2 | 1.71E-08 | 0.14% | 0.09% | ZB | ZC | | | ZG | | | | | | | | |
| **Totals for Top 100 Dominant Seismic Events** | | **8.51E-06** | **71.6%** | **43.6%** | **Percent Contribution of Seismic Top Events for the Top 100 Seismic Core Damage Sequences** | | | | | | | | | | | | |
| | | | | | **ZB 98%** | **ZC 88%** | **ZD 51%** | **ZP 51%** | **ZG 49%** | **ZE 15%** | **ZH 10%** | **ZF 3%** | **ZS 1%** | **ZI 1%** | **ZA 1%** | **ZW 0%** | **ZN 0%** |
| **Totals for All Seismic Events** | | **1.19E-05** | **100%** | **60.9%** | **Percent Contribution of Seismic Top Events for All Seismic Core Damage Sequences** | | | | | | | | | | | | |
| | | | | | **ZB 99%** | **ZC 89%** | **ZD 54%** | **ZP 43%** | **ZG 43%** | **ZE 11%** | **ZH 9%** | **ZF 5%** | **ZS 3%** | **ZI 3%** | **ZA 2%** | **ZW 2%** | **ZN 0%** |

| UNIT 1 SEISMIC TOP EVENT DESCRIPTIONS | INITIATING EVENT | PGA Range (g) |
|---|---|---|
| ZB - ERF DIESEL GENERATOR POWER | SEIS1 | 0.10 to 0.25 |
| ZC - OFFSITE GRID | SEIS2 | 0.25 to 0.35 |
| ZD - EMERGENCY DC POWER | SEIS3 | 0.35 to 0.50 |
| ZP - UNIT 1 PRIMARY AUXILIARY BUILDING | SESI4 | 0.50 to 1.00 |
| ZG - RIVER WATER SYSTEM/INTAKE STRUCTURE | SEIS5 | 1.00 to 1.33 |
| ZE - EMERGENCY AC POWER | | |
| ZH - HHSI COLD LEG INJECTION | | |
| ZF - VITAL INSTRUMENT BUS POWER | | |
| ZS - REFUELING WATER STORAGE TANK | | |
| ZI - REACTOR PLANT CCW | | |
| ZA - AUXILIARY FEEDWATER | | |
| ZW - NORMAL DC POWER | | |
| ZN - CONTAINMENT INSTRUMENT AIR | | |

## Table 3.B-8
## Unit 2 Top 100 Seismic Core Damage Sequences

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | ZQ | ZR | ZI | ZF |
| 1 | SEIS3 | 4.40E-07 | 4.53% | 1.83% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 2 | SEIS3 | 4.34E-07 | 4.48% | 1.81% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 3 | SEIS3 | 1.62E-07 | 1.67% | 0.67% | ZB | ZC | ZM | ZW | ZG | ZP | | | | | | |
| 4 | SEIS3 | 1.59E-07 | 1.64% | 0.66% | ZB | ZC | ZM | | ZG | | | | | | | |
| 5 | SEIS3 | 1.57E-07 | 1.62% | 0.65% | ZB | ZC | ZM | | | ZP | | | | | | |
| 6 | SEIS3 | 1.44E-07 | 1.49% | 0.60% | ZB | ZC | ZM | ZW | | | ZE | | | | | |
| 7 | SEIS2 | 1.14E-07 | 1.18% | 0.48% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 8 | SEIS2 | 1.11E-07 | 1.14% | 0.46% | ZB | ZC | ZM | | | ZP | | | | | | |
| 9 | SEIS3 | 1.10E-07 | 1.13% | 0.46% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 10 | SEIS3 | 1.09E-07 | 1.12% | 0.45% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 11 | SEIS4 | 1.03E-07 | 1.06% | 0.43% | ZB | ZC | ZM | ZW | ZG | ZP | | ZD | | | | |
| 12 | SEIS2 | 1.02E-07 | 1.05% | 0.42% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 13 | SEIS4 | 9.98E-08 | 1.03% | 0.42% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | | | | |
| 14 | SEIS2 | 9.85E-08 | 1.02% | 0.41% | ZB | ZC | ZM | | ZG | | | | | | | |
| 15 | SEIS4 | 8.97E-08 | 0.92% | 0.37% | ZB | ZC | ZM | ZW | ZG | ZP | | | | | | |
| 16 | SEIS4 | 8.71E-08 | 0.90% | 0.36% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | | | | | |
| 17 | SEIS2 | 7.61E-08 | 0.78% | 0.32% | ZB | ZC | | ZW | | ZP | | | | | | |
| 18 | SEIS2 | 7.38E-08 | 0.76% | 0.31% | ZB | ZC | | | | ZP | | | | | | |
| 19 | SEIS2 | 6.77E-08 | 0.70% | 0.28% | ZB | ZC | | ZW | ZG | | | | | | | |
| 20 | SEIS2 | 6.56E-08 | 0.68% | 0.27% | ZB | ZC | | | ZG | | | | | | | |
| 21 | SEIS4 | 6.48E-08 | 0.67% | 0.27% | ZB | ZC | ZM | ZW | ZG | ZP | | ZD | ZQ | | | |
| 22 | SEIS4 | 6.30E-08 | 0.65% | 0.26% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | ZQ | | | |
| 23 | SEIS3 | 5.85E-08 | 0.60% | 0.24% | ZB | ZC | ZM | | ZG | ZP | | | | | | |
| 24 | SEIS3 | 5.71E-08 | 0.59% | 0.24% | ZB | ZC | | ZW | ZG | | | | | | | |
| 25 | SEIS4 | 5.66E-08 | 0.58% | 0.24% | ZB | ZC | ZM | ZW | ZG | ZP | | | ZQ | | | |
| 26 | SEIS3 | 5.64E-08 | 0.58% | 0.23% | ZB | ZC | | ZW | | ZP | | | | | | |

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **ZB** | **ZC** | **ZM** | **ZW** | **ZG** | **ZP** | **ZE** | **ZD** | **ZQ** | **ZR** | **ZI** | **ZF** |
| 27 | SEIS4 | 5.50E-08 | 0.57% | 0.23% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | | ZQ | | | |
| 28 | SEIS2 | 5.43E-08 | 0.56% | 0.23% | ZB | | ZM | ZW | | ZP | | | | | | |
| 29 | SEIS3 | 5.40E-08 | 0.56% | 0.22% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 30 | SEIS3 | 5.37E-08 | 0.55% | 0.22% | ZB | ZC | ZM | ZW | ZG | | ZE | | | | | |
| 31 | SEIS3 | 5.33E-08 | 0.55% | 0.22% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 32 | SEIS3 | 5.30E-08 | 0.55% | 0.22% | ZB | ZC | ZM | ZW | | ZP | ZE | | | | | |
| 33 | SEIS3 | 5.21E-08 | 0.54% | 0.22% | ZB | ZC | ZM | | | | ZE | | | | | |
| 34 | SEIS4 | 5.12E-08 | 0.53% | 0.21% | ZB | ZC | ZM | ZW | ZG | | | ZD | | | | |
| 35 | SEIS4 | 4.98E-08 | 0.51% | 0.21% | ZB | ZC | ZM | ZW | ZG | | ZE | ZD | | | | |
| 36 | SEIS3 | 4.93E-08 | 0.51% | 0.21% | ZB | ZC | ZM | ZW | ZG | | | | ZQ | | | |
| 37 | SEIS3 | 4.87E-08 | 0.50% | 0.20% | ZB | ZC | ZM | ZW | | ZP | | | ZQ | | | |
| 38 | SEIS2 | 4.83E-08 | 0.50% | 0.20% | ZB | | ZM | ZW | ZG | | | | | | | |
| 39 | SEIS3 | 4.53E-08 | 0.47% | 0.19% | ZB | ZC | ZM | ZW | | | | ZD | | | | |
| 40 | SEIS4 | 4.48E-08 | 0.46% | 0.19% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 41 | SEIS4 | 4.35E-08 | 0.45% | 0.18% | ZB | ZC | ZM | ZW | ZG | | ZE | | | | | |
| 42 | SEIS3 | 4.04E-08 | 0.42% | 0.17% | ZB | ZC | ZM | ZW | ZG | ZP | | | | | | |
| 43 | SEIS3 | 3.97E-08 | 0.41% | 0.17% | ZB | ZC | ZM | | ZG | | | | | | | |
| 44 | SEIS4 | 3.93E-08 | 0.40% | 0.16% | ZB | ZC | ZM | ZW | | ZP | | ZD | | | | |
| 45 | SEIS3 | 3.93E-08 | 0.40% | 0.16% | ZB | ZC | ZM | | | ZP | | | | | | |
| 46 | SEIS4 | 3.82E-08 | 0.39% | 0.16% | ZB | ZC | ZM | ZW | | ZP | ZE | ZD | | | | |
| 47 | SEIS2 | 3.61E-08 | 0.37% | 0.15% | ZB | | | ZW | | ZP | | | | | | |
| 48 | SEIS3 | 3.60E-08 | 0.37% | 0.15% | ZB | ZC | ZM | ZW | | | ZE | | | | | |
| 49 | SEIS3 | 3.44E-08 | 0.36% | 0.14% | ZB | | ZM | ZW | ZG | | | | | | | |
| 50 | SEIS4 | 3.43E-08 | 0.35% | 0.14% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 51 | SEIS3 | 3.40E-08 | 0.35% | 0.14% | ZB | | ZM | ZW | | ZP | | | | | | |
| 52 | SEIS4 | 3.33E-08 | 0.34% | 0.14% | ZB | ZC | ZM | ZW | | ZP | ZE | | | | | |
| 53 | SEIS4 | 3.23E-08 | 0.33% | 0.13% | ZB | ZC | ZM | ZW | ZG | | | ZD | ZQ | | | |
| 54 | SEIS2 | 3.21E-08 | 0.33% | 0.13% | ZB | | | ZW | ZG | | | | | | | |
| 55 | SEIS4 | 3.15E-08 | 0.32% | 0.13% | ZB | ZC | ZM | ZW | ZG | | ZE | ZD | ZQ | | | |

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **ZB** | **ZC** | **ZM** | **ZW** | **ZG** | **ZP** | **ZE** | **ZD** | **ZQ** | **ZR** | **ZI** | **ZF** |
| 56 | SEIS4 | 3.12E-08 | 0.32% | 0.13% | ZB | ZC | ZM | ZW | ZG | ZP | | ZD | | ZR | | |
| 57 | SEIS4 | 3.03E-08 | 0.31% | 0.13% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | | ZR | | |
| 58 | SEIS2 | 2.86E-08 | 0.29% | 0.12% | ZB | ZC | ZM | ZW | | ZP | | | | | | |
| 59 | SEIS4 | 2.83E-08 | 0.29% | 0.12% | ZB | ZC | ZM | ZW | ZG | | | | ZQ | | | |
| 60 | SEIS2 | 2.77E-08 | 0.29% | 0.12% | ZB | ZC | ZM | | | ZP | | | | | | |
| 61 | SEIS4 | 2.75E-08 | 0.28% | 0.11% | ZB | ZC | ZM | ZW | ZG | | ZE | | ZQ | | | |
| 62 | SEIS4 | 2.72E-08 | 0.28% | 0.11% | ZB | ZC | ZM | ZW | ZG | ZP | | | | ZR | | |
| 63 | SEIS4 | 2.65E-08 | 0.27% | 0.11% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | | | ZR | | |
| 64 | SEIS4 | 2.57E-08 | 0.26% | 0.11% | ZB | ZC | ZM | ZW | ZG | ZP | | ZD | | | | |
| 65 | SEIS2 | 2.54E-08 | 0.26% | 0.11% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 66 | SEIS4 | 2.50E-08 | 0.26% | 0.10% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | | | | |
| 67 | SEIS4 | 2.48E-08 | 0.26% | 0.10% | ZB | ZC | ZM | ZW | | ZP | | ZD | ZQ | | | |
| 68 | SEIS2 | 2.47E-08 | 0.25% | 0.10% | ZB | ZC | ZM | ZW | | | ZE | | | | | |
| 69 | SEIS2 | 2.46E-08 | 0.25% | 0.10% | ZB | ZC | ZM | | ZG | | | | | | | |
| 70 | SEIS4 | 2.41E-08 | 0.25% | 0.10% | ZB | ZC | ZM | ZW | | ZP | ZE | ZD | ZQ | | | |
| 71 | SEIS2 | 2.39E-08 | 0.25% | 0.10% | ZB | ZC | ZM | | | | ZE | | | | | |
| 72 | SEIS4 | 2.24E-08 | 0.23% | 0.09% | ZB | ZC | ZM | ZW | ZG | ZP | | | | | | |
| 73 | SEIS4 | 2.18E-08 | 0.22% | 0.09% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | | | | | |
| 74 | SEIS4 | 2.17E-08 | 0.22% | 0.09% | ZB | ZC | ZM | ZW | | ZP | | | ZQ | | | |
| 75 | SEIS4 | 2.10E-08 | 0.22% | 0.09% | ZB | ZC | ZM | ZW | | ZP | ZE | | ZQ | | | |
| 76 | SEIS3 | 2.10E-08 | 0.22% | 0.09% | ZB | ZC | | ZW | ZG | ZP | | | | | | |
| 77 | SEIS3 | 2.06E-08 | 0.21% | 0.09% | ZB | ZC | | | ZG | | | | | | | |
| 78 | SEIS3 | 2.04E-08 | 0.21% | 0.08% | ZB | ZC | | | | ZP | | | | | | |
| 79 | SEIS3 | 1.99E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | | | | | | |
| 80 | SEIS3 | 1.97E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | | | | | |
| 81 | SEIS4 | 1.97E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | | ZD | ZQ | ZR | | |
| 82 | SEIS4 | 1.96E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | | | | ZD | | | | |
| 83 | SEIS5 | 1.95E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | ZQ | ZR | | |
| 84 | SEIS3 | 1.95E-08 | 0.20% | 0.08% | ZB | ZC | ZM | | ZG | | | | | | | |

| *Rank* | *Seismic Initiating Event* | *Core Damage Frequency* | *Percent of Seismic CDF* | *Percent of Total CDF* | *Combination of Seismic Top Event Failures in the Core Damage Sequence* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **ZB** | **ZC** | **ZM** | **ZW** | **ZG** | **ZP** | **ZE** | **ZD** | **ZQ** | **ZR** | **ZI** | **ZF** |
| 85 | SEIS3 | 1.94E-08 | 0.20% | 0.08% | ZB | ZC | ZM | | ZG | | ZE | | | | | |
| 86 | SEIS3 | 1.93E-08 | 0.20% | 0.08% | ZB | ZC | ZM | | | ZP | | | | | | |
| 87 | SEIS3 | 1.92E-08 | 0.20% | 0.08% | ZB | ZC | ZM | | | ZP | ZE | | | | | |
| 88 | SEIS4 | 1.91E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | ZE | ZD | ZQ | ZR | | |
| 89 | SEIS4 | 1.91E-08 | 0.20% | 0.08% | ZB | ZC | ZM | ZW | | | ZE | ZD | | | | |
| 90 | SEIS2 | 1.90E-08 | 0.20% | 0.08% | ZB | ZC | | ZW | | ZP | | | | | | |
| 91 | SEIS3 | 1.87E-08 | 0.19% | 0.08% | ZB | ZC | | ZW | | | ZE | | | | | |
| 92 | SEIS2 | 1.84E-08 | 0.19% | 0.08% | ZB | ZC | | | | ZP | | | | | | |
| 93 | SEIS3 | 1.82E-08 | 0.19% | 0.08% | ZB | ZC | ZM | ZW | ZG | ZP | | | ZQ | | | |
| 94 | SEIS3 | 1.78E-08 | 0.18% | 0.07% | ZB | ZC | ZM | | ZG | | | | ZQ | | | |
| 95 | SEIS3 | 1.77E-08 | 0.18% | 0.07% | ZB | ZC | ZM | ZW | | | ZE | | | | | |
| 96 | SEIS3 | 1.76E-08 | 0.18% | 0.07% | ZB | ZC | ZM | | | ZP | | | ZQ | | | |
| 97 | SEIS4 | 1.72E-08 | 0.18% | 0.07% | ZB | ZC | ZM | ZW | ZG | ZP | | | ZQ | ZR | | |
| 98 | SEIS4 | 1.71E-08 | 0.18% | 0.07% | ZB | ZC | ZM | ZW | | | | | | | | |
| 99 | SEIS3 | 1.70E-08 | 0.17% | 0.07% | ZB | ZC | ZM | ZW | ZG | | | | | | | |
| 100 | SEIS2 | 1.69E-08 | 0.17% | 0.07% | ZB | ZC | | ZW | ZG | | | | | | | |
| **Totals for Top 100 Dominant Seismic Events** | | **5.40E-06** | **55.7%** | **22.5%** | **Percent Contribution of Seismic Top Events for the Top 100 Seismic Core Damage Sequences** | | | | | | | | | | | |
| | | | | | **ZB 100%** | **ZC 94%** | **ZM 85%** | **ZW 78%** | **ZG 58%** | **ZP 58%** | **ZE 31%** | **ZD 22%** | **ZQ 21%** | **ZR 8%** | **ZI 0%** | **ZF 0%** |
| **Totals for All Seismic Events** | | **9.70E-06** | **100%** | **40.4%** | **Percent Contribution of Seismic Top Events for All Seismic Core Damage Sequences** | | | | | | | | | | | |
| | | | | | **ZB 98%** | **ZC 90%** | **ZM 84%** | **ZW 75%** | **ZG 55%** | **ZP 54%** | **ZE 27%** | **ZD 19%** | **ZQ 17%** | **ZR 9%** | **ZI 2%** | **ZF 2%** |

| UNIT 2 SEISMIC TOP EVENT DESCRIPTIONS | INITIATING EVENT | PGA Range (g) |
|---|---|---|
| ZB - ERF DIESEL GENERATOR POWER | SEIS1 | 0.10 to 0.25 |
| ZC - OFFSITE GRID | SEIS2 | 0.25 to 0.35 |
| ZM - STATION AIR COMPRESSORS | SEIS3 | 0.35 to 0.50 |
| ZW - NORMAL AC/DC POWER | SESI4 | 0.50 to 1.00 |
| ZG - SERVICE WATER SYSTEM/INTAKE STRUCTURE | SEIS5 | 1.00 to 1.33 |
| ZP - UNIT 2 PRIMARY AUXILIARY BUILDING | | |
| ZE - EMERGENCY AC POWER | | |
| ZD - EMERGENCY DC POWER | | |
| ZQ - DEMINERALIZED WATER STORAGE TANK | | |
| ZR - UNIT 2 FUEL BUILDING | | |
| ZI - PRIMARY PLANT CCW | | |
| ZF - VITAL INSTRUMENT BUS POWER | | |

## Table 3.B-10
## Unit 1 Retained Seismic Core Damage Sequences After Screening

| Rank | Seismic Initiating Event | Core Damage Frequency | Percent of Seismic CDF | Percent of Total CDF | Combination of Seismic Top Event Failures in the Core Damage Sequence | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ZB | ZC | ZD | ZE | ZF | ZH | ZS | ZI | ZA | ZW | ZN |
| 1 | SEIS3 | 5.67E-07 | 4.77% | 2.90% | ZB | ZC | ZD | | | | | | | | |
| 2 | SEIS2 | 5.03E-07 | 4.23% | 2.57% | ZB | ZC | ZD | | | | | | | | |
| 5 | SEIS2 | 3.91E-07 | 3.29% | 2.00% | ZB | | ZD | | | | | | | | |
| 9 | SEIS1 | 2.63E-07 | 2.22% | 1.35% | ZB | | ZD | | | | | | | | |
| 10 | SEIS3 | 2.20E-07 | 1.85% | 1.12% | ZB | ZC | ZD | | | | | | | | |
| 13 | SEIS2 | 1.95E-07 | 1.64% | 1.00% | ZB | ZC | ZD | | | | | | | | |
| 15 | SEIS3 | 1.42E-07 | 1.19% | 0.73% | ZB | ZC | ZD | | | | | | | | |
| 17 | SEIS2 | 1.26E-07 | 1.06% | 0.64% | ZB | ZC | ZD | | | | | | | | |
| 30 | SEIS3 | 7.72E-08 | 0.65% | 0.40% | ZB | ZC | | ZE | | | | | | | |
| 31 | SEIS3 | 7.29E-08 | 0.61% | 0.37% | ZB | | ZD | | | | | | | | |
| 36 | SEIS3 | 5.49E-08 | 0.46% | 0.28% | ZB | ZC | ZD | | | | | | | | |
| 42 | SEIS2 | 4.86E-08 | 0.41% | 0.25% | ZB | ZC | ZD | | | | | | | | |
| 49 | SEIS2 | 4.20E-08 | 0.35% | 0.22% | ZB | ZC | | ZE | | | | | | | |
| 63 | SEIS3 | 2.92E-08 | 0.25% | 0.15% | ZB | ZC | ZD | ZE | | | | | | | |
| 66 | SEIS3 | 2.91E-08 | 0.24% | 0.15% | ZB | ZC | ZD | | | ZH | | | | | |
| 69 | SEIS3 | 2.83E-08 | 0.24% | 0.15% | ZB | ZC | | | ZF | | | | | | |
| 87 | SEIS2 | 2.02E-08 | 0.17% | 0.10% | ZB | | | ZE | | | | | | | |
| 90 | SEIS3 | 1.93E-08 | 0.16% | 0.10% | ZB | ZC | | ZE | | | | | | | |
| 95 | SEIS2 | 1.89E-08 | 0.16% | 0.10% | ZB | ZC | | | ZF | | | | | | |
| 99 | SEIS2 | 1.74E-08 | 0.15% | 0.09% | | ZC | ZD | | | | | | | | |
| **Totals for Retained Seismic Event Sequences** | | **2.86E-06** | **24.1%** | **14.7%** | **Percent Contribution of Seismic Top Events in the Retained Seismic Core Damage Sequences** | | | | | | | | | | |
| | | | | | **ZB 95%** | **ZC 80%** | **ZD 70%** | **ZE 25%** | **ZF 10%** | **ZH 5%** | **ZS 0%** | **ZI 0%** | **ZA 0%** | **ZW 0%** | **ZN 0%** |

## Table 3.B-11
## Unit 2 Retained Seismic Core Damage Sequences After Screening

| *Rank* | *Seismic Initiating Event* | *Core Damage Frequency* | *Percent of Seismic CDF* | *Percent of Total CDF* | *Combination of Seismic Top Event Failures in the Core Damage Sequence* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **ZB** | **ZC** | **ZM** | **ZE** | **ZW** | **ZD** | **ZQ** | **ZR** | **ZI** | **ZF** |
| 6 | SEIS3 | 1.44E-07 | 1.49% | 0.60% | ZB | ZC | ZM | ZE | ZW | | | | | |
| 33 | SEIS3 | 5.21E-08 | 0.54% | 0.22% | ZB | ZC | ZM | ZE | | | | | | |
| 39 | SEIS3 | 4.53E-08 | 0.47% | 0.19% | ZB | ZC | ZM | | ZW | ZD | | | | |
| 48 | SEIS3 | 3.60E-08 | 0.37% | 0.15% | ZB | ZC | ZM | ZE | ZW | | | | | |
| 68 | SEIS2 | 2.47E-08 | 0.25% | 0.10% | ZB | ZC | ZM | ZE | ZW | | | | | |
| 71 | SEIS2 | 2.39E-08 | 0.25% | 0.10% | ZB | ZC | ZM | ZE | | | | | | |
| 91 | SEIS3 | 1.87E-08 | 0.19% | 0.08% | ZB | ZC | | ZE | ZW | | | | | |
| 95 | SEIS3 | 1.77E-08 | 0.18% | 0.07% | ZB | ZC | ZM | ZE | ZW | | | | | |
| **Totals for Retained Seismic Event Sequences** | | **3.62E-07** | **3.7%** | **1.5%** | **Percent Contribution of Seismic Top Events in the Retained Seismic Core Damage Sequences** | | | | | | | | | |
| | | | | | **ZB 100%** | **ZC 100%** | **ZM 88%** | **ZE 88%** | **ZW 75%** | **ZD 13%** | **ZQ 0%** | **ZR 0%** | **ZI 0%** | **ZF 0%** |