ENERGY NORTHWEST

Sudesh K. Gambhir
Columbia Generating Station
P.O. Box 968, PE04
Richland, WA 99352-0968
Ph. 509.377.8313 | F. 509.377.2354
sgambhir@energy-northwest.com

January 28, 2011
GO2-11-032

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

Subject: **COLUMBIA GENERATING STATION, DOCKET NO. 50-397 RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE COLUMBIA GENERATING STATION, LICENSE RENEWAL APPLICATION**

References:

1) Letter, GO2-10-011, dated January 19, 2010, WS Oxenford (Energy Northwest) to NRC, "License Renewal Application"

6) Letter dated July 1, 2010, NRC to WS Oxenford (Energy Northwest), "Request for Additional Information for the Review of the Columbia Generating Station License Renewal Application – SAMA Review," (ADAMS Accession No. ML101760421)

7) Letter, GO2-10-138, dated September 17, 2010, SK Gambhir (Energy Northwest) to NRC, "Response to Request for Additional Information for the Review of the Columbia Generating State License Renewal Application"

8) Letter dated November 10, 2010, NRC to SK Gambhir (Energy Northwest), "Request for Additional Information for the Review of the Columbia Generating Station License Renewal Application – SAMA Review," (ADAMS Accession No. ML102870984)

9) Letter dated December 2, 2010, NRC to SK Gambhir (Energy Northwest), "Request for Additional Information for the Review of the Columbia Generating Station License Renewal Application – SAMA Review," (ADAMS Accession No. ML103330246)

Dear Sir or Madam:

By Reference 1, Energy Northwest requested the renewal of the Columbia Generating Station (CGS) operating license. Via Reference 2, the Nuclear Regulatory Commission (NRC) requested additional information pertaining to the Severe Accident Mitigation Alternatives (SAMA) analysis. In Reference 3, Energy Northwest submitted responses to the Request for Additional Information (RAI) contained in Reference 2.

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In References 4 and 5, the NRC requested additional information pertaining to certain responses provided by Energy Northwest in Reference 3. Transmitted herewith in Attachment 2 is the Energy Northwest response to the RAIs contained in References 4 and 5. Enclosure 1 contains Amendment 24 to the License Renewal Application (LRA) that was submitted in Reference 1.

Certain responses in Reference 3 relied upon the results of a sensitivity study, which was to be provided at a later date. Transmitted herewith in Attachment 3 is the sensitivity study based upon the Columbia Integrated Full Power Probabilistic Safety Assessment Model Revision 7.1 referred to in Reference 3.

No new commitments are included in this response. A total of sixteen SAMA candidates will be considered for implementation.

If you have any questions or require additional information, please contact Abbas Mostala at (509) 377-4197.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the date of this letter.

Respectfully,

Jack T. Baker
for
SK Gambhir
Vice President, Engineering

Attachment 1: List of Acronyms
Attachment 2: Response to Request for Additional Information
Attachment 3: Sensitivity Study Based upon the Integrated PSA Model Rev. 7.1
Enclosure 1: Amendment 24 to the LRA

cc: NRC Region IV Administrator
NRC NRR Project Manager
NRC Senior Resident Inspector/988C
EFSEC Manager
RN Sherman – BPA/1399
WA Horin – Winston & Strawn
D Doyle - NRC NRR (w/a)
BE Holian - NRC NRR
RR Cowley – WD

LIST OF ACRONYMS
Attachment 1

AC	Alternating Current
ADS	Automatic Depressurization System
AOC	Averted Off-Site Property Damage Costs
AOE	Averted Occupational Exposure
AOSC	Averted On-Site Costs
APE	Averted Public Exposure
AR	Action Request
AST	Alternative Source Term
ATWS	Anticipated Transient Without Scram
BED	Basic Event Data
BOC	Break Outside Containment
BOP	Balance of Plant
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CAS	Control Air System
CCF	Common Cause Failure
CDF	Core Damage Frequency
CET	Containment Event Trees
CGS	Columbia Generating Station
CIA	Containment Instrument Air System
CIV	Containment Isolation Valve
CPT	Control Power Transformer
CRC	Curriculum Review Committee
CRD	Control Rod Drive
CRDM	Control Rod Drive Mechanism
CST	Condensate Storage Tank
DC	Direct Current
DG	Diesel Generator (used interchangeably with EDG)
DMA	Diesel Mixed Air
EAC	Executive Authorization Committee
EAL	Emergency Action Level
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator (interchangeable with DG)
EOP	Emergency Operating Procedure
EPG	Emergency Procedure Guideline
ER	Environmental Report
F&Os	Fact and Observations
FP	Fire Protection
FPSA	Fire Probabilistic Safety Assessment
F-V	Fussell-Vesely
FW	Feedwater
HEP	Human Error Probability
HPCS	High Pressure Core Spray
HRA	Human Reliability Analysis
HVAC	Heating, Ventilation and Air Conditioning
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination - External Events

ISLOCA	Interfacing System Loss of Coolant Accident
LCO	Limiting Condition for Operation
LERF	Large Early Release Frequency
LLOCA	Large Loss of Coolant Accident
LOCA	Loss of Coolant Accident
LOOP	Loss of Off-Site Power
LPCI	Low Pressure Coolant Injection
LPCS	Low Pressure Core Spray
LRA	License Renewal Application
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System
MCC	Motor Control Center
MLOCA	Medium Loss of Coolant Accident
MO	Motor Operator
MOC	Mechanism Operated Cell
MOV	Motor Operated Valve
MRule	Maintenance Rule
MS	Main Steam
MSIV	Main Steam Isolation Valve
MSPI	Mitigating System Performance Indicator
MSO	Multiple Spurious (Equipment) Operations
NC-FTO	Normally Closed – Fail to Open
NC-FTRC	Normally Closed – Fail to Remain Closed
NDE	Non-Destructive Examination
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
NUMARC	Nuclear Management and Resources Council
OOS	Out of Service
PCS	Power Conversion System
PDS	Plant Damage State
PRA	Probabilistic Risk Assessment
PRC	Project Review Committee
PSA	Probabilistic Safety Assessment
RAI	Request for Additional Information
RAW	Risk Achievement Worth
RCC	Reactor Closed Cooling
RCIC	Reactor Core Isolation and Cooling
rem	roentgen equivalent man
RFW	Reactor Feedwater
RG	Regulatory Guide
RHR	Residual Heat Removal
RHRSW	Residual Heat Removal Service Water
RPV	Reactor Pressure Vessel
RRW	Risk Reduction Worth
RWCU	Reactor Water Cleanup
SAG	Severe Accident Guideline
SAMA	Severe Accident Mitigation Alternative(s)

SAT	Systematic Approach to Training
SBO	Station Blackout
SDC	Shutdown Cooling
SGT	Standby Gas Treatment
SLC	Standby Liquid Control
SLOCA	Small Loss of Coolant Accident
SORV	Stuck Open Relief Valve
SPC	Suppression Pool Cooling
SPSA	Seismic Probabilistic Safety Assessment
SRV	Safety Relief Valve
SSEL	Safe Shutdown Equipment List
SW	(Standby) Service Water
TREQ	Training Request
TS	Technical Specifications
TSW	Plant Service Water

BACKGROUND:

The NRC has issued two additional letters requesting information for the SAMA analysis: ADAMS Accession No. ML102870984 dated November 10, 2010, and ADAMS Accession No. ML103330246 dated December 2, 2010. The following table presents a list of the RAI questions and the location of the responses.

Note: All references in this attachment refer to the list of references contained in the cover letter.

RAI	Date	Location
3.b-1	12/2/10	Attachment 2
3.d(i)-1	11/10/10	Attachment 2
3.d(ii)-1	12/2/10	Attachment 3 Section 2.2
3.i-1	12/2/10	Attachment 2 (Corrected LRA page in Enclosure 1)
5.a-1i	12/2/10	Attachment 2
5.d-1i	12/2/10	Attachment 2 (SAMAs FR-03, OT-07R also evaluated in Attachment 3)
5.l-1i	12/2/10	Attachment 2 – included in response to 6.j-1ii (SAMA FR-08 was also evaluated in Attachment 3)
5.l-1ii	12/2/10	Attachment 2
6.b-1i	12/2/10	Attachment 2 – included in response to 6.j-1ii (SAMAs AC/DC-02, 03, 15, 16 were also evaluated in Attachment 3)
6.c(i)-1	12/2/10	Attachment 2
6.c(ii)-1	12/2/10	Attachment 2 (SAMA CW-03 is also evaluated in Attachment 3)
6.h(c,d)-1	12/2/10	Attachment 2 (SAMAs FR-07a, 07b also evaluated in Attachment 3)
6.j-1	11/10/10	Attachment 3 Section 4.3 and Appendix A Tables A-15, A-16
6.j-1ii	12/2/10	Attachment 2 and Attachment 3 Section 4.2 and Appendix B Table B-8
6.j-1iv	12/2/10	Attachment 2

NRC Request:

3.b-1 Given that the use of NUREG/CR-6850 was limited to only the refinement of electrical hot short probabilities, describe the conservatisms remaining in the fire PSA beyond those that may have been associated with the use of NUREG/CR-6850 used to support SAMA analysis.

Energy Northwest Response:

Areas of conservatism exist in the use of full compartment burn-up, rather than more detailed fire scenarios for some risk-significant fire areas. Also, conservative fire ignition frequencies are used. Although a significant amount of detailed fire scenario modeling has been performed for PSA Rev. 6.2, additional detailed scenario modeling of risk significant fire areas was not completed. Detailed fire scenario modeling would allow reduced risk using current plant configuration. An additional conservatism is in modeling of ignition frequencies. Newer industry data for fire ignition frequencies are significantly lower (on the order of a factor of two in some cases) than the fire frequencies used for PSA Rev. 6.2.

NRC Request:

3.d(i)-1 The response states that the "electronic database used to select and locate cables does not include all conduit locations," and that "most, but not all" of the multiple spurious equipment operations (MSOs) that may need to be modeled have been captured and that, for those not captured, the response to RAI 6.j will account for the incompleteness. The response continues to the conclusion that the "model incompleteness is judged to be encompassed by the provided sensitivity analysis," which includes the use of a 95th percentile uncertainty band on the base fire core damage frequency (CDF). (The response to RAI 6.j further cites sensitivity analysis via the 95th percentile approach). As Columbia estimates a fire CDF using an analysis that goes beyond the typical fire individual plant examination – external events (IPEEE), enhancements to reduce potential conservatisms, as well as enhancements to remove potential non-conservatisms, that might exist in an IPEEE-like estimate of fire CDF should be present. For example, source-target-specific fire scenarios should have been used in lieu of more conservative assumptions of total room burn-up; and hot short probabilities typically of at least 0.3 should have been assumed in lieu of potentially non-conservative lower values. Please describe these enhancements, including those used with regard to compensating for any incompleteness in the cable location database and modeling of MSOs as cited in the response.

Energy Northwest Response:

To respond to this request, a sensitivity study was performed using PSA Rev. 7.1, which integrates Internal Events, Fire and Seismic PSA models and facilitates the use of the upgraded Internal Events Level 1 and 2 models by the Fire and Seismic models. Rev. 7.1 also includes an update of the hot short probabilities to 0.3 for all of the 130 fire-induced spurious operations modeled, with the exception of some spurious operations of air-operated valves within the condensate system where hot short durations were evaluated and modeled (see response to RAI 3.d(ii)-1 in Attachment 3 for further sensitivity results associated with hot shorts).

Modeling of MSOs is an area of incompleteness in the Fire model. Conservative treatment of hot short modeling was used in part to respond to this incompleteness. Additionally, in response to Enforcement Guidance Memorandum EGM 09-02, plant modifications are in progress to address MSOs in safe shutdown circuits. Once implemented in the plant, a model update will occur. This effort supports, but is separate from the SAMA evaluation process and would be duplicative for safe shutdown components.

Generally, the industry has seen some increase in CDF contribution from inclusion of MSOs in PSAs. The full quantitative impact of inclusion of MSOs for accident mitigating systems is not known at this time. It is estimated that the impact would not be significant enough to impact the SAMA analysis results when the 95th percentile uncertainty factor (multiplier of 2.6 for Fire) is applied to the benefit results.

The FPSA model (both Rev. 6.2 and the Rev. 7.1 integrated model) contain selected source-target-specific fire scenarios in lieu of more conservative assumptions of total room burn-up. This was primarily performed for the higher risk fire zones. The lower risk fire zones were included in the model using conservative full room burn-up assumptions. A description of the detailed fire modeling is reported in section E5.5.2 of the ER. However, the amount of detailed fire zone modeling using source target methodology is incomplete and further reduction in conservatism is possible. This incompleteness is judged to not be significant enough to result in masking of importance.

Another area of identified incompleteness is the modeling of circuits routed in conduit. The current Cable and Raceway (Edison) database was reviewed. This database has been upgraded after the issuance of Rev. 6.2 FPSA. This database has been in an update activity during the last two years and has indentified the conduit that was not included in the Rev. 6.2 Fire model. This update provided building and, in most cases, the fire zone locations of the conduits. However, the routing within the fire zone is not exact enough in the database for further refinement without walkdowns and detailed fire modeling within the zone. Nevertheless, the Integrated PSA Model Rev. 7.1 was modified to include fire impacts to the conduits and enclosed circuits and a sensitivity evaluation performed. Refinements at the scenario level in many instances could not be made. That is, conduits whose location was known only at the zone level based on the data in Edison, were assumed to be failed for all fire scenarios within that zone. Further refinements for this sensitivity evaluation were not possible at this time without walkdowns and additional scenario development. Although this creates very conservative modeling and potential masking of importance of those circuits with more refined detail, the determination of the RRW for SAMA analysis is of value for assessing the incompleteness. The sensitivity evaluation used six existing SAMA cases that are representative of important systems and fire compartments at CGS to determine if the conduit modeling incompleteness would give an indication of impacting the SAMA results. Table 3.d(i)-1 provides the comparative results of these six SAMA cases.

Table 3.d(i)-1			
SAMA Case	Description	Original RRW (Fire)	Sensitivity RRW (Fire)
AC/DC-27	Install permanent hardware changes that make it possible to establish 500 kV backfeed through the main step-up transformer.	1.615	1.047
FR-07b	Improve the fire resistance of critical cables	1.036	1.000
FR-09R	Install early fire detection in the following Reactor Building physical analysis units: R-1B, R-1D, R-1J, R-1L, R-1C, R-1K	1.183	1.398[1]
FR-08	Protect RHR and SW cables from fires.	2.284	1.915
FR-12R	Install early fire detection in the following physical analysis units: T-1A, T-12, T-1C, T-1D	1.141	1.241[1]
FR-11R	Install early fire detection in the following physical analysis units: RC-02, RC-03, RC-05, RC-04, RC-07, RC-08, RC-11, RC-14, RC-13, RC-1A	2.266	1.067

[1]FR-09R and FR-12R: The increase in RRW was less than the Uncertainty Factor in Table 4-1

The sensitivity evaluation RRWs that are smaller in the modified model is most likely due to lack of refinement in detailed modeling of the fire impacts to conduits that are routed in large zones or span multiple zones. The conservatism is partially masking the benefit seen from the individual SAMA candidates. The increase in RRW values associated with SAMA candidates for two of the more important fire compartments were within the uncertainty factor of Table 4.1. However, there is not a significant increase in the RRW value that would impact the SAMA results. This fact supports the judgment that the conduit modeling incompleteness in the FPSA model does not impact the SAMA results.

NRC Request:

3.i-1 In the response, Table 3.i-1 (as well as Table E.4-4 in the ER) shows that PDS 2C (Transient with stuck-open SRV or LOCA with loss of containment heat removal and containment failure occurs prior to core damage with the reactor vessel at low pressure) does not apply to the internal events PSA, but does apply to fire PSA, while at the same time PDS 2D (Transient with loss of containment heat removal and containment fails prior to core damage with the reactor vessel at high pressure) applies to the internal events PSA but not the fire PSA. This appears to be inconsistent. Furthermore, it is not clear why the fire PSA does not include fire-induced containment bypass events (see page 54 of the response). Clarify the apparent discrepancy between consideration of PDS 2C and 2D in the fire PSA. Provide justification on why the fire PSA does not include fire-induced containment bypass events.

Energy Northwest Response:

Table E.4-4 in the ER identified a PDS 2C that was reproduced in the CGS RAI response to 3.i in Reference 3. The reference to PDS 2C has been identified as an error. PDS 2C does not exist in any portion of the CGS PSA model. The values for PDS 2D (Loss of containment decay heat removal, containment failed, high RCS pressure; low pressure injection failed and decay heat removal failed) for the Level 1 Fire were shown inadvertently in the 2C row. The row with the 2C identification will be deleted. Corrected Tables 3.i-1 and 3.i-2 are provided below.

Table 3.i-1 Comparison of Level 1 by PDS for Internal Events and Fire PSA

PDS	Level 1 Internal Events PSA		Level 1 Fire PSA	
	Frequency (/yr)	Percent	Frequency (/yr)	Percent
1A1	5.1E-08	1.1%	0.0E+00	0.0%
1A2	8.4E-07	17.5%	8.3E-07	11.2%
1A3A	4.7E-08	1.0%	0.0E+00	0.0%
1A3B	9.8E-08	2.0%	3.2E-07	4.3%
1B0[(1)]	3.1E-07	6.5%	2.4E-06	32.4%
1C	1.5E-07	3.1%	0.0E+00	0.0%
1G	4.9E-07	10.2%	1.6E-06	21.6%
1HA	3.5E-08	0.7%	0.0E+00	0.0%
1HB	4.7E-08	1.0%	7.7E-08	1.0%
2B[(1)]	1.6E-09	0.0%	2.8E-08	0.4%
2D[(1)(2)]	5.1E-07	10.6%	1.5E-06	20.3%
3C	3.0E-07	6.3%	N/A	N/A
4BA	1.1E-07	2.3%	2.7E-10	0.0%
4BL	6.4E-08	1.3%	0.0E+00	0.0%
5	1.5E-07	3.1%	Note 2	0.0%
6A1A	3.0E-07	6.3%	0.0E+00	0.0%
6A1B	7.4E-07	15.4%	3.7E-07	5.0%
6A2	2.3E-08	0.5%	7.6E-08	1.0%
6B1	3.3E-07	6.9%	2.7E-07	3.6%
6B2A	5.7E-08	1.2%	0.0E+00	0.0%
6B2B	1.4E-07	2.9%	3.7E-08	0.5%

Note (1): PDSs associated with long term Loss of Decay Heat Removal scenarios.
Note (2): Node ISO in the Fire CETs captures the potential for containment bypass events. The node probability is conservatively based on the Internal Events MSIV CCF failure to isolate probability.

Table 3.i-2 Comparison of Level 2 LERF by PDS for Internal Events and Fire PSA				
PDS	Level 2 LERF Internal Events PSA		Level 2 LERF Fire PSA	
	Frequency (/yr)	Percent	Frequency (/yr)	Percent
1A1	5.5E-09	0.8%	0.0E+00	0.0%
1A2	9.1E-08	13.9%	9.0E-08	36.6%
1A3A	2.9E-10	0.0%	0.0E+00	0.0%
1A3B	4.3E-09	0.7%	1.3E-07	52.8%
1B0(1)	0.0E+00	0.0%	0.0E+00	0.0%
1C	1.5E-07	23.0%	0.0E+00	0.0%
1G	3.8E-10	0.1%	1.23E-09	0.5%
1HA	2.7E-11	0.0%	0.0E+00	0.0%
1HB	3.6E-11	0.0%	5.97E-11	0.0%
2B(1)	0.0E+00	0.0%	0.0E+00	0.0%
2D(1)	0.0E+00	0.0%	0.0E+00	0.0%
3C	2.3E-10	0.0%	N/A	N/A
4BA	1.1E-07	16.8%	2.7E-10	0.1%
4BL	6.4E-08	9.8%	0.0E+00	0.0%
5	1.5E-07	23.0%	0.0E+00	0.0%
6A1A	2.0E-08	3.1%	0.0E+00	0.0%
6A1B	5.0E-08	7.7%	2.5E-08	10.2%
6A2	0.0E+00	0.0%	0.0E+00	0.0%
6B1	0.0E+00	0.0%	0.0E+00	0.0%
6B2A	0.0E+00	0.0%	0.0E+00	0.0%
6B2B	0.0E+00	0.0%	0.0E+00	0.0%

Note (1): PDSs associated with long term Loss of Decay Heat Removal scenarios.
Note (2): Node ISO in the Fire CETs captures the potential for containment bypass events. The node probability is conservatively based on the Internal Events MSIV CCF failure to isolate probability.

Fire induced containment bypass events are addressed in the FPSA model. PDS State 5, which is used to capture LOCA outside containment with failure to isolate the break in the Level 1 PSA, is not used for the FPSA. Instead, the Fire Level 2 CETs contain a first branch node that asks if the containment is isolated. The value used for this branch node is consistent with the value used for the Internal Events node for loss of containment. This value is based on the Internal Events CCF of the MSIVs to isolate. The assumption is that the most impacting result of a fire to containment isolation would be to cause a major containment isolation pathway to not close or to inadvertently open. The node for failure of containment isolation for fire events primarily impacts the large-early, non-scrubbed (LEN) release category in the PSA model, thereby maximizing its importance. This is a modeling simplification for the PSA Rev. 6.2 model.

For FPSA Rev. 6.2, the LERF analysis uses a probability of 7.8E-04 for failure of containment isolation for all PDSs. It is dominated by the CCF of a pair of MSIVs to close, multiplied by the 4 pairs of MSIVs. For FPSA Rev. 7.1, the LERF analysis uses a probability of 2.72E-03 for failure of containment isolation for all PDSs. It is dominated by the probability for pre-existing containment failures.

The only ISLOCA pathway from the containment that contains two in-series MOVs is the RHR shutdown cooling suction line that is isolated by MOVs RHR-V-8 and RHR-V-

9. Valve RHR-V-9 is maintained in the closed position during normal plant operation with power removed from the motor via a protected isolation switch maintained in the "ISOLATE" position. Spurious control and power signals resulting from hot shorts cannot cause the valve motor to energize. The de-energized (isolated) power feeder has been routed in a grounded steel conduit to protect it against external three-phase hot shorts. A fire-induced three phase hot short impacting the RHR-V-9 power feeder, per NUREG/CR-6850, is significantly less than the probability for failure of containment isolation modeled in the FPSA.

Thus, the likelihood for a fire-induced ISLOCA is found to be significantly less than the values used for failure of containment isolation.

NRC Request:

5.a-1i The response states that 72 cost-beneficial industry SAMAs were evaluated. Of these, 51 SAMAs were determined to not be applicable to CGS, have already been implemented at CGS, or were already considered in the ER. This suggests that 21 of the 72 SAMAs were further evaluated. In addition, the RAI response states that these "remaining industry cost-beneficial candidates, along with the 4 candidates specifically identified in the RAI, are listed in Table 5.a-1, and an assessment of the applicability to CGS is provided." This suggests that Table 5.a-1 should have 25 SAMA candidate entries, however, the table only provides an assessment of 16 SAMAs. Clarify the discrepancy between the 25 SAMAs that should have been further considered, and the 16 SAMAs that were further considered in Table 5.a-1.

Energy Northwest Response:

All 72 cost-beneficial industry SAMA candidates were evaluated. A number of the candidates were duplicates of each other. Twenty-one of the SAMA candidates were determined to be not applicable to CGS. Twenty of the SAMA candidates were determined to be already implemented at CGS with an additional one candidate being a duplicate. Ten of the SAMA candidates were already evaluated in the ER with an additional two candidates being duplicates. As such, the remaining eighteen SAMA candidates were further evaluated, which included the four candidates specifically identified in the original RAI 5.a. Of the 18 candidates, two were duplicates, which were omitted from Table 5.a-1, leaving sixteen SAMA candidates.

NRC Request:

5.d-1i In the response in Table 5.d-1 there are several basic events (e.g., HS-CIAV-MO30A, HS-CIAV-MO20, CIAHUMNV104BH3-F) that were not considered because the fire PSA conservatively does not credit the air accumulators installed at each of the SRV's and so the basic event is judged to not be a realistic contribution to risk. Provide an assessment of what the RRW would be for these events if the air accumulators were credited and whether this would lead to additional SAMA candidates.

Energy Northwest Response:

The basic events, HS-CIAVMO30A, HS-CIAV-MO20, and CIAHUMNV104BH3-F were evaluated and a direct approach to assess the benefit from protecting these components from fire through new SAMA cases was performed. Additionally, two SAMA candidates for addressing the benefit of improving the pneumatic components' reliability for the SRVs was also performed to bound the improvement that crediting the air accumulators to the SRVs would provide.

The hot short basic events were evaluated by performing a new SAMA case FR-03 using the integrated PSA Rev 7.1 model. The Fire RRW associated with protecting CIA-MO-30A and CIA-MO-20 from failure (along with three other hot shorts) due to Fire was 1.064. This SAMA was found to be NOT cost-beneficial. See Table B-8 in Attachment 3. Basic Event CIAHUMNV104BH3-F was evaluated as part of the new SAMA Candidate OT-07R to improve procedures and operator training to identify systems and operator actions determined to be important from the PSA. See Table B-8.

The existing SAMA candidate CC-08 effectively evaluated the benefit of including the SRV air accumulators in the PSA model by improving the reliability of the most important of the SRVs. SAMA candidate CC-08 evaluated doubling the reliability of the seven ADS valves. The calculated RRW was 1.000, indicating little to no risk improvement. A second existing SAMA candidate IA-05 doubled the reliability of all SRVs and MSIV pneumatic components and produced an RRW of 1.001. Both of these candidates were screened as very low benefit and a cost-benefit analysis was not performed.

NRC Request:

5.l-1i The proposed SAMA was evaluated using the baseline assumptions and for a sensitivity case assuming a 3% discount rate. Provide an assessment of this proposed SAMA for the uncertainty analysis sensitivity case presented in response to RAI 6.j and follow-up RAI 6.j-1i.

Energy Northwest Response:

This RAI concerns SAMA candidate FR-08. See response to RAI 6.j-1ii in the following pages and the sensitivity study in Attachment 3.

NRC Request:

5.l-1ii Provide the detailed cost-benefit results for this proposed SAMA (i.e., Tables 11-2, 11-3 and 11-4 results).

Energy Northwest Response:

The detailed cost-benefit results (base cost) for SAMA candidate FR-08 are presented in Table 5.l-1ii-1 below.

Table 5.l-1ii-1

Case 28 (FR-08) (Cables – RHRSW)	**Internal Events**	**Fire**	**Seismic**
Off-site Annual Dose (rem)	3.68E+00	1.88E+00	6.75E+00
Off-site Annual Property Loss ($)	$6,140	$3,274	$11,106
Comparison CDF	4.80E-06	7.41E-06	5.25E-06
Comparison Dose (rem)	3.68E+00	8.60E+00	6.75E+00
Comparison Cost ($)	$6,140	$15,547	$11,106.17
Enhanced CDF	4.80E-06	2.08E-06	5.25E-06
Reduction in CDF	**0.00%**	**71.94%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**78.12%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$459	$0
Long Term Dose Savings (On-site)	$0	$2,002	$0
Total Accident Related Occupational Exposure (AOE)	$0	$2,461	$0
Cleanup/Decontamination Savings (On-site)	$0	$75,076	$0
Replacement Power Savings (On-site)	$0	$110,736	$0
Averted Costs of On-site Property Damage (AOSC)	$0	$185,812	$0
Total On-site Benefit	**$0**	**$188,274**	**$0**
Averted Public Exposure (APE)	$0	$175,360	$0
Averted Off-site Damage Savings (AOC)	$0	$160,168	$0
Total Off-site Benefit	**$0**	**$355,517**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$523,791**	**$0**

NRC Request:

6.b-1i SAMAs AC/DC-02, AC/DC-03, AC/DC-15, and AC/DC-16 were evaluated using the baseline assumptions. Provide an assessment of these SAMAs for

the uncertainty analysis sensitivity case presented in response to RAI 6.j.

Energy Northwest Response:

See response to RAI 6.j-1ii in the following pages.

NRC Request:

6.c(i)-1 The response did not answer the question. Provide the time available to recover offsite power with RCIC operating assumed in the baseline PSA without the SAMA.

Energy Northwest Response:

The time available to recover offsite power with RCIC operating assumed in the baseline PSA Rev. 6.2 is eight hours with DC power load-shedding and six hours without load-shedding.

The time available to recover offsite power with RCIC operating assumed in the baseline Integrated PSA Model Rev. 7.1 is seven hours with DC power load-shedding and five hours without load-shedding.

NRC Request:

6.c(ii)-1 The response did not provide the requested information for SAMA CW-03. Provide a description of the PSA model changes for this SAMA in layman terms.

Energy Northwest Response:

SAMA candidate CW-03 is to replace the ECCS pump motors with air-cooled motors. The pump motor cooling dependencies modeled for the low pressure ECCS pump motors were set to a low value (1.0E-09). Note: There is no external pump motor cooling for HPCS, so there was no change for the HPCS pump motor.

NRC Request:

6.h(c,d)-1 Both SAMAs FR-07a and FR-07b provide cost estimates based on assuming that polymeric cables would be replaced by metal-sheathed ("armored?") ones so as to prevent electrical circuit failure. Depending upon the failure mode involved (short circuit, short to power ["hot short"], open circuit, grounded circuit, etc.), the use of metal-sheathed cables may or may not prevent the assumed electrical failure from occurring (cable degradation can occur due solely to heat transfer even if there is no flame impingement directly on the cable jacketing). Specifically, if the electrical failure could result from degradation WITHIN a specific cable, such as an INTRA-cable hot short, vs. degradation requiring two or more cables to interact, such as an INTER-cable hot short, the use of metal sheathing may not preclude failure. Discuss the specific electrical failure modes that the SAMA intends to prevent and justify that the use of metal-sheathed cables will prevent these from occurring.

Energy Northwest Response:

Energy Northwest agrees with the RAI discussion on circuit failure modes and the need to ensure that the types of mitigation selected provide the appropriate protection for the circuits involved. It was never intended to indicate that armored cabling could be used for mitigation of all spurious operations. The intent of selecting metal-jacketed (armored) cable as an example in SAMA candidates FR-07a and FR-07b was to address, with a relatively lower cost of implementation, some of the circuit failure modes that cause spurious operations. By using this approach, the estimated cost for implementation of the SAMA candidates was conservatively minimized. Additionally, CGS has actual cost information from installation of armored cable, upon which to base the cost estimate.

Armored cabling is among the least costly of a variety of options to mitigate fire-induced spurious operations. Options such as Meggitt cable, Darmatt wrap or other approved wrapping systems are more expensive. The choice of fire protection enhancement will depend on detailed circuit analyses that include consideration of the circuit logic, the routing, the presence of energized intra-conductors or energized external inter-conductors, the routing through the fire area, and required fire hour rating.

During the implementation phase of these cost-beneficial SAMA candidates, specific protective schemes applicable to the circuit failure mode(s) of concern will be selected. For example, the criteria for using armored cabling would include: a) the circuit is normally de-energized with no energized intra-cable conductors existing, b) a design basis related fire would cause no change in the component function, and c) no impact on post-fire safe shutdown would occur; that is, if this cable is routed in 3-hour fire areas, it would be routed away from fire-induced falling debris, etc. There is one spurious operation event examined by SAMA candidates FR-07a and FR-07b that could potentially utilize armored cabling in lieu of the more expensive Meggitt-type protection. Mitigation of other spurious operations would require a Meggitt cabling system or a

combination of enclosed raceways with Darmatt or other approved wrapping at increased cost for implementation.

This cost-benefit analysis approach utilized is conservative. Further detailed engineering analysis is not necessary at this time for the SAMA evaluation.

NRC Request:

6.j-1ii It is unclear how the "Estimated Benefit" in Table 6.j-2 were developed using the uncertainty factors provided in Table 6.j-1. For example, for SAMA AC/DC-27, assuming 7% discount rate, the baseline total benefit from the ER was stated to be $56,044 for internal events, $184,421 for fire events, $0 for seismic events, and $56,044 for other external events, resulting in a total baseline (internal + external) benefit of $296,509. Applying the uncertainty factors from Table 6.j-1 in an uncertainty benefit of $151,319 ($56,044 × 2.7) for internal events, $571,705 ($184,421 × 3.1) for fire events, and $151,319 ($56,044 × 2.7) for other external events, resulting in a total uncertainty (internal + external) benefit of $874,343. However, Table 6.j-2 reports the estimated benefit to be $586,944. The uncertainty factors should be applied to all of the elements of the benefit calculation (i.e., APE, AOC, AOE, and AOSC) since each is weighted by CDF. Describe how the uncertainty analysis was performed and justify the "Estimated Benefits" provided in Table 6.j-2.

Energy Northwest Response:

Upon further review of the calculation used to support the Reference 3 response to RAI 6.j, Energy Northwest determined that the uncertainty factors were not applied to all elements of the benefit calculation. The benefits have been recalculated by applying the uncertainty factors to all of the elements of the benefit calculation (APE, AOC, AOE and AOSC). The uncertainty factors from the Reference 3 response to RAI 6.j were utilized in this calculation. The results are presented in Table 6.j-1ii-1 below.

Table 6.j-1ii-1				
SAMA ID	**Modification**	**Estimated Benefit**	**2008 Estimated Cost**	**Sensitivity Case Conclusion**
AC/DC-01	Provide additional DC battery capacity.	$104,545	$1,799,200	Not Cost Effective
AC/DC-02	Replace lead acid batteries with fuel cells.	$104,545	$1,040,000	Not Cost Effective
AC/DC-03	Add portable, diesel driven battery charger to existing DC system.	$104,545	$500,000	Not Cost Effective
AC/DC-10	Provide an additional DG.	$717,764	$10,816,000	Not Cost Effective
AC/DC-15	Install a gas turbine generator.	$717,764	$2,080,000	Not Cost Effective
AC/DC-16	Install tornado protection of gas turbine generator.	$717,764	$2,080,000	Not Cost Effective
AC/DC-23	Develop procedures to repair or replace failed 4 kV breakers.	$60,639	$375,000	Not Cost Effective
AC/DC-27	Install permanent hardware changes that make it possible to establish 500 kV backfeed through the main step-up transformer.	$874,344	$1,700,000	Not Cost Effective
AC/DC-28	Reduce common cause failures between EDG-3 and EDG1/2.	$199,746	$100,000	Cost Effective
AC/DC-29	Replace EDG-3 with a diesel diverse from EDG-1 and EDG-2.	$418,599	$4,200,000	Not Cost Effective
AT-05	Add an independent boron injection system.	$15,550	$800,000	Not Cost Effective
AT-07	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	$0	$1,124,864	Not Cost Effective
AT-13	Automate SLC injection in response to ATWS event.	$503	$660,000	Not Cost Effective
AT-14	Diversify SLC explosive valve operation.	$1,006	$370,000	Not Cost Effective
CB-01	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	$0	$5,600,000	Not Cost Effective
CB-03	Increase leak testing of valves in ISLOCA paths.	$0	$400,000	Not Cost Effective
CB-08	Revise EOPs to improve ISLOCA identification.	$0	$20,000	Not Cost Effective
CB-09	Improve operator training on ISLOCA coping.	$0	$30,000	Not Cost Effective
CC-01	Install an independent active or passive high pressure injection system.	$2,573,180	$29,120,000	Not Cost Effective
CC-02	Provide an additional high pressure injection pump with independent diesel.	$2,573,180	$5,200,000	Not Cost Effective
CC-03b	Raise RCIC backpressure trip set points.	$147,815	$82,000	Cost Effective
CC-20	Improve ECCS suction strainers.	$0	$10,000,000	Not Cost Effective
CP-01	Install an independent method of suppression pool cooling.	$1,615,307	$6,000,000	Not Cost Effective
CW-02	Add redundant DC control power for pumps.	$75,396	$650,000	Not Cost Effective

Table 6.j-1ii-1				
SAMA ID	**Modification**	**Estimated Benefit**	**2008 Estimated Cost**	**Sensitivity Case Conclusion**
CW-03	Replace ECCS pump motors with air-cooled motors.	$314,158	$1,124,864	Not Cost Effective
CW-04	Provide self-cooled ECCS seals.	$314,158	$675,000	Not Cost Effective
CW-07	Add a service water pump.	$530,799	$6,136,000	Not Cost Effective
FR-03	Install additional transfer and isolation switches.	$647,723	$2,000,000	Not Cost Effective
FR-07a	Improve the fire resistance of cable to the containment vent valve.	$1,034,480	$400,000	Cost Effective
FR-07b	Improve the fire resistance of cable to transformer E-TR-S	$233,882	$100,000	Cost Effective
FR-08	Protect RHR and SW cable for fire	$1,623,752	$1,250,000	Cost Effective
HV-02	Provide a redundant train or means of ventilation.	$616,660	$480,000	Cost Effective
SR-03	Modify safety-related CST	$0	$980,000	Not Cost Effective

Based upon the results in Table 6.j-1ii-1, the following SAMA candidates are cost-beneficial: **AC/DC-28, CC-03b, FR-07a, FR-07b, FR-08 and HV-02**. All of these SAMA candidates will be considered for implementation through the normal processes for evaluating possible plant changes at CGS.

NRC Request:

6.j-1iv SAMA CC-03b was determined to be cost-beneficial in the uncertainty analysis. Describe Energy Northwest's plans regarding further evaluation of this SAMA and any other SAMAs determined to be cost-beneficial in response to RAIs and the forthcoming sensitivity study.

Energy Northwest Response:

The following processes are used in the review of cost-beneficial SAMA candidates:

- Action Request (AR) Process – Used for tracking procedure revision requests, design change requests, engineering evaluations and training requests
- Project Proposal, Approval and Funding Process – Used to structure the review and approval of the cost-beneficial SAMA candidates
- Plant Modification and Configuration Control Process – Used for implementing plant modifications
- Processing of Procedures – Used for implementing procedure changes
- Systematic Approach to Training (SAT) Process- Used for implementing training

SAMA Candidates Requiring Plant Modifications:

Each of the cost-beneficial SAMA candidates is entered into the Action Request system. These SAMA candidates will be AR type EVAL (Evaluation) requiring a technical evaluation. The disposition of the technical evaluation can be a design change, major maintenance, program or other assignment. For actions requiring budget and support to track costs, a project will be established. Projects will follow a three phase project proposal and approval process to address the (1) planning (scope study and project plan development), (2) design, and (3) implementation phases individually. The first step of the process generally involves issue identification and prioritization. Then project funding estimates are developed as part of the project proposal. If the project cost is estimated to be ≥$250,000, a business case will be prepared and included with the project proposal.

The project proposal is reviewed by the Project Review Committee (PRC) to review the project ranking and determine whether the project should be approved, the appropriate funding level, and the appropriate funding year(s). If the project is approved by PRC and is ≥$250,000, the project proposal is reviewed by the Executive Authorization Committee (EAC) for final approval. If the project is approved, it will be placed on the Long Range Plan and will be implemented using Energy Northwest processes for project management, configuration control and design changes (plant design change, minor plant design change, or minor alteration). If the project is not approved, the project owner will close out any follow-up actions requested by PRC and cancel the AR if future approval is not foreseen.

It is possible that a SAMA candidate could be tabled by PRC/EAC awaiting additional information. The information request would likely fall into one of the following categories:

- PRC identified a correction that needs to be made in the SAMA analysis. The impact of the correction needs to be determined.
- PRC identified an alternate solution that will meet the SAMA goal at a lower cost. The alternate solution needs to be examined.
- PRC requests a PSA sensitivity study to determine the effect of implementing a specified SAMA subset on this SAMA candidate.
- PRC requests a PSA sensitivity study to determine the effect of already approved SAMA candidates on this SAMA candidate.
- PRC requests coordination of this SAMA candidate with related MSPI margin recovery activities. The details of this coordination need to be presented to PRC.

A tabled SAMA candidate will be represented to PRC and EAC (as appropriate) when the requested information has been assembled. At the completion of the review by

PRC/EAC, there will be no tabled SAMA candidates. Each PRC/EAC decision and its rationale will be documented in the minutes of the associated PRC/EAC meeting.

SAMA Candidates Requiring Procedure Changes:

Each of the cost-beneficial SAMA candidates is entered into the Action Request system. If the SAMA candidate consists entirely of a procedure revision for which the technical basis exists, a procedure revision will be initiated to implement the SAMA candidate via the normal procedure review and approval process.

If the SAMA candidate requires further development of the technical basis, additional AR assignments will be made to engineering to support development of the procedure revision. It is possible that the technical basis cannot be developed as described in the SAMA analysis. In this case, the SAMA candidate may not be cost-beneficial and thus will not be implemented. If implementation will continue, a procedure revision will be initiated to implement the SAMA candidate via the normal procedure review and approval process.

SAMA Candidates Requiring Training:

Requests for training are made using a training request (TREQ). The Training Department reviews all TREQs and assigns them to the appropriate Curriculum Review Committee (CRC). The CRC is composed of a line management team member appropriate to the scope of oversight responsibility of the CRC, line supervisor(s), job incumbent(s) and a training supervisor/instructor. The CRC will review the information provided in the TREQ to determine if the TREQ should be approved or if more information is needed in order to disposition the TREQ.

If the training is approved, an AR type TREQ will be initiated to track development and implementation of the training using the SAT process. If more information is needed, the CRC will enter a description of what is needed and generate an AR type CRC assignment to ensure the addition information is collected. The TREQ will be reviewed at the next CRC meeting. If the TREQ is not approved, the reason for not approving the training will be provided and the TREQ will be closed.

Energy Northwest

Sensitivity Study

Based Upon the

Columbia Generating Station

Integrated Full Power Probabilistic Safety Assessment

Model Revision 7.1 dated September 2010

1.0 INTRODUCTION

In letter GO2-10-011 (Reference 1), Energy Northwest requested the renewal of the CGS operating license. In a letter dated July, 1, 2010 (Reference 2), the NRC requested additional information pertaining to the SAMA analysis. In letter GO2-10-138 (Reference 3), Energy Northwest submitted responses to the SAMA RAIs. Certain responses relied upon the results of a sensitivity study, which was to be provided at a later date, and which was to be based upon the Integrated PSA Model Rev. 7.1. As such, this document augments the responses provided in Reference 3 and provides the results of the sensitivity study. The table below provides a cross-reference of the specific RAI referencing the sensitivity study using Rev. 7.1 of the Integrated PSA Model to the location within this Attachment.

Note: All references in this attachment refer to the list of references contained in the cover letter.

RAI	Location
1.a	Sections 2.0, 2.3, 2.5, 5.0 Appendix A Tables A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8 Appendix B
1.c	Same as 1.a above
1.e	Section 2.1
2.c	Same as 1.a above
2.d	Section 2.4
2.f	Same as 5.c below
5.a	Section 3.2 and Appendix B
5.c	Section 3.1, 5.0 Appendix A Tables A-9, A-10, A-11, A-12, A-13, A-14 Appendix B
5.d	Section 3.2 and Appendix B
5.e	Section 3.2 and Appendix B
5.j	Section 3.2 and Appendix B
5.l	Section 3.2 and Appendix B
5.m	Section 3.2 and Appendix B
6.b	Section 3.2 and Appendix B

2.0 PSA MODEL REVISION

The NRC requested that Energy Northwest provide the following information, which is excerpted from Reference 2:

NRC Request:

1) Provide the following information regarding the Level 1 Probabilistic Safety Assessment (PSA) used for the Severe Accident Mitigation Alternatives (SAMA) analysis:

   a. ... Identify whether a newer PSA model is available, and if so, provide a brief description of the major changes relative to the PSA Revision 6.2, and provide an assessment of the impact on the results of the SAMA evaluation (e.g., increased benefit or additional SAMAs if the baseline core damage frequency (CDF) has increased; any new candidate SAMAs for newly-identified dominant sequences or risk-significant basic events).

   c. ER Section E.5.2 presents a list of seven technical reviews (covering internal events and fire, and Level 1 and Level2) of the PSA (page E-31) an a list of four external peer reviews (page E-32) that contributed to updating the PSA models. Provide the following relative to these reviews ... an assessment of their impact on the SAMA evaluation.

2) Provide the following information relative to the Level 2 analysis:

   c. ER Section E.5.5.1 lists peer review findings and other self-identified areas that are in progress for the next revision and characterizes them as not expected to significantly alter the SAMA analysis findings. ... Justify the conclusion that the unresolved findings are not expected to significantly alter the results of the SAMA analysis.

Energy Northwest Response:

The basis for the SAMA evaluation presented in Reference 1 is Rev. 6.2 of the PSA. A newer Internal Events PSA Level 1 and Level 2 model, Rev. 7.1, is now available that has been upgraded to comport with RG 1.200 Rev. 2, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," through the peer review process. This model was not available at the time the original SAMA analysis was performed. The Fire and Seismic PSA models have not been upgraded but have been integrated with the new Internal Events model, including integration with the Internal Events Level 2 CET to achieve consistent release categories.

The source of the changes to the Level 1 and Level 2 Internal Events (including flooding) model were from primarily three sources: (1) a number of peer review F&Os remaining from the 2004 peer review, (2) areas of model incompleteness

identified by CGS internal reviews (as identified in section E.5 of the ER) and (3) RG 1.200 Rev. 2 and associated ASME standard for the Level 1, LERF, and Flooding modeling. A significant PSA upgrade effort was required to incorporate these improvements into Rev. 7.0 of the CGS PSA. Rev. 7.0 also updated the model to include added plant design changes, such as DG-4 and DG-3 cross-connect, procedure changes, and CGS plant initiator history and component failure history. The subsequent peer review of Rev. 7.0 Level 1 and Level 2 Internal Events and Flooding was performed in August 2009 and the report was issued in January 2010. F&Os from this peer review that could significantly impact the model quantification were incorporated in Rev. 7.1. A review of the remaining F&Os associated with Supporting Requirements that were graded as Capability 1 or not met, identified none that should be incorporated that would significantly impact the results of SAMA analysis process.

Energy Northwest has elected to perform a sensitivity study using Rev. 7.1 of the Integrated PSA Model to assess the impact of the model change (including incorporation of previously identified F&Os that were not incorporated into Rev. 6.2 of the PSA) on the results of the SAMA evaluation presented in Reference 1.

Modeling enhancements made as a result of upgrading the Internal Events PSA to RG 1.200 Rev. 2 resulted in a higher baseline CDF and a lower LERF for the Integrated PSA Model Rev. 7.1 relative to Rev. 6.2. The changes in CDF and LERF are characterized below.

CDF – Integrated PSA Model Rev. 7.1

The Rev. 7.1 CDF (Internal Events) is 7.4E-06/rx-year, which is a 55% increase from the Rev. 6.2 CDF (Internal Events) of 4.77E-06/rx-year. Table A-1 (Internal Events) provides the changes in CDF for Rev. 7.1 relative to Rev. 6.2 for all initiating events, along with a characterization of the changes in terms of plant changes and the Internal Events and Flooding upgrade to RG 1.200 Rev. 2. Similar tables for CDF comparisons for the FPSA and SPSA are provided in Tables A-1 (Fire) and A-1 (Seismic).

LERF – Integrated PSA Model Rev. 7.1

The Rev 7.1 LERF is 3.6E-07/rx-year, which is a 44% decrease from the Rev. 6.2 LERF of 6.5E-07/rx-year. Table A-2 provides a comparison of LERF contributions for PSA Models Rev. 6.2 and Rev. 7.1 for the Internal Events. Similar tables for Fire and Seismic are not provided; however, Tables A-12 and A-14 provide the LERF basic events for Fire and Seismic and present the review for potential SAMA candidates. These tables contain the important initiating events associated with Fire and Seismic LERF. A comparison table for Fire and Seismic similar to Table A-2 would provide little additional insight. The Rev. 7.1 Level 2 analysis for Columbia includes the following enhancements / upgrades:

- Provides a CET that includes sufficient detail to quantify effects of plant modifications and changes in procedures.
- Establishes added success paths for recovery of degraded core conditions within the reactor vessel (e.g., Three Mile Island Unit 2 events). These paths involve recovery actions during in-vessel core melt progression accidents.
- Incorporates the EPG/SAG-based emergency procedures at CGS. This includes containment flooding.
- Interfaces with the BWROG/NUMARC containment safety study to incorporate the latest input on severe accident issues as they affect containment response (e.g., direct containment heating, heat management, seal performance).
- Establishes plant specific deterministic calculations to support the improved success criteria using MAAP calculations as the basis.
- Provides a traceable documentation path through the CET so that both qualitative and quantitative insights can be developed.
- Couples the dependencies between Level 1 accident sequences and the Level 2 evaluation by linking the Level 1 and 2 accident sequences.
- Incorporates responses to issues identified in NUREG-1150 "Severe Accident Risks; An Assessment for Five U.S. Nuclear Power Plants" in a more visible manner.
- Expands the CET to encompass an entire spectrum of radionuclide release end states. Plant specific MAAP calculations are used as the basis for characterizing the radionuclide end states for individual Level 2 CET sequences. For example, some CET scenarios that were characterized as LERF in the Rev. 6.2 model were re-characterized as non-LERF in the Rev. 7.1 model (e.g., due to changes in the calculated release timing).

These Rev. 7.1 refinements contributed to the reduction in the LERF frequency relative to Rev. 6.2.

Table A-2 examines important basic events from the Rev. 6.2 LERF quantitative results with RRW values greater than 1.005. This set of basic events produces the greatest potential reductions to Rev. 6.2 LERF if refinements to the modeling were made. Each of the events is examined for potential corresponding refinements that were made for Rev. 7.1, which provides particular insights into the lower LERF produced from Rev. 7.1 relative to Rev. 6.2.

Based on the review documented in Table A-2, the Rev. 7.1 LERF decreased from the Rev. 6.2 LERF primarily because:

1. Rev. 6.2 internal flooding accident sequences were all assumed to go to LERF, which is conservative. In Rev. 7.1, internal flooding accident sequences were assigned to realistic PDSs and accident classes, rather than assigning them all to LERF.

2. Refinements to the LOCA outside containment modeling produced a net reduction in accident Class 5A and therefore reduction in LERF.

3. Rev. 7.1 modeling refinements reduced the likelihood for the occurrence of an ex-vessel steam explosion that fails containment, which produced a reduction in LERF.

Table 2-1 lists the SAMA candidates identified from a review of the results of the Integrated PSA Model Rev. 7.1 that will be considered for further cost-benefit evaluation. The cost-benefit results are provided in Appendix B.

Table 2-1: New SAMA Candidates Identified from the Integrated PSA Model Rev. 7.1

SAMA	Description
AT-15R	Modifications to make use of HPCS more likely for ATWS (such as use of auto-bypass, installing throttle valve, etc.)
FL-07R	Protect HPCS from flooding resulting from ISLOCA events.
OT-09R	For the non-LOCA initiating events, credit the Z (PCS recovery) function.
FL-04R	Add Isolation valves for SW, TSW, and FP in the Control Building for rapid isolation given an internal flood.
FL-05R	Add leak detection instruments in drain lines from Control Building compartments to detect leaks and flooding.
FL-06R	Add additional NDE and inspections to increase probability of detecting degraded lines in raw water systems in the Control Building.

2.1 TRUNCATION LIMITS

The NRC requested that Energy Northwest provide the following information, which is excerpted from Reference 2:

NRC Request:

1) Provide the following information regarding the Level 1 Probabilistic Safety Assessment (PSA) used for the Severe Accident Mitigation Alternatives (SAMA) analysis:

   e. ... Explain the basis for the truncation limits selected.

Energy Northwest Response:

The PSA model is subject to a number of approximations. One of these approximations arises from cutset truncation. Truncation limits are established to address computational time and computer storage capacity limitations, and assurance is needed to ensure that the appropriate limits are selected. In order to select reasonable and acceptable truncation limits, truncation studies are performed to assess the convergence of the quantified results as a function of the truncation limits imposed. Fault tree and event tree cutsets are truncated at a

sufficiently low cutoff value so that dependencies associated with significant cutsets or accident sequences are not eliminated.

There are three distinct truncation limits that were used in the Integrated PSA Model Rev. 7.1 for each of the hazards that comprise the integrated model. In quantifying the model for solution of the SAMA cases, the auto-truncation feature in WinNUPRA was disabled entirely for the Integrated PSA Model Rev. 7.1.

Fault Tree Truncation: For the Internal Events, Fire and Seismic PSA solution, the fault tree truncation limits are assigned to be 1E-10 or lower. This approach provides assurance that when system level cutsets are merged to create sequence level cutsets, any significant shared cutset terms and dependencies, such as support system dependencies, are not truncated during sequence quantification.

Event Tree Truncation: For the Internal Events Level 1 and Level 2 PSA, a sensitivity of truncation limits was performed to gain evidence of convergence toward a stable result. The truncation at 5E-12/yr for the event tree solution shows that it is a reasonable value for base CDF and LERF model quantification. Convergence in accordance with the ASME standard for the Level 1 model occurs by 1E-11/rx-yr. Convergence in the Level 2 Internal Events model occurs near 5E-12/rx-yr. Therefore, a common truncation value was selected as 5E-12/rx-yr for the Internal Events (includes flooding) portion of the Integrated PSA Model Rev. 7.1.

For the Fire and Seismic PSA models, Level 1 and Level 2, a formal sensitivity to demonstrate convergence was not performed. Instead, truncation levels were assigned based on the judgment of the model analysts in order to address the need to ensure no significant accident sequences are inadvertently eliminated and the need to avoid excessively burdensome solution times. The truncations are as follows:

- Fire Level 1: 1E-11/rx-year (six orders of magnitude below the quantified Fire Level 1 result)
- Fire Level 2: 1E-12/rx-year (four orders of magnitude below the quantified Fire Level 2 result)
- Seismic Level 1: 1E-12/rx-year (six orders of magnitude below the quantified Seismic Level 1 result)
- Seismic Level 2: 1E-12/rx-year (six orders of magnitude below the quantified Seismic Level 2 result)

Global Truncation: After the individual sequences are all calculated, they are concatenated to yield a global core damage equation, which includes cutsets for all sequences from the associated initiators. In the Integrated PSA Model Rev. 7.1, the global core damage equation truncation limit has been maintained the same as the event tree truncation limit to best preserve the cutset integrity.

The above truncation limits ensure that significant shared cutset terms and dependencies, such as support system dependencies, are not truncated during sequence quantification. The quantification time for the integrated model for some SAMA cases exceeded seven hours. SAMA results would not be significantly altered by further reduction in truncation limits and would result in significantly longer computational time. Additionally, the applicable RG 1.200 Supporting Requirements, SR QU-B3, was specifically reviewed as part of the Internal Events PSA peer review and graded as "met' by the peer review team.

2.2 HOT SHORT PROBABILITY

The NRC requested that Energy Northwest provide the following information, which is excerpted from Reference 5:

NRC Request:

3.d(ii)-1 Where control power transformers are not present, NUREG/CR-6850 indicates hot short probabilities may be double the 0.3 value (i.e., 0.6). If the treatment "did not take into account the specific circuit and cabling configurations," what is the basis on which the 0.3 value "was judged to be an appropriate representative ... and reasonable for the license renewal application (LRA)?" Furthermore, what is the basis for concluding that the response to RAI 6.j will "account for" this "potential modeling uncertainty?"

Energy Northwest Response:

A sensitivity evaluation was performed to assess the potential incompleteness of the CGS FPSA related to modeling of hot shorts. The Rev. 7.1 FPSA model was modified, and selected SAMA cases, FR-03, FR-07a and FR-07b, were rerun with the modified model. These SAMA cases are appropriate for this sensitivity because these hot shorts have RRW significance and they impact numerous important functions, such as primary offsite power source, SRV and MSIV pneumatic supply components, ADS relief valves, and RHR.

First, for selected hot short events (nine total), a circuit evaluation was performed to verify that a control power transformer (CPT) was present. The hot short probabilities for these nine hot short events remained at 0.3 in the model, which is the highest best estimate value for circuits with a CPT per NUREG/CR-6850 "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities." For all other hot short events, a circuit evaluation was not performed, and the model was modified to revise the remaining hot shorts to a probability of 0.6, which is the highest best estimate value for circuits without a CPT per NUREG/CR-6850. This sensitivity evaluation is judged to be a bounding calculation for this model incompleteness.

The resulting CDFs from the sensitivity evaluation (i.e., the modified model) increased relative to the base (i.e., unmodified) model. The delta-CDF for the three SAMA cases also increased relative to the base. The results are shown in Table 2-2.

As shown on the table, the increase in delta-CDF varies by a factor of 1.1 to 2 for the three SAMA cases. The 95th percentile uncertainty factor for Fire for the Integrated PSA Model Rev. 7.1 is 2.6 (see section 4.2). Thus, the sensitivity evaluation demonstrates that the use of the 95th percentile uncertainty factor for these SAMA candidates in determining their cost-benefit is sufficient to address this area of model incompleteness.

Table 2-2: Sensitivity Evaluation for SAMA Cases FR-03, FR-07a, FR-07b

SAMA Case	Description	Base Fire CDF	Sensitivity Fire CDF	Original Delta-CDF	Sensitivity Delta-CDF	Delta-CDF Factor Increase
FR-03-I	This SAMA examines protecting CGS circuits from hot shorts for the fire most important hot short events. To obtain the sensitivity delta-CDF, the following hot short probabilities were reduced to zero for the most risk significant hot shorts: HS-EAC-TRS HS-CIAV-MO20 HS-CIAV-MO30A HS-ADS-OPEN HS-RHRV-MO-6B	1.37E-05	1.43E-05	8.2E-07	1.3E-06	1.5
FR-07a-I	This SAMA examines protecting containment vent from fire damage. To obtain the sensitivity delta-CDF, all equipment for containment vent (valves, containment air, cables and power supplies) were assumed to be free from fire damage.	1.37E-05	1.43E-05	4.1E-06	4.5E-06	1.1
FR-07b-I	This SAMA examines protecting cables that would disable TR-S due to hot short. To obtain the sensitivity delta-CDF, the hot short probability for TR-S was reduced to zero: HS-EAC-TRS	1.37E-05	1.43E-05	4.8E-07	9.6E-07	2

2.3 CGS PSA MODEL – LEVEL 2

Appendix A Tables A-3 through A-5 provide the Level 2 release categories and frequencies for Internal Events, Fire and Seismic, respectively, for the Integrated PSA Model Rev. 7.1. These tables are equivalent to ER Tables E.4-3, E.4-5 and E.4-6, respectively, provided for the Rev. 6.2 model in Reference 1. A direct comparison is not meaningful due to the expansion of release categories in the Integrated PSA Model Rev. 7.1 as discussed below.

2.4 UPGRADED MODULAR ACCIDENT ANALYSIS PROGRAM CASES

The NRC requested that Energy Northwest provide the following information, which is excerpted from Reference 2:

NRC Request:

2) Provide the following information relative to the Level 2 analysis:

   d. ... Provide information on the selection of the MAAP case for each release category, in particular how scenarios of less than dominant frequency but larger potential consequences were considered.

Energy Northwest Response:

In Reference 3, Energy Northwest responded to the original NRC RAI associated with the release categories used with the Rev. 6.2 Phase 2 SAMA candidate evaluations. At that time, Energy Northwest also recognized that upgraded MAAP cases have been produced as part of the upgrade of the Internal Events PSA Model Rev. 7.1.

The following information is provided:

- Changes to MAAP cases used to support the Integrated PSA Model Rev. 7.1
- Updated PSA Model Rev. 7.1 release categories
- Updated MAAP cases used to support the Level 3 SAMA evaluation for this sensitivity study

Changes to MAAP Cases Used to Support Internal Events PSA Model Rev. 7.1

In support of the Internal Events PSA Model Rev. 7.1, the CGS plant specific MAAP 4.0.4 parameter file was reviewed and revised to update parameters that represent the current CGS configuration (e.g., 3486 MWth power level and ATRIUM-10 core). Approximately 50 MAAP runs originally used to support PSA Model Rev. 6.2 were re-run using the updated CGS MAAP 4.0.4 parameter file. Furthermore, approximately 100 additional MAAP runs were performed to support the development of the Internal Events PSA Model Rev. 7.1 using the

updated CGS MAAP 4.0.4 parameter file. The additional MAAP runs supported the development of Level 1 PSA success criteria and HRA timings and the Level 2 release category definitions and HRA timings.

Updated PSA Model Rev. 7.1 Release Categories

The Level 2 release categories used in support of Rev. 6.2 of the PSA (and the ER) were defined based on the following:

- Containment Failure Mode (Large or Small) (i.e., failure size equivalent of 6 inch diameter or greater is Large)
- Time of Containment Failure (Early or Late) (i.e., release at 4 hours or less is Early)
- Scrubbing of Fission Product (Scrubbed or Non-scrubbed) (i.e., CsI release of 0.1 or greater is Non-scrubbed)

For PSA Model Rev. 6.2, the LEN category (Large, Early release, Not scrubbed) was modeled to correspond to the NRC definition of LERF.

For the Integrated PSA Model Rev. 7.1, the Level 2 CET structures were completely upgraded and Level 2 release categories were completely redefined. Table 2-3 provides the revised release severity and timing classifications. For example, the definition for the "Early" time category has been changed from "Less than 4 hours" in Rev. 6.2 to "Less than 3 hours" in Rev. 7.1 based on the latest CGS Emergency Action Levels (EALs) for declaring a General Emergency and the latest evacuation time estimates. The High/Early (H/E) release category (i.e., greater than 0.1 CsI release magnitude and less than 3 hour release timing) is modeled to correspond to the NRC definition of LERF. The release categories assigned to individual Level 2 CET sequences are based on the updated Level 2 MAAP runs to support the Integrated PSA Model Rev. 7.1.

Updated MAAP Cases Used to Support Level 3 SAMA Evaluation

Updated MAAP cases have been selected to support the Level 3 SAMA analysis based on the Integrated PSA Model Rev. 7.1. Table 2-4 provides a summary of the updated MAAP cases selected to represent the nine (9) updated release category definitions provided in Table 2-3. (Note: The "Late" time category is not used for the Integrated PSA Model Rev. 7.1). For the High/Early release category, case CGS080523 is representative of a break outside containment (BOC) sequence.

The updated MAAP cases shown in Table 2-4 have been chosen based on a detailed review of the Rev. 7.1 Internal Events PSA model quantitative contributors to each of the release categories. A quantitative weighted evaluation was performed based on the dominant cutset contributors and the

associated MAAP cases for individual release categories. For example, the High/Early release category includes many contributors with a wide variety of associated MAAP cases ranging from CsI release fractions of 0.1 up to 0.93 (i.e., BOC scenario MAAP case CGS080523 mentioned above). The quantitative weighted evaluation considered the following:

- One of the dominant contributors to the Internal Events High/Early frequency is Class 5 (BOC sequence) at 1.36E-07/yr. The Class 5 MAAP case is CGS080523 with a CsI release of 0.93. The other dominant contributors to the Internal Events High/Early frequency are Class 4BA and 4BL (ATWS sequences) at 1.79E-07/yr. The ATWS High/Early frequency is dominated by wetwell water space failures with successful RPV depressurization. This ATWS scenario is similar to MAAP case CGS080521 with a CsI release of 0.19. A CsI weighted average of Class 5 and 4A for these MAAP cases is: [1.36E-07×0.93 + 1.79E-07×0.19] ÷ 3.15E-07 = 0.51. This CsI value is close to the value for Class 4A MAAP case CGS080518, which has a CsI release of 0.58.

- Timing: The General Emergency is declared at 45 min for Class 4. MAAP Case CGS080518 shows containment failure at 8 minutes with core damage at 59 minutes such that the release for Class 4 is in the Early timeframe. In addition, the General Emergency is declared at approximately 17 min for Class 5. MAAP Case CGS080523 shows that core damage occurs at approximately 21 minutes such that the release for the BOC scenario is in the Early timeframe.

Case CGS080523 was ultimately selected for the High/Early release category based on the high contribution of BOC and ISLOCA containment bypass sequences to the Rev. 7.1 Internal Events PSA results. In addition, containment bypass events represent the dominant contributor to the Rev. 7.1 Level 2 external events Seismic PSA model results.

Table 2-3

RELEASE SEVERITY AND TIMING CLASSIFICATION SCHEME[1]

Release Severity	
Classification Category	Cs Iodide % in Release
High (H)	Greater than 10
Medium or Moderate (M)	1 to 10
Low (L)	0.1 to 1
Low-low (LL)	Less than 0.1
No iodine (OK)	0

Release Timing	
Classification Category	Time of Initial Release[2] Relative to Time for General Emergency Declaration
Late (L)[3]	Greater than 24 hours
Intermediate (I)	3 to 24 hours
Early (E)	Less than 3 hours[4]

RADIONUCLIDE RELEASE CATEGORIES DERIVED FOR COLUMBIA GENERATING STATION

Time of Release	Magnitude of Release			
	H	M	L	LL
E	H/E	M/E	L/E	LL/E
I	H/I	M/I	L/I	LL/I
L [3]	H/L	M/L	L/L	LL/L

(1) The combinations of severity and timing classifications results in one OK release category and 12 other release categories of varying times and magnitudes.

(2) The cue for the General Emergency declaration is taken to be the time when EALs are exceeded. The declaration of the General Emergency begins the time for evacuation.

(3) The "Late" time category is not used for the Integrated PSA Model Rev. 7.1.

(4) Evacuation time for the Columbia EPZ is found to be less than 3 hours.

Table 2-4: Summary of Updated Rev 7.1 MAAP Runs to Use as Input to MACCS2 Calculations

Release Category[1]	MAAP Cases[2]	Representative Case Description	CGS Accidents Class[3]	CsI Release Fraction[4]	CGS GE Decl. (hr)[5]
OK – Containment Intact	CGS080524	MSIV Closed, No RPV Injection, No Depressurization, SPC and Sprays Available, Containment Intact,	1A2	3.6E-6	0.75
High/Early (LERF-BOC)	CGS080523	BOC, LLOCA on MS line, No RPV Injection, No SPC or Sprays	5	0.93	0.28
High/Intermediate	CGS080530	SBO, MSIV Closed, RCIC for 4 hr until battery depletion, No Depressurization, No SPC or Sprays, $2ft^2$ Drywell Failure	6B2	0.25	1.25
Moderate/Early	CGS080519	ATWS with SLC Failure, MSIV Closed, RCIC, CRD, and LPCI Available, 7 SRVs at Top of Active Fuel, 1 Loop SPC Available, No Sprays, $2ft^2$ Wetwell Air Space Failure	4BA	9.5E-3[6]	0.75
Moderate/Intermediate	CGS080511t	MSIV Closed, LPCS Available, 7 SRVs at -183", No SPC or Sprays, $2ft^2$ Drywell Failure	1B0	1.6E-2	25.85
Low/Early	CGS080505a	MSIV Closed, No RPV Injection, 7 SRVs at -183", No SPC or Sprays, Containment Isolation Failure	1G	2.1E-2	0.75
Low/Intermediate	CGS080511t	MSIV Closed, LPCS Available, 7 SRVs at -183", No SPC or Sprays, $2ft^2$ Drywell Failure	1B0	1.6E-2	25.85
Low Low/Early	CGS080529	LLOCA, No RPV Injection, Containment Flood with FP System at RPV Failure, No SPC or Sprays, Containment Vent Available ($1ft^2$)	3C	3.4E-4	0.25
Low Low/Intermediate	CGS080509	MSIV Closed, No RPV Injection, 7 SRVs at -183", Sprays Available, No SPC, $28in^2$ Wetwell Air Space Failure	1G	2.0E-4	0.75

Notes

(1) CGS Release category is based on the Integrated PSA Model Rev. 7.1 Level 2 model.

(2) CGS MAAP case is the representative case for corresponding release category. Case CGS0508511t is used for M/I and also for L/I release bins. The conservatism associated with this case for the L/I bin is acceptable because the L/I bin frequency is very low.

(3) CGS accident class designation based on CGS naming convention.

(4) MAAP CsI release fraction at the end of the run.

(5) CGS General Emergency declaration time.

(6) CsI value is slightly below the typical 1E-02 moderate magnitude definition. This MAAP case is judged most reflective of the driving sequences for this bin and is therefore judged appropriate.

2.5 CGS PSA MODEL – LEVEL 3

Base case sensitivity results generated by the Integrated PSA Model Rev. 7.1 for Internal Events, Fire, and Seismic (per release category) are reported in Appendix A Tables A-6, A-7 and A-8, respectively. These tables show the estimated population dose (whole body dose in person-rem/year) and the economic impact in dollars/year. These tables are equivalent to ER Tables E.7-1, E.7-2 and E.7-3, respectively, provided for the Rev. 6.2 model in Reference 1.

3.0 SAMA CANDIDATE SELECTION

3.1 LEVEL 1 AND 2 BASIC EVENTS IMPORTANCE LISTS

The NRC requested that Energy Northwest provide the following information, which is excerpted from Reference 2:

NRC Request:

2) Provide the following information relative to the Level 2 analysis:

   f. The ER does not provide an importance list of either Level 1 or Level 2 basic events and so it is not possible to ascertain the significance of recovery events or operator actions in the PSAs. Discuss the extent to which recovery of systems or operator actions following the onset of core damage is credited in the Level 2 assessment and how recovery is modeled.

5) Provide the following with regard to the SAMA identification and screening process:

   c. ... Provide a basic events importance list, in decreasing order of risk reduction worth (RRW), for the Level 1 and Level 2 internal, fire and seismic PSA results that includes a description of each basic event, identifies the RRW and probability of each basic event, and identifies the SAMA(s) that address each basic event and how. Provide the information for all basic events having an RRW benefit value greater than the minimum cost of a procedure change at CGS.

Energy Northwest Response:

Basic events importance lists are presented in Appendix A Tables A-9 through A-14 in decreasing order of RRW for the Level 1 and Level 2 Internal Events, Fire and Seismic PSA results from Rev. 7.1 of the Integrated PSA Model.

The basic event importance lists are truncated at an RRW importance value estimated to provide a maximum cost-benefit equal to the lowest cost of a procedure change at the plant. A simple procedure change is judged to be the

lowest cost SAMA candidate possible. A value of $12,000 is conservatively chosen as the lowest cost for implementing a procedure change. Procedure changes of this nature need no engineering calculations or significant training development.

The cost-benefit versus RRW assumes that cost-benefit is directly proportional to the reduction in CDF. Cost is not perfectly correlated with CDF due to the fact that different scenarios, even with the same CDF, will result in different distributions of release categories. It is judged that this correlation provides a reasonable estimate of potential benefit. When coupled with what is judged to be a low cost for a procedure change, this provides a strong confidence that cost-effective SAMA candidates will be captured.

In addition to the cost estimate for a simple procedure change, an estimate is made for the lowest cost for which a simple plant hardware change can be made. It is conservatively estimated that any plant hardware change cannot be implemented for less than $100,000.

Each of the basic events with RRW importance values equivalent to an estimated cost-benefit equal to or greater than the cost of a simple procedure change have been dispositioned as follows:

- Any SAMA candidates from the original cost-benefit analysis that address the basic event have been identified,
- Any basic events that require a plant hardware fix and has a calculated RRW equating to less than $100,000 in cost-benefit are screened from further consideration, and
- For all remaining basic events at least one SAMA candidate is created.

The estimated benefit based on RRW uses the following maximum attainable benefit for the three categories of events:

Table 3-1: Maximum Benefit by Hazard

Total Benefit Internal Events	$500,446
Total Benefit Fire	$863,256
Total Benefit Seismic	$436,020

Based on the above maximum attainable benefits, the estimated benefits based on RRW by hazard have been developed. Table 3-2 provides a representative selection of estimated benefits. The following formula is used for deriving the estimated benefit based on RRW:

$$EB_{(BE)} = B_t \times (1 - 1/RRW)$$

where:

$EB_{(BE)}$ = The estimated benefit based on a basic event
B_t = The total benefit for the hazard (Internal Events) from Table 3-1
RRW = The RRW for the basic event from the PSA, by hazard, assuming the basic event failure probability is reduced to zero.

Similar formulas are used for development of the estimated benefit based on RRW for the fire and seismic hazards.

The RRW for the Level 2 PSA basic events may be calculated based on LERF rather than CDF. Additional conservatism is added by treating Level 2 PSA basic event RRW values based on LERF as if they were based on CDF (i.e., the use of B_t significantly overstates their benefit), and the degree of conservatism could be large.

Table 3-2: Estimated Benefit based on RRW for Basic Event Screening

RRW	Internal Events (Benefit by CDF)	Fire (Benefit by CDF)	Seismic (Benefit by CDF)
1.01	$4,954.91	$8,547.09	$4,317.03
1.015	$7,395.75	$12,757.48	$6,443.65
1.02	$9,812.67	$16,926.59	$8,549.41
1.025	$12,206.00	$21,055.02	$10,634.63
1.03	$14,576.10	$25,143.38	$12,699.61
1.04	$19,247.92	$33,202.15	$16,770.00
1.05	$23,830.76	$41,107.43	$20,762.86
1.06	$28,327.13	$48,863.55	$24,680.38
1.07	$32,739.46	$56,474.69	$28,524.67
1.08	$37,070.07	$63,944.89	$32,297.78
1.09	$41,321.23	$71,278.02	$36,001.65
1.1	$45,495.09	$78,477.82	$39,638.18
1.15	$65,275.57	$112,598.61	$56,872.17
1.2	$83,407.67	$143,876.00	$72,670.00
1.25	$100,089.20	$172,651.20	$87,204.00
1.3	$115,487.54	$199,212.92	$100,620.00

Table 3-3 lists the SAMA candidate identified from a review of the Level 1 and Level 2 basic events importance lists that will be considered for further cost-benefit evaluation. The cost-benefit results are provided in Appendix B.

Table 3-3: New SAMA Candidates Identified from Basic Events Importance Lists

SAMA	Description
CB-10R	Provide additional NDE and inspections of MS piping in Turbine Building

3.2 SAMA CANDIDATES IDENTIFIED IN GO2-10-138 (REFERENCE 3)

Several of the RAI responses in Reference 3 identified additional SAMA candidates that would be evaluated for cost-benefit using the Integrated PSA Model Rev. 7.1. Table 3-4 identifies the specific RAI responses and additional SAMA candidate identifiers. These SAMA candidates have been considered for cost-benefit evaluation. The results are provided in Appendix B.

Table 3-4: New SAMA Candidates Identified GO2-10-138 (Reference 3)

RAI	SAMA	Description of Potential SAMA
5.a	FW-05R	Examine the potential for operators to control RFW and avoid a reactor trip
	CC-26R	Install hard pipe from diesel fire pump to vessel
	FL-05R FL-04R FL-06R	Improve control building flooding scenarios
	CC-24R	Backfeed the HPCS system with SM-8 to provide a third power source for HPCS
	CC-25R	Enhance alternate injection reliability by including RHRSW and fire water crosstie in maintenance program
	OT-10R	Increase Fire Pump House Building integrity to withstand higher winds so the fire system will be capable of withstanding a severe weather event
	OT-08R	Install explosion protection around CGS transformers
5.a 5.e	OT-07R	Improve procedures and operator training to identify systems and operator actions determined to be important from the PSA
5.d	FR-09R	Install early detection for FR1J (physical analysis unit R-1J)
		Install early detection for FR1D (physical analysis unit R-1D)
	FR-11R	Install early detection for FW14 (analysis unit RC-14)
		Install early detection for FW04 (analysis unit RC-04)
		Install early detection for FW11 (analysis unit RC-11)
		Install early detection for FW03 (analysis unit RC-03)
		Install early detection for FW08 (analysis unit RC-08)
		Install early detection for FW05 (analysis unit RC-05)
		Install early detection for FW02 (analysis unit RC-02)
		Install early detection for FW13 (analysis unit RC-13)
		Install early detection for FW1A (analysis unit RC-1A)
	FR-10R	Install early fire detection in the Control Room (RC-10)
	AC/DC-30R	Provide an additional DG diverse from DG-1 and DG-2
	FR-12R	Install early detection for FT1A (physical analysis unit T-1A)

Table 3-4: New SAMA Candidates Identified GO2-10-138 (Reference 3)

RAI	SAMA	Description of Potential SAMA
		Install early detection for FT12 (physical analysis unit T-12)
5.j	SR-05R	Increase seismic ruggedness of MCC-7F and MCC-8F
5.l	FR-08	Improve the fire resistance of cables to RHR and SW
5.m	FW-04	Add a motor-driven FW pump
6.b	AC/DC-02	Replace lead-acid batteries with fuel cells (SAMA previously subsumed)
	AC/DC-03	Add a portable, diesel-driven battery charger to existing DC system (SAMA previously subsumed)
	AC/DC-15	Install a gas turbine generator (SAMA previously subsumed)
	AC/DC-16	Install tornado protection on gas turbine generator (SAMA previously subsumed)

4.0 SENSITIVITY CASES

Energy Northwest has determined that the sensitivity cases of 3% discount rate and 95th percentile factor for CDF are the leading sensitivity cases from the original group of SAMA candidates considered for further evaluation. As such, it is appropriate to run sensitivity cases associated with Rev. 7.1 of the PSA using the 3% discount rate and the 95th percentile factor for CDF.

4.1 3% DISCOUNT FACTOR

The first sensitivity case investigates the sensitivity of each analysis case to the discount rate by assuming a lower discount rate of 3% per year. As discussed in Section E.8 of the ER, the base discount rate is 7% per year. The results of this sensitivity case are presented in Appendix B Table B-8 as Sensitivity Case #1.

4.2 95th PERCENTILE FACTOR FOR CDF

The second sensitivity case investigates the impact of using uncertainty factors for Internal Events, Fire and Seismic based on the 95th percentile CDF for each analysis. The uncertainty factors are derived from the ratio for the 95th percentile to the mean point estimate for Internal Events, Fire and Seismic CDF. Table 4-1 provides the uncertainty factors used. The results of this sensitivity case are presented in Appendix B Table B-8 as Sensitivity Case #2.

Table 4-1: Uncertainty Factors

	Uncertainty Factors
Internal Events	2.4
Fire	2.6
Seismic	3.0

4.3 APPLICATION OF UNCERTAINTY TO PHASE 1 SCREENING

In Reference 4, the NRC requested that Energy Northwest provide the following information:

NRC Request:

6.j-1 The uncertainty analysis presented in response to this RAI did not re-evaluate the Phase 1 SAMAs using the maximum uncertainty benefit (from eliminating all internal and external risk) from applying the uncertainty factors provided in Table 6.j-1. Specifically, the maximum baseline benefit in the ER is reported to be $1.9M, while applying the Table 6.j-1 uncertainty factors would increase the maximum benefit to $5.6M (NRC staff estimate). Provide an assessment of each Phase 1 SAMA eliminated using Screening Criterion D and E to determine whether any Phase 1 SAMAs originally screened should have a Phase 2 cost-benefit evaluation performed. Provide a Phase 2 cost-benefit evaluation for any SAMA not screened.

Energy Northwest Response:

Section E.12 in the ER provided a qualitative justification for not applying the 95th percentile uncertainty to Phase 2 SAMA candidates. RAI 6.j in Reference 2 requested that an additional sensitivity analysis associated with the CDF uncertainty be applied to the Phase 2 SAMA results. Energy Northwest provided the requested sensitivity analysis in Reference 3. In Reference 4, the NRC requested that the CDF uncertainty be applied to the Phase 1 screening of potential SAMA candidates. NEI 05-01, "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document," does not specifically require that uncertainty be applied to Phase 1 screening; however, such an application has merit and would confirm that no SAMA candidates were inadvertently screened using the qualitative method for judging the candidates' potential cost-benefit. The two criteria identified in NEI-05-01 that would be most impacted by applying the 95th percentile uncertainty factor to Phase 1 screening are Criterion D (Excessive Implementation Cost) and Criterion E (Very Low Benefit).

Table E.10-1 in the ER presented the results of the Phase 1 SAMA candidate screening using the criteria defined in section E.10.1 through E.10.5. As requested, each of the SAMA candidates screened as either Criterion D or Criterion E have been reevaluated using an RRW benefit related to the maximum benefit obtained and applying the uncertainty factors based on the 95th percentile CDF uncertainty of each hazard of the Integrated PSA Model Rev. 7.1.

In order to evaluate most of the SAMA candidates screened as Criterion E, the PSA modeling is modified to represent the candidate's improvement and to develop an RRW based on its improvement of the specific hazard or hazards that are affected (i.e., base-CDF for each hazard divided by improved-CDF for the

hazard due to the SAMA candidate). Once the RRW is established for a SAMA candidate, its benefit (multiplied by the 95th percentile uncertainty factor) can be derived and then assessed as to whether it is below the cost of a procedure change or a small design change, or whether the cost of implementation greatly exceeds the RRW uncertainty benefit such that a further evaluation in Phase 2 is not required. If the SAMA candidate affects more than one hazard, the benefit for each hazard (adjusted for the 95th percentile uncertainty) is added to produce a final uncertainty benefit for screening consideration.

This approach provides a more quantitative approach for the Phase 1 Criterion E screening basis. There is good correlation between RRW benefit and Phase 2 SAMA benefits to justify this approach to Phase 1 screening. This correlation is demonstrated in the following table for four specific SAMA candidates.

Table 4-2: Comparison of Phase 2 Benefit Results to RRW Benefits

SAMA	Phase 2 Benefit with uncertainty (See Table B-8)	RRW		RRW Benefit with uncertainty
FR-07a Note 1	$839,005	Fire Other LERF Total	1.43 1.43 1.000	$675,000 $675,000 0 $1,350,000
CW-07 Note 2	$475,184	Int. Events Fire Seismic Other LERF (fire) Total	1.12 1.15 1.00 1.12 1.255	$129,000 $285,000 $1,000 $129,000 $456,000 $1,000,000
AC/DC-01 Note 3	$8,125	Int. Events Fire Seismic Other LERF Total	1.005 1.000 1.001 1.005 1.000	$6,000 0 $1,500 $6,000 0 $13,500
AC/DC-23 Note 3	$173,164	Int. Events Fire Seismic Other LERF Total	1.06 1.02 1.00 1.06 1.0015	$66,000 $42,000 0 $66,000 $50,000 $224,000

(1) SAMA candidate FR-07a has a Phase 2 calculated benefit (with 95th percentile uncertainty factor) of $839,005 (see Table B-8). The RRW of FR-07a is 1.43 for Fire and yields a benefit based on RRW (with uncertainty) of $675,000 based on Fire alone. Since there is no impact to Internal Events, the RRW for Other External Events is set equal to the primary hazard benefit. The resulting benefit is $1,350,000 and exceeds the amount calculated by the Phase 2 analysis.

(2) SAMA candidate CW-07 provides an example of a SAMA that has an impact on more than one hazard. The Phase 2 calculated benefit with uncertainty is $475,184. The RRW values for this SAMA are 1.12, 1.15, 1.00, 1.12, and 1.255 for Internal Events, Fire, Seismic, Other External Events, and LERF, respectively. The corresponding RRW benefit is $1,000,000 with uncertainty. Again, the RRW benefit exceeds that of the actual Phase 2 result.

(3) SAMA candidates AC/DC-01 and AC/DC-23 provide examples of SAMA candidates with low Phase 2 benefits. The Phase 2 benefit of AC/DC-01 with uncertainty is $8,125 and its RRW benefit with uncertainty is $13,500. Similarly, the AC/DC-23 Phase 2 benefit with uncertainty is $173,164 and its RRW benefit is $224,000.

This method can also be used for screening Criterion D SAMA candidates whose implementation costs do not exceed the total maximum benefit. If sufficient difference between the RRW benefit and the implementation cost exists, the candidate can be screened as excessive cost and not considered for further evaluation since a sufficient basis is available, through the RRW benefit, to conclude that the SAMA candidate would not be cost-beneficial.

In some instances, the implementation cost estimates have been revisited from those provided in Reference 1. The previous estimates for SAMA candidates AT-10, CP-12, CP-22, CP-24, and CC-12 were based on industry estimates. These estimates were phrased as 'the cost would exceed a specific value'. That value was usually the maximum cost-benefit for that licensee. No approximate estimated cost for the SAMA candidate was provided. With the inclusion of the uncertainty factor based on the 95th percentile sensitivity, the previous entries require a CGS specific estimate to assess the cost-benefit based on maximum uncertainty benefit. The CGS estimates are in accordance with the intent of NEI-05-01. However, the estimates are sufficiently low so that a cost-beneficial SAMA candidate will not be inadvertently screened out. Details of the cost estimates for these SAMA candidates are presented below:

- AT-10 and CP-12 Implementation Cost Estimate Details

  Cost implementation estimates for SAMA candidates AT-10 and CP-12 are related in that both candidates provide for a filtered containment vent to remove decay heat. This allows the suppression pool to remain effective. The primary difference in the conceptual design was one of size. SAMA candidate AT-10 assumes a filtered containment vent sufficient to accommodate an ATWS event (assumed at 100% power) for a reasonable period of time to allow extra ordinary measures to be implemented to shutdown the reactor.

  The design concept for the ATWS-sized cooling vent was that it would require a hardened vent piping from the wetwell to a large tank outside of the reactor building. Since no primary containment penetrations exist of sufficient size, the potential for modifying the wetwell access hatch was conceptualized. This would replace the existing hatch with one modified for dual purpose (entry and venting). A removal spool piece would be installed between the modified wetwell hatch and the hardened ATWS-sized piping. Pipe routing and supports would be required inside the Reactor Building to avoid the large secondary containment access hatch used for refueling operations and dry cask loading. The piping would exit the secondary containment through secondary containment isolation valves and modifications of the reinforced Reactor Building concrete walls. The piping externally would transition above a Diesel Generator room and to a large pressure-rated tank at ground level. The tank would have the ability to absorb heat and filter the suppression pool discharge (assuming steam at 220-300°F). A small self-contained diesel generator similar to DG-4 would be available for powering the multiple SGT

fans. Drains from the enclosure to Radwaste processing would be provided. Project management and security impacts were also considered.

The cost for the ATWS-sized filtered containment vent to remove decay heat was estimated as follows:

a. Design - $2,600,000
b. NRC approval - $1,200,000
c. Materials and installation pressure vessel and pad - $2,500,000
d. Modification of wetwell equipment hatch - $1,000,000
e. Large sized piping and solation valves from hatch to Reactor Building penetration: assume 60"- 72" piping - $1,250,000
f. New Reactor Building penetration with inboard/outboard isolation valves – $1,400,000
g. Piping to ATWS-sized gravel bed enclosure (not estimated)
h. Gravel bed enclosure or vent filters from gravel bed enclosure – $400,000
i. Drain system collection back to Radwaste processing - $850,000
j. Project support - $800,000
k. Security impacts - $750,000

Total: $12,750,000

The design concept for CP-12 (Install a filtered containment vent to remove decay heat) was similar except that the pressure vessel size was reduced yielding a $1,000,000 reduction.

Total $11,750,000

- CP-22 Implementation Cost Estimate Details

SAMA candidate CP-22 proposes to increase the depth of the concrete base mat or to use an alternate concrete material to ensure melt-through does not occur.

The cost estimate for this SAMA candidate assumes thickening the concrete base mat using materials and methods typical of underground tunneling methods standard in underground roadway or underwater rapid transit tunneling projects. The project would be performed in sections or slices in order to avoid massive underground Reactor Building support structures. The cost estimate assumes design, NRC approval, materials, rebar installation, removal of existing below-ground infrastructure conflicts, micro-tunneling, pit excavation, horizontal concrete slurry injection, spoils and re-compaction and miscellaneous project support including security.

The cost for approximately doubling the Reactor Building base depth was estimated as follows:

a. Design - $5,000,000
b. NRC - $1,500,000
c. 48" micro-tunneling - $12,000,000
d. Pit excavation - $2,500,000
e. Utility/infrastructure conflicts - $6,000,000
f. Rebar material and placement- $2,000,000
g. Horizontal concrete slurry injection - $4,000,000
h. Spoils - $400,000
i. Project Support - $2,500,000

Total: $35,900,000

- CP-24 Implementation Cost Estimate Details

SAMA candidate CP-24 proposes to construct a building of sufficient size adjacent to the Reactor Building/containment to be maintained at a vacuum in order to provide additional means to filter releases. This SAMA candidate would improve the release mitigation effectiveness of the secondary containment (Reactor Building).

A building sized to the Reactor Building space ~ 3.5 E+06 cubic feet would be cost-prohibitive. However, a lesser cost option would be to build a large tank which could be maintained at a higher vacuum than the current reactor building at a reduced size. The vacuum could be established and maintained by motor driven vacuum pumps powered by self-contained diesel generators similar to DG-4.

The cost for this SAMA candidate was estimate as follows:

a. Design - $2,250,000
b. NRC approval - $1,500,000
c. Tank - $2,000,000
d. Motor driven vacuum pumps w/building - $1,250,000
e. Diesel w/building - $1,250,000
f. Piping to Reactor Building - $1,000,000
g. Penetration of Reactor Building and isolation valves - $1,000,000
h. Security impacts -$800,000
i. Project support - $800,000

Total: $11,850,000

- CC-12 Implementation Cost Estimate

  SAMA candidate CC-12 proposes to establish a diverse low pressure system to support injection. CGS design has four existing low pressure systems and one high pressure injection system (HPCS) that can be used for low pressure injection. Initially, this SAMA candidate was screened as low benefit. In response to the NRC RAI to reexamine the Phase 1 screening using an RRW uncertainty benefit method, this candidate was found to have a moderate risk improvement; therefore, it was re-examined. The re-examination found that the RRW uncertainty benefit was approximately $1,000,000. A CGS-specific cost estimate was not developed for this SAMA candidate. The cost estimate developed by Vermont Yankee is used.

For some SAMA candidates that had been screened as Criterion D or Criterion E, no RRW value can be generated by the PSA. SAMA candidates of this nature are those that only affect the release amount and not its frequency. SAMA candidates CP-12 and CP-13 of Table A-15 are of this nature. These SAMA candidates scrub releases to reduce the dose to the public but do not affect the frequency of the release; thus, an RRW is not possible to generate. For these SAMA candidates, a search of the industry Phase 2 SAMA analysis has been performed. The search identified that SAMA candidates CP-12 and CP-13 have been evaluated by other BWRs using a Phase 2 analysis. Their benefit and implementation costs have been reviewed for applicability to CGS. Where appropriate, these references are used to assess the likely benefit and costs at CGS and are used in the Phase 1 screening of the candidates.

Finally, in a few cases, the reevaluation has determined that a revised screening criterion is warranted or that the SAMA candidate has effectively been addressed by an alternate SAMA candidate that was developed during the response to the original set of RAIs. In some cases, application of the uncertainty factor has changed the screening from Criterion E (Very Low Benefit) to one of the other four criteria. In addition, a few SAMA candidates have been determined to either be not applicable to CGS (Criterion A) or to have already been implemented (Criterion B) (or are in the process of being implemented). The screening criteria for the affected SAMA candidates have been revised as appropriate and justification provided.

The results of the reevaluation of the original Criterion D and Criterion E SAMA candidates using the approaches described above are presented in Tables A-15 and A-16, respectively. No additional SAMA candidates were identified from the reevaluation.

Energy Northwest concludes that the RRW benefit method provides high assurance in discerning the cost-benefit potential of these SAMA candidates. The use of the RRW uncertainty benefit method requires the first step of a Phase 2 evaluation to be performed (i.e., modeling the SAMA candidate in the PSA) for Criterion E candidates. This method is also useful in supporting the screening of Criterion D candidates whose estimated implementation cost does not exceed the maximum uncertainty benefit. For these cases, an RRW uncertainty benefit can be established and its potential for being cost-beneficial readily determined. This approach results in a more thorough evaluation of the candidates' importance for risk mitigation. These results support the use of the qualitative Phase 1 screening approach prescribed by NEI 05-01. The use of the RRW uncertainty benefit method is effective as an additional check for those candidates for which some doubt exists as to a candidate's potential benefit without having to perform a full Phase 2 evaluation.

5.0 CONCLUSIONS

As shown in Attachment 2, the following SAMA candidates were determined to be cost-beneficial using PSA Rev. 6.2: **AC/DC-28, CC-03b, FR-07a, FR-07b, FR-08 and HV-02.**

Based upon the results in Table B-8, the following additional SAMA candidates are cost-beneficial: **SR-05R, FL-05R, FL-04R, FL-06R, CC-24R, CC-25R, OT-07R, FW-05R, OT-09R and FR-11R.**

All of the above SAMA candidates (16 total) will be considered for implementation through the normal processes for evaluating possible plant changes at CGS as described in Attachment 2 RAI 6.j-1iv.

APPENDIX A

PSA MODEL REVISION

Table A-1 (Internal Events)	Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1
Table A-1 (Fire)	Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1
Table A-1 (Seismic)	Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1
Table A-2	Comparison of LERF Contributions for PSA Models Rev. 6.2 and Rev. 7.1
Table A-3	Internal Events Level 2 Release Categories
Table A-4	Fire Level 2 Release Categories
Table A-5	Seismic Level 2 Release Categories
Table A-6	Base Case Sensitivity Results for Internal Events *(release category, whole body dose, economic impact)*
Table A-7	Base Case Sensitivity Results for Fire *(release category, whole body dose, economic impact)*
Table A-8	Base Case Sensitivity Results for Seismic *(release category, whole body dose, economic impact)*
Table A-9	Level 1 Internal Events Basic Events Importance List
Table A-10	Level 2 Internal Events Basic Events Importance List
Table A-11	Level 1 Fire Basic Events Importance List
Table A-12	Level 2 Fire Basic Events Importance List
Table A-13	Level 1 Seismic Basic Events Importance List
Table A-14	Level 2 Seismic Basic Events Importance List
Table A-15	Re-evaluation of Phase 1 Screening of Criterion D SAMA Candidates
Table A-16	Re-evaluation of Phase 1 Screening of Criterion E SAMA Candidates

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
IS	ISLOCA	1.02E-07	1%	3.8E-10	0%	Several ISLOCA event tree revisions that arose from F&Os resulted in increased CDF ISLOCA for Rev. 7.1: pipe rupture likelihood now based on published data; if piping doesn't rupture, it leaks (no credit for "no leakage"); early isolation probability increased based on updated guidance; initiating event frequency based on most current failure data.	268.5
S1	MLOCA	7.83E-08	1%	3.6E-10	0%	Revised HEPs from the updated HRA caused an increase in CDF contribution from MLOCA.	219.7
TSH6	Loss of Bus SH-6	2.58E-08	0%	3.7E-10	0%	Enhanced modeling realism caused the CDF to increase: the backup source of cooling for CRD operation is impacted by the loss of the 6.9kV bus SH-6.	69.9

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
TTC2	Turbine Trip ATWS Low Power	1.39E-09	0%	5.3E-11	0%	ATWS contributions increased due to not crediting HPCS, LPCS, and LPCI injection based on insights from plant procedures and Operations to minimize power flow oscillations. This was driven by the EOPs, where HPCS is allowed to be used only under certain restrictive conditions for power level control.	26.2
TFC	Loss of FW ATWS	5.33E-07	7%	2.2E-08	0.5%	See TTC2.	24.8
TMC	MSIV Closure ATWS	2.13E-07	3%	9.1E-09	0%	See TTC2.	23.4
TIC	SORV ATWS	1.22E-07	2%	5.7E-09	0%	See TTC2.	21.3
TTSW	Loss of TSW	1.62E-08	0%	9.5E-10	0%	Loss of TSW initiating event frequency increased for Rev. 7.1. The previous initiating event fault tree modeling had deficiencies relative to the requirements of the ASME/ANS PRA Standard's requirements. The new initiating event frequency for the TTW initiator is also now in close agreement with generic initiating event data.	16.9
TCC	Loss of Condenser ATWS	3.39E-07	5%	2.2E-08	0.5%	See TTC2.	15.1
TIA	Loss of CIA	8.29E-08	1%	7.2E-09	0%	The initiating event frequency increased for Rev. 7.1, which reflects plant-specific experience.	11.5

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
TM	MSIV Closure	3.56E-07	5%	4.6E-08	1%	In accordance with the ASME/ANS PRA Standard, initiating event TM now includes bus losses that cause MSIV Closure, which include a loss of 4160V switchgear E-SM-7 and a loss of 480V bus E-SL-71.	7.7
MS	Manual Shutdown	7.87E-07	11%	1.3E-07	3%	Manual Shutdown now includes explicit modeling of TS LCO related shutdowns that could arise from failures of equipment modeled in the PSA, driven by the ASME/ANS PRA Standard.	6.2
A	LLOCA	6.02E-10	0%	9.7E-11	0%	Potential CCF plugging of ECCS suppression pool suction strainers is now modeled.	6.2
S2	SLOCA	2.40E-08	0%	4.0E-09	0%	The increase to the SLOCA contribution was primarily due to an update of the human failure event dependency analysis.	6.1
TTC	Turbine Trip ATWS Full Power	1.43E-07	2%	2.5E-08	0.5%	See TTC2.	5.8

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
LOCA Outside Containment	LOCA Outside Containment	5.83E-07	8%	1.5E-07	4%	For Rev. 7.1, LOCA outside containment modeling now includes explicit modeling for all potential sources (MS, RFW, RWCU, RCIC), rather than only MS. LOCAs outside containment also now account for the environmental impacts to plant equipment as required by the ASME/ANS PRA Standard, e.g., impacts to 4160V buses SM-1, SM-2 and SM-3 in the Turbine Building.	3.8
TF	Loss of FW	7.19E-07	10%	1.9E-07	4%	The human reliability dependency analysis was updated, which was a significant reason for the increased contribution from TF.	3.8
Internal Flooding	Internal Flooding	2.32E-06	31%	7.4E-07	15%	Flood sources were identified in the Radwaste / Control Building and are now modeled in the Rev. 7.1 PSA. This upgrade was driven by supporting requirements IFSO-A1 and ISFO-A5 to identify flooding sources from fire, service water systems, etc., for a range of break sizes	3.1
SR	Reactor Level Instrument Line Break	1.42E-07	2%	7.0E-08	1%	Relatively similar contribution	2.0
TC	Loss of Condenser	3.69E-07	5%	2.2E-07	4.5%	Similar to TF	1.7

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
TT	Turbine Trip	1.48E-07	2%	1.1E-07	2%	No Significant change in the CDF result.	1.3
CR-HV	Loss of Control Room HVAC	4.15E-10	0%	4.1E-10	0%	No Significant change	1.0
TI	Inadvertent Open Relief Valve / SORV	8.27E-08	1%	2.1E-07	4%	No Significant change	0.4
T(E)N	LOOP	9.25E-08	1%	3.0E-07	6%	The LOOP initiating event frequency was updated to the most current data.	0.3
TCAS	Loss of Control and Service Air	2.38E-08	0%	1.0E-07	2%	No significant change	0.2
SBO-I	SBO with RCIC Available	6.51E-08	1%	5.3E-07	12%	DG-3 crosstie is modeled in Rev. 7.1.	0.1
SBO-R	SBO with RCIC Unavailable	6.01E-08	1%	1.1E-06	23%	Rev. 7.1 produced a significant reduction in the contribution from SBO-R, primarily due to a large reduction in RCIC failure-to-run data provided by NUREG/CR-6928, and the modeling of the DG-3 cross-ties.	0.1
TSH5	Loss of SH-5	1.08E-11	0%	3.2E-10	0%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
RPVR	Excessive LOCA (RPV Rupture)	9.95E-09	0%	3.0E-07	7%	Initiating event frequency revised downward based on NRC expert elicitation.	0.0

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
TSM3	Loss of SM-3	1.08E-11	0%	3.5E-10	0%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
TSM1	Loss of SM-1	2.72E-10	0%	1.4E-08	0%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
TSM2	Loss of SM-2	9.53E-10	0%	6.2E-08	1%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
TDC2	Loss of Div 2 DC Power	5.50E-11	0%	7.1E-09	0%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
TDC1	Loss of Div 1 DC Power	4.70E-11	0%	7.8E-09	0%	Refined unavailability for EACTRL-ASHE-W3D1 (unavailability of offsite power to TR-S) reduced this CDF contribution significantly.	0.0
TEC	LOOP / ATWS	4.79E-08	1%	n/a - new	0%	New initiating event	n/a
FLCqL (flood results in consequential LOOP)	Flood Consequential LOOP	Combined with Internal Flood	n/a	n/a - new IE	0%	New initiating event	n/a
DDC	Loss of Div 1 and Div 2 DC Power	8.61E-09	0%	n/a - new IE Group	0%	New initiating event	n/a

Table A-1 (Internal Events): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Total CDF:		Rev 7.1 - 7.4E-06		Rev 6.2 - 4.77E-06		Overall Factor Difference:	1.54
Initiator	**Description**	**CDF (/rx-yr)**	**Percentage of total CDF**	**CDF (/rx-yr)**	**Percentage of total CDF**	**Discussion**	**Factor Difference**
FLSBR(flood followed by consequential LOOP results in SBO with RCIC unavailable)	Flood SBO following Consequential LOOP - RCIC Unavailable	Combined with Internal Flood	n/a	n/a - new IE	0%	New initiating event	n/a
FLSBI (flood followed by consequential LOOP results in SBO with RCIC available)	Flood SBO following Consequential LOOP - RCIC Available	Combined with Internal Flood	n/a	n/a - new IE	0%	New initiating event	n/a
DAC	Loss of SM-7 and SM-8 Due to CCF	3.32E-09	0%	n/a	0%	New initiating event	n/a
Loss of Div 1 and Div 2 Switchgear HVAC	No longer an initiating event	0	0%	4.3E-07	9%	No longer an initiating event based on updated room heat-up calculations	n/a
SG1HV	No longer an initiating event	0	0%	1.4E-08	0%	No longer an initiating event based on updated room heat-up calculations	n/a
SG2HV	No longer an initiating event	0	0%	1.0E-09	0%	No longer an initiating event based on updated room heat-up calculations	n/a

Table A-1 (Fire): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1[2]

Fire Compartment	Rev 6.2 Fire CDF (/rx-yr)	Rev. 7.1 Fire CDF (/rx-yr)	Fire CDF Difference	Percentage Increase[1]	Discussion
Total	**3.6E-06**	**1.37E-05**	**1.01E-05**	**278%**	
W07 (Radwaste 467' Division 2 Electrical Equipment)	9.0E-08	1.7E-06	1.6E-06	44%	The Rev. 7.1 FPSA modeling of long term RCIC operation differs from the Rev. 6.2 FPSA in crediting RCS makeup in the event RCIC fails to continue to run due to containment back-pressure. The assumption that an RCS makeup source was available was not carried forward for Rev 7.1 FPSA. The Integrated PSA Model Rev. 7.1 was established for SAMA evaluations and this conservatism is judged appropriate for the SAMA application. This resulted in an increased importance for fire compartment W07.
T1C (Turbine Generator East 441')	5.2E-08	1.3E-06	1.3E-06	36%	Based on the revised Rev. 7.1 RFW fault tree model, RFW is now failed if a full compartment burnout occurs. Modeling of additional dependencies in the Rev 7.1 Internal Events model identified increased importance to this fire compartment.
W04 (Radwaste 467' Division 1 Electrical Equipment Room)	8.4E-07	1.7E-06	8.6E-07	24%	Rev. 7.1 has a conservatism in modeling the failure of some Division 2 equipment associated with this fire compartment. The investigation into this conservatism was not completed prior to performing the sensitivity study. When this conservatism is removed, the Rev. 7.1 W04 compartment fire CDF decreases by a factor of about two. Overall fire CDF decreases by about 6%. This modeling would not adversely affect the SAMA analysis results by screening out a cost-beneficial SAMA candidate.
W08 (Radwaste 467' Switchgear Room #2)	3.6E-07	9.7E-07	6.1E-07	17%	See discussion for compartment W07.

Table A-1 (Fire): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1[2]

Fire Compartment	Rev 6.2 Fire CDF (/rx-yr)	Rev. 7.1 Fire CDF (/rx-yr)	Fire CDF Difference	Percentage Increase[1]	Discussion
Total	**3.6E-06**	**1.37E-05**	**1.01E-05**	**278%**	
W03 (Radwaste 467'-525' Cable Chase)	4.5E-07	9.4E-07	5.0E-07	14%	The Rev. 6.2 FPSA credits one train of RHR to be available and not failed for a fire in this compartment. This was not carried forward to the Rev. 7.1 integrated model. The investigation to confirm this modeling assumption was not completed prior to performing the sensitivity study. When this conservatism is removed, the Rev. 7.1 W03 compartment fire CDF decreases by a factor of about two. Overall fire CDF decreases by about 3%. This modeling would not adversely affect the SAMA analysis results by screening out a cost-beneficial SAMA candidate.
W14 (Radwaste 467' Switchgear Room #1)	1.0E-06	1.4E-06	4.5E-07	12%	The Rev. 6.2 FPSA model provided non-repair probabilities to recover fire-induced losses of offsite power. This assumption was removed for Rev 7.1 integrated FPSA. This resulted in an increase in risk importance in the Rev 7.1 model for this compartment.
R1C (Southeast Reactor Building 471')	2.0E-08	3.9E-07	3.7E-07	10%	Increased CDF in Rev. 7.1 for reasons similar to compartment R1K.
W1A (Radwaste Building 437')	1.2E-07	4.4E-07	3.2E-07	8.8%	See discussion for compartment W07.
W13 (Radwaste 525' Emergency Chiller)	2.0E-07	4.9E-07	2.9E-07	7.9%	See discussion for compartment W07.
R1L (Reactor Building 572')	3.3E-09	2.4E-07	2.3E-07	6.4%	See discussion for compartment W07.
W02 (Cable Spreading Room)	2.2E-07	4.4E-07	2.2E-07	6.0%	For one fire scenario modeled for W02, RHR is modeled as completely failed due to fire impacts. This is conservative. See the discussion for compartment W03.
T1A (Turbine Generator West 441')	1.6E-07	2.9E-07	1.3E-07	3.6%	See discussion for compartment W07.
T1D (Turbine Generator West 471')	4.9E-08	1.6E-07	1.1E-07	2.9%	See discussion for compartment W07.

Table A-1 (Fire): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1[2]

Fire Compartment	Rev 6.2 Fire CDF (/rx-yr)	Rev. 7.1 Fire CDF (/rx-yr)	Fire CDF Difference	Percentage Increase[1]	Discussion
Total	**3.6E-06**	**1.37E-05**	**1.01E-05**	**278%**	
T1H (Turbine Generator Center 501')	3.5E-09	1.1E-07	1.0E-07	2.8%	See discussion for compartment W07.
R1B (Northeast Reactor Building 471')	5.8E-08	1.6E-07	1.0E-07	2.8%	This was a methodology change for Rev. 7.1. A 0.5 recovery probability was applied in Rev. 6.2 to re-close RHR-V-27A if it spuriously opens due to fire. RG 1.200 requires that analysis be performed to demonstrate that RHR-V-27A would not be damaged by the hot short by bypass of torque limit switch. The 0.5 credit was removed for Rev. 7.1.
T10 (West Transformer Vault)	1.9E-09	8.6E-08	8.4E-08	2.3%	See discussion for compartment T1C.
T1I (Turbine Generator East 501')	3.0E-09	8.4E-08	8.1E-08	2.2%	See discussion for compartment W07.
T1G (Turbine Generator West 501')	9.4E-09	8.7E-08	7.7E-08	2.1%	See discussion for compartment W07.
W05 (Radwaste 467' Battery Room 1)	2.5E-07	3.2E-07	6.4E-08	1.8%	A human failure event for aligning SW as an alternate injection source was added to the modeling in Rev. 7.1.
R1K	2.0E-08	6.9E-08	4.9E-08	1.4%	A model linking problem in Rev 6.2 was corrected and incorporated into Rev 7.1. This produced a small increase in the compartment risk importance.
S01	2.6E-09	4.6E-08	4.3E-08	1.2%	See discussion for compartment W07.
R1E	6.5E-10	4.1E-08	4.0E-08	1.1%	See discussion for compartment R1K.

[1] Computed for each compartment by dividing CDF Difference for each compartment by the total Rev. 6.2 Fire CDF.
[2] This table compares CDF for all fire compartments whose Rev. 7.1 CDF increased by at least 1% from the Rev. 6.2 Fire compartment CDF.

Table A-1 (Seismic): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Seismic Damage State	Description of Seismic Impacts	Rev. 7.1 CDF (/rx-year)	Rev. 6.2 CDF (/rx-year)	CDF Difference	Percentage Difference	Discussion
Total		4.9E-06	5.3E-06	-3.9E-07	-7.4%	
SDS38	BOP, CST, LOOP, N2 Tank, DGs stalled and not re-started	9.5E-08	5.8E-08	3.7E-08	63.8%	In Rev. 7.1 Internal Events RCIC suction from the suppression pool is not credited due to operational preference in procedures to use the CST. For this seismic damage state, the CST is unavailable; therefore RCIC is modeled as unavailable, which produces a reasonably conservative net higher CDF for Rev. 7.1.
S2P3 (1)	BOP, CST, LOOP, small-small LOCA	6.8E-08	3.4E-08	3.3E-08	97.1%	CDF increased for reasons similar to seismic damage SDS38.
SDS2 (1)	BOP, CST, LOOP, small-small LOCA	4.8E-08	2.0E-08	2.8E-08	140.0%	CDF increased for reasons similar to seismic damage SDS38.
S523	BOP, CST, LOOP, N2 Tank, small-small LOCA, DG 1&2, Div. III	1.4E-07	1.3E-07	1.1E-08	8.5%	CDF increased for reasons similar to seismic damage SDS38.
S1129	BOP, CST, LOOP, N2 Tank, SLOCA, DG 1&2, Div. III	1.8E-08	1.6E-08	1.3E-09	8.1%	CDF increased for reasons similar to seismic damage SDS38.
SDS20 (3)	BOP, CST, LOOP, N2 Tank, small-small LOCA	1.0E-09	3.2E-10	7.1E-10	221.9%	CDF increased for reasons similar to seismic damage SDS38.
S20P3 (3)	BOP, CST, LOOP, N2 Tank, small-small LOCA	1.2E-09	5.8E-10	5.8E-10	100.0%	CDF increased for reasons similar to seismic damage SDS38.
SDS3 (2)	BOP, CST, LOOP, small-small LOCA, Div. III	9.3E-10	8.1E-10	1.2E-10	14.8%	CDF increased for reasons similar to seismic damage SDS38.
SDS8	BOP, CST, LOOP, SLOCA	1.4E-10	3.4E-11	1.0E-10	294.1%	CDF increased for reasons similar to seismic damage SDS38.
SDS21	BOP, CST, LOOP, N2 Tank, small-small LOCA, Div. III	2.7E-10	2.3E-10	4.0E-11	17.4%	CDF increased for reasons similar to seismic damage SDS38.
S1331	BOP, CST, LOOP, N2 Tank, SLOCA, Div. I&II, Div. III, Offsite AC Not Recoverable	1.6E-08	1.6E-08	3.0E-11	0.2%	CDF increased for reasons similar to seismic damage SDS38.
SDS26	BOP, CST, LOOP, N2 Tank, SLOCA	2.3E-11	5.3E-12	1.8E-11	339.6%	CDF increased for reasons similar to seismic damage SDS38.

Table A-1 (Seismic): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Seismic Damage State	Description of Seismic Impacts	Rev. 7.1 CDF (/rx-year)	Rev. 6.2 CDF (/rx-year)	CDF Difference	Percentage Difference	Discussion
Total		4.9E-06	5.3E-06	-3.9E-07	-7.4%	
SDS42	Failure of RPV and/or Category I Buildings	2.4E-06	2.4E-06	0.0E+00	0.0%	No Change
SDS41	Wide-spread failure of SSEL equipment	1.6E-06	1.6E-06	0.0E+00	0.0%	No Change
SLAC	BOP, CST, LOOP, N2 Tank, MLOCA, Div. I&II, Div. III, Offsite AC Not Recoverable	1.1E-07	1.1E-07	0.0E+00	0.0%	No Change
S725	BOP, CST, LOOP, N2 Tank, small-small LOCA, Div. I&II, Div. III, Offsite AC Not Recoverable	1.0E-07	1.0E-07	0.0E+00	0.0%	No Change
SDS40	Seismic Failure to Scram and Failure to Mitigate	7.9E-09	7.9E-09	0.0E+00	0.0%	No Change
S2P2 (1)	BOP, CST, LOOP, small-small LOCA	0.0E+00	1.8E-07	-1.8E-07	-100.0%	CCF probabilities were updated for Rev. 7.1 Internal Events. There was a reduction in the CCF probabilities for the DGs as a result of this update, a net reduction in CDF for this seismic damage state occurred.
S624	BOP, CST, LOOP, N2 Tank, small-small LOCA, Div. I&II, Offsite AC Not Recoverable	9.0E-08	2.2E-07	-1.3E-07	-59.1%	For Rev. 7.1, the likelihood for failure of HPCS injection given containment failure was refined to remove conservatism. This produced a net reduction in the CDF for this seismic damage state.
SDS4	BOP, CST, LOOP, small-small LOCA, DG 1&2	8.2E-08	1.8E-07	-1.0E-07	-55.6%	CDF decreased for reasons similar to seismic damage S624.
SDS22	BOP, CST, LOOP, N2 Tank, small-small LOCA, DG 1&2	2.8E-08	6.2E-08	-3.4E-08	-54.8%	CDF decreased for reasons similar to seismic damage S624.
S1836	BOP, CST, LOOP, N2 Tank, MLOCA, Div. I&II, Offsite AC Not Recoverable	8.1E-09	2.0E-08	-1.2E-08	-60.0%	CDF decreased for reasons similar to seismic damage S624.
S1230	BOP, CST, LOOP, N2 Tank, SLOCA, Div. I&II, Offsite AC Not Recoverable	7.4E-09	1.8E-08	-1.0E-08	-55.6%	CDF decreased for reasons similar to seismic damage S624.

Table A-1 (Seismic): Comparison CDF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Seismic Damage State	Description of Seismic Impacts	Rev. 7.1 CDF (/rx-year)	Rev. 6.2 CDF (/rx-year)	CDF Difference	Percentage Difference	Discussion
Total		4.9E-06	5.3E-06	-3.9E-07	-7.4%	
SDS16	BOP, CST, LOOP, MLOCA, DG 1&2	3.9E-09	8.9E-09	-5.0E-09	-56.2%	CDF decreased for reasons similar to seismic damage S624.
SDS10	BOP, CST, LOOP, SLOCA, DG 1&2	3.7E-09	8.1E-09	-4.4E-09	-54.3%	CDF decreased for reasons similar to seismic damage S624.
S20P2 (3)	BOP, CST, LOOP, N2 Tank, small-small LOCA	0.0E+00	4.4E-09	-4.4E-09	-100.0%	CDF decreased for reasons similar to seismic damage S2P2.
SDS34	BOP, CST, LOOP, N2 Tank, MLOCA, DG 1&2	2.8E-09	6.3E-09	-3.6E-09	-57.1%	CDF decreased for reasons similar to seismic damage S624.
SDS28	BOP, CST, LOOP, N2 Tank, SLOCA, DG 1&2	2.7E-09	6.0E-09	-3.3E-09	-55.0%	CDF decreased for reasons similar to seismic damage S624.
S3P2 (2)	BOP, CST, LOOP, small-small LOCA, Div. III	3.7E-09	4.6E-09	-8.3E-10	-18.0%	CDF decreased for reasons similar to seismic damage S2P2.
S8P2 (4)	BOP, CST, LOOP, SLOCA	1.3E-10	7.2E-10	-5.9E-10	-81.9%	CDF decreased for reasons similar to seismic damage S2P2.
S21P2 (4)	BOP, CST, LOOP, N2 Tank, small-small LOCA, Div. III	1.1E-09	1.4E-09	-2.6E-10	-18.6%	CDF decreased for reasons similar to seismic damage S2P2.
SDS14 (4)	BOP, CST, LOOP, MLOCA	2.9E-11	2.4E-10	-2.1E-10	-87.5%	CDF decreased for reasons similar to seismic damage S2P2.
SDS15 (4)	BOP, CST, LOOP, MLOCA, Div. III	1.5E-10	3.4E-10	-1.9E-10	-55.9%	CDF decreased for reasons similar to seismic damage S2P2.
S26P2 (4)	BOP, CST, LOOP, N2 Tank, SLOCA	1.0E-11	1.7E-10	-1.6E-10	-94.1%	CDF decreased for reasons similar to seismic damage S2P2.
SDS33 (4)	BOP, CST, LOOP, N2 Tank, MLOCA, Div. III	1.0E-10	2.2E-10	-1.2E-10	-54.5%	CDF decreased for reasons similar to seismic damage S2P2.
SDS32 (4)	BOP, CST, LOOP, N2 Tank, MLOCA	6.4E-12	6.8E-11	-6.1E-11	-89.7%	CDF decreased for reasons similar to seismic damage S2P2.
SDS27 (4)	BOP, CST, LOOP, N2 Tank, SLOCA, Div. III	6.1E-11	1.1E-10	-5.2E-11	-47.3%	CDF decreased for reasons similar to seismic damage S2P2.
SDS9 (4)	BOP, CST, LOOP, SLOCA, Div. III	1.2E-10	1.6E-10	-4.2E-11	-26.3%	CDF decreased for reasons similar to seismic damage S2P2.

(1) S2P2, S2P3 and SDS2 were reported together in Table E.3-10. They were separated to allow direct comparison between revisions.
(2) SDS3 and S3P2 were reported together in Table E.3-10. They were separated to allow direct comparison between revisions.
(3) SDS20, S20P2, and S20P3 were reported together in Table E.3-10. They were separated to allow direct comparison between revisions

(4) These damage states were below the level of detail provided in Table E.3-10

Table A-2: Comparison of LERF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Rev. 6.2 Basic Event Name	Basic Event Description	Point Est.	F-V IMPORT	RAW	RRW	Comparison to Rev. 7.1
IE-V	CLASS V SEQUENCE	1.52E-07	2.33E-01	1531424.63	1.303	The frequency for Class 5A in Rev. 7.1 reduced to 1.3E-07/rx-year. Although the ISLOCA contribution to Class 5A increased for Rev. 7.1, the contribution to Class 5A from MS LOCAs outside containment reduced due to modeling refinements, producing a net frequency reduction of approximately 13 percent for Class 5A and also a reduction in LERF.
IE-IC	CLASS IC	1.52E-07	2.33E-01	1531424.63	1.303	In Rev. 6.2 all internal flooding accident sequences were assigned to the large early release accident class, which is conservative. Realistic PDSs were assigned for internal flooding accident sequences in Rev. 7.1, which produced a reduction in LERF.
STMEXP-OTHER	STEAM EXPLOSION OCCURS IN PEDESTAL AT VESSEL FAILURE	7.00E-01	1.93E-01	1.08	1.239	Rev. 7.1 modeling refinements reduced the likelihood for the occurrence of an ex-vessel steam explosion that fails containment, which produced a reduction in LERF.
IE-IVBA	ATWS EVENTS WITH VESSEL INITIALLY INTACT	1.13E-07	1.73E-01	1531424.75	1.209	The frequency for Class IVBA approximately doubled in Rev. 7.1 to 2.3E-07. The increased contribution to LERF from this doubling of Class 1VBA in Rev. 7.1 is offset by other Rev. 7.1. LERF modeling refinements.
IE-IA2	CALSS IA-2 SEQUENCE	8.43E-07	1.39E-01	165008.84	1.162	The frequency for Class 1A2 approximately doubled in Rev. 7.1 to 1.6E-06. The increased contribution to LERF from this doubling of Class 1A2 in Rev. 7.1 is offset by other Rev. 7.1. LERF modeling refinements.

Table A-2: Comparison of LERF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Rev. 6.2 Basic Event Name	Basic Event Description	Point Est.	F-V IMPORT	RAW	RRW	Comparison to Rev. 7.1
ADSHUMNSTARTH3LL	OPERATORS FAIL TO RESPOND IN TIME TO INITIATE ADS PRIOR TO VESSEL FAILURE	1.00E-01	1.36E-01	2.23	1.158	Rev. 6.2 conservatively assumes a 0.1 likelihood for failure to depressurize prior to vessel failure. Modeling for failure to depressurize prior to vessel failure was refined for Rev. 7.1.
IE-VIA1	CLASS VI-A-1 DURING SHORT TERM SBO	1.03E-06	1.08E-01	105058.65	1.121	The frequency for PDS 6A1 (core damage short term during SBO) decreased from 1.0E-06/rx-year in Rev. 6.2 to 6.1E-08/rx-year in Rev. 7.1, which reduces the Rev. 7.1 LERF.
IE-IVBL	ATWS EVENTS WITH VESSEL INITIALLY BREACHED	6.38E-08	9.77E-02	1531424.88	1.108	The frequency for Class 4BL approximately doubled in Rev. 7.1 to 1.7E-07. The increased contribution to LERF from this doubling of Class 4BL in Rev. 7.1 is offset by other Rev. 7.1. LERF modeling refinements.
HPCS-FAIL-6A1-M	HPCS FAILURE DUE TO MECHANICAL FAULT	7.10E-01	7.68E-02	1.03	1.083	The Rev. 6.2 Level 2 PSA distinguished between HPCS mechanical and electrical failures because recovery of HPCS electrical failure was credited. The Rev. 7.1 Level 2 PSA does not credit recovery of HPCS, so this basic event is no longer modeled.
DEPSYS-FAIL	DEPRESSURIZATION SYSTEM HARDWARE FAILURE ON DEMAND	5.00E-02	6.82E-02	2.3	1.073	Likelihood for depressurization system mechanical failure given core damage was refined from 5E-02 in Rev. 6.2 to approximately 1.1E-03 in Rev. 7.1, which decreased the Rev. 7.1 LERF.

Table A-2: Comparison of LERF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Rev. 6.2 Basic Event Name	Basic Event Description	Point Est.	F-V IMPORT	RAW	RRW	Comparison to Rev. 7.1
SHELL----FAIL	SHELL FAILURE DUE TO HIGH PRESSURE MECHANICAL FAILURE	4.00E-01	6.04E-02	1.09	1.064	The CGS Rev. 7.1 Level 2 PSA models a similar failure mode with basic event L2-PHE-TDZ-MAP-- "OP=F; Excess Debris Discharged to Outer DW". Basic event L2-PHE-TDZ-MAP-- is modeled with a probability of 0.1 in the Level 2 TD node "Injection Established to RPV or Drywell For Ex-Vessel Debris Cooling". The probability of 0.4 used in the Rev. 6.2 model is judged to be conservative because it is based on information in NUREG-1150 for Mark I drywell liner failure probability. The CGS Mark II containment and pedestal configuration is sufficiently different than the Mark I containment referenced in NUREG-1150 to justify a lower probability in the CGS Rev. 7.1 Level 2 PSA model.
LPSHUMNRESTORE	FAILURE TO REALIGN AND START LOW PRESSURE SYSTEMS	1.00E-01	5.73E-02	1.52	1.061	The CGS Rev. 7.1 Level 2 PSA credits alignment of the SW-B crosstie to RHR B for alternate RPV injection. Given failure to align the SW-B crosstie to RHR B prior to core damage, the conditional HEP for failure to perform this operator action prior to containment failure is 1.6E-02. The HEP is based on plant specific procedures for performing all crosstie actions within the main Control Room and plant specific MAAP runs to support the sequence timing.

Table A-2: Comparison of LERF Contributions for PSA Models Rev. 6.2 and Rev. 7.1

Rev. 6.2 Basic Event Name	Basic Event Description	Point Est.	F-V IMPORT	RAW	RRW	Comparison to Rev. 7.1
HPCS-FAIL-6A1-E	HPCS FAILURE DUE TO ELECTRICAL FAULT	2.90E-01	3.14E-02	1.08	1.032	The Rev. 6.2 Level 2 PSA distinguished between HPCS mechanical and electrical failures because recovery of HPCS electrical failure was credited. The Rev. 7.1 Level 2 PSA does not credit recovery of HPCS, so this basic event is no longer modeled.
NPWRVF-6A1	NO POWER RECOVERY PRIOR TO VESSEL FAILURE ~ 3HR	2.10E-01	2.25E-02	1.08	1.023	In the CGS Rev. 7.1 Level 2 PSA, short term SBO scenarios credit basic event L2-PHE-AC-RX-OPF "Failure to Recover AC Prior to Vessel Failure - Early CD Sequence". Given failure to recover offsite AC power prior to core damage, basic event L2-PHE-AC-RX-OPF is modeled with a conditional probability of 0.41 to represent the approximate 40 minutes available for additional offsite AC power recovery prior to vessel failure.
IE-IA1	CLASS 1A1	5.08E-08	8.38E-03	165004.97	1.008	The frequency for Class 1A1 approximately tripled in Rev. 7.1 to 1.7E-07/rx-year. The increase in the frequency for Class 1A1 in Rev. 7.1 is offset by other Rev. 7.1. LERF modeling refinements.
IE-IA3	CLASS I-A-3	1.45E-07	6.96E-03	47979.66	1.007	In Rev. 7.1, the frequency for class 1A3 is smaller, 5.4E-08/rx-year, which decreased the Rev. 7.1 LERF.
HPCS-FAIL-1A3-M	HPCS FAILURE DUE TO MECHANICAL FAULT	6.74E-01	6.51E-03	1	1.007	The Rev. 6.2 Level 2 PSA distinguished between HPCS mechanical and electrical failures because recovery of HPCS electrical failure was credited. The Rev. 7.1 Level 2 PSA does not credit recovery of HPCS, so this basic event is no longer modeled.

Table A-3: Internal Events Level 2 Release Categories

Release Category	Description	Frequency (per year)	Percentage
OK	Containment Intact	0	0.0%
H/E	High/Early (LERF-BOC)	3.66E-07	4.9%
H/I	High/Intermediate	2.35E-07	3.1%
M/E	Moderate/Early	2.19E-07	2.9%
M/I	Moderate/Intermediate	4.07E-06	54.5%
L/E	Low/Early	2.30E-08	0.3%
L/I	Low/Intermediate	3.86E-09	0.1%
LL/E	Low Low/Early	1.64E-07	2.2%
LL/I	Low Low/Intermediate	5.33E-07	7.1%

Table A-4: Fire Level 2 Release Categories

Release Category	Description	Frequency (per year)	Percentage
OK	Containment Intact	0	0.0%
H/E	High/Early (LERF-BOC)	4.35E-08[1]	0.3%
H/I	High/Intermediate	7.93E-08	0.6%
M/E	Moderate/Early	1.77E-08	0.1%
M/I	Moderate/Intermediate	8.55E-06	62.3%
L/E	Low/Early	2.33E-08	0.2%
L/I	Low/Intermediate	8.49E-09	0.1%
LL/E	Low Low/Early	8.61E-07	6.3%
LL/I	Low Low/Intermediate	6.13E-07	4.5%

[1] The H/E release decreased from 2.46 E-07 in Rev. 6.2 (LEN) to 4.35 E-08 in Rev. 7.1 for the FPSA. The decreases for the Internal Events and Seismic hazards were of approximately the same amount but a lower percentage change primarily since the Fire Level 2 H/E frequency is dominated by Loss of RPV makeup scenarios. For the Rev 7.1 Level 2 PSA, the likelihood for Loss of RPV makeup scenarios leading to the H/E end state is much smaller than compared to the Rev 6.2 model. For example, the Rev. 7.1 Level 2 MAAP runs show that Loss of RPV makeup scenarios generally result in delayed containment failure (i.e., non-early release). For the Rev 7.1 Level 2 model, the dominant contributors to the H/E end state for Loss of RPV makeup scenarios involve failures such as Containment Isolation failure, Hydrogen Deflagration, or other phenomenological events which are low probability events.

Table A-5: Seismic Level 2 Release Categories

Release Category	Description	Frequency (per year)	Percentage
OK	Containment Intact	0	0.0%
H/E	High/Early (LERF-BOC)	1.87E-06	38.5%
H/I	High/Intermediate	6.09E-07	12.5%
M/E	Moderate/Early	4.46E-09	0.1%
M/I	Moderate/Intermediate	1.12E-06	23.0%
L/E	Low/Early	4.9E-09	0.1%
L/I	Low/Intermediate	7.17E-10	0.0%
LL/E	Low Low/Early	1.29E-07	2.7%
LL/I	Low Low/Intermediate	5.75E-07	11.8%

Table A-6: Base Case Sensitivity Results for Internal Events

Release Category	Whole Body Dose (50 miles, person-rem/yr)	Economic Impact (50 miles, $/yr)
OK	1.50E-03	6.66E-02
H/E	7.36E-01	1.05E+03
H/I	3.41E-01	6.18E+02
M/E	2.06E-01	2.09E+02
M/I	4.03E+00	5.09E+03
L/E	3.13E-02	4.42E+01
L/I	3.82E-03	4.83E+00
LL/E	1.87E-02	1.57E+00
LL/I	1.24E-01	5.97E+01
TOTAL	**5.49E+00**	**7.08E+03**

Table A-7: Base Case Sensitivity Results for Fire

Release Category	Whole Body Dose (50 miles, person-rem/yr)	Economic Impact (50 miles, $/yr)
OK	2.79E-03	1.24E-01
H/E	8.74E-02	1.25E+02
H/I	1.15E-01	2.09E+02
M/E	1.67E-02	1.69E+01
M/I	8.46E+00	1.07E+04
L/E	3.17E-02	4.47E+01
L/I	8.40E-03	1.06E+01
LL/E	9.82E-02	8.26E+00
LL/I	1.42E-01	6.87E+01
TOTAL	**8.96E+00**	**1.12E+04**

Table A-8: Base Case Sensitivity Results for Seismic

Release Category	Whole Body Dose (50 miles, person-rem/yr)	Economic Impact (50 miles, $/yr)
OK	4.35E-04	1.93E-02
H/E	3.76E+00	5.37E+03
H/I	8.83E-01	1.60E+03
M/E	4.20E-03	4.26E+00
M/I	1.11E+00	1.40E+03
L/E	6.66E-03	9.41E+00
L/I	7.09E-04	8.96E-01
LL/E	1.47E-02	1.24E+00
LL/I	1.33E-01	6.44E+01
TOTAL	**5.91E+00**	**8.45E+03**

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
CM	Mechanical failure of scram system	1.249	2.15E-06	CGS has an aggressive CRDM replacement / rebuild program (25-29 per outage). This replaces all drives within approximately 14 years (185 total drives). A rebuilt CRDM costs on average $100K. The SAMA would be associated with increasing the maintenance to improve the reliability. Doubling the replacement program frequency to 53 per outage would result in a cost of 92.5*$100K = $9.2M over 7 years or $1.3M per year. The RRW importance measure of 1.246 corresponds to an estimated maximum benefit of $100K. Therefore, this is not cost effective. SAMA candidate AT-09 to provide alternate rod insertion is already implemented at CGS. No additional SAMA candidates are required.
HPS---------T3LL	HPCS unavailability due to test & maintenance (MRule data)	1.208	1.36E-02	HPCS is currently highly reliable. Improvement beyond this is counter-productive to total unavailability. The ability to perform on-line maintenance in a timely manner (not just in refueling outages) is necessary to maintain high reliability. SAMA candidates CC-01 and CC-02, which provide additional high pressure injection capability, increase high pressure injection availability. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
ATWH-HPLPRSTH3XX	Operator fails to restart HPCS or LPCS/LPCI during an ATWS	1.171	1.00E+00	SAMA candidate OT-07R evaluates improving procedures and operator training, including this operator action, and SAMA candidate AT-15R evaluates a plant modification that would improve the success of this operator action. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point *Estimate*	Resolution
RHRH-ATWSDC-H3XX	Operator fails to bypass RHR SDC interlocks during ATWS	1.162	8.13E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and actions shown to be important by the PSA. This basic event is included in SAMA OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
CF-FAILS-INJECT	HPCS failure due to containment failure	1.149	8.30E-02	SAMA candidates CC-01 and CC-02, which provide additional high pressure injection capability, increase high pressure injection availability. SAMA candidate CP-01, which provides additional SPC capability, reduces containment failure probability. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
TF	Loss of FW initiating event frequency	1.121	2.00E-01	SAMA candidates FW-01 and FW-04, which provide FW upgrades, reduce Loss of FW frequency. FW-01 is already implemented at CGS. FW-04 is evaluated for cost-benefit. SAMA candidate FW-05R, provide manual control of RFW on loss of DC, reduces Loss of FW frequency. This candidate is also evaluated for cost-benefit. No additional SAMA candidates are required.
SW-OPER	Standby SW percent operating time	1.118	1.12E-01	This basic event represents the percent of time Standby SW is in operation. Procedures are in place to minimize SW operation, and the SRV leakage reduction program has been effective at reducing SPC requirements. Significant improvement beyond this is not considered feasible. Not a SAMA candidate.
TC	Loss of Condenser initiating event frequency	1.094	1.60E-01	Any improvement in main condenser reliability will require a major hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
EACENG-EDG3-S424	DG-3 failure to run for 24 hours	1.063	3.95E-02	SAMA candidates AC/DC-28 and AC/DC-29, which provide DG-3 CCF reduction, improve HPCS power reliability. SAMA candidate CC-24R, which provides DG-3 backfeed, improves HPCS power reliability. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
EACTRL-S----T3--	Startup transformer E-TR-S unavailability due to test & maintenance (MRule data)	1.049	1.46E-03	Current unavailability of TR-S overall is 1.46 E-03/year. Improvement beyond this is counter-productive to total unavailability. The ability to perform on-line maintenance in a timely manner (not just in refueling outages) is necessary to maintain high reliability. SAMA candidates AC/DC-14 and AC/DC-27, which provide additional off-site power options, increase power availability. AC/DC-14 is evaluated in Table A-15. AC/DC-27 is evaluated for cost-benefit. No additional SAMA candidates are required.
TSWHUMNIC525H3LL	Operator fails to isolate major TSW leak in Radwaste Building Elevation 525	1.047	1.00E+00	SAMA candidates FL-05R and FL-04R, which provide flooding detection and isolation, reduce the probability of operator failure. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHR----B----T3LL	RHR Train B unavailability due to test & maintenance (MRule data)	1.045	7.96E-03	RHR Train B has high reliability and is green on the MSPI. Further improvement in reliability will require hardware changes or an additional shutdown heat removal system. An example is adding a heat exchanger to RHR Train C with interconnecting piping similar to RHR Train A and B and a connection to SW Train B. Since the benefit from the RRW value is well below $100K, this basic event will not be considered further. SAMA candidate CP-01, which provides an additional SPC system, increases low pressure injection availability. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
IE-FLD-C502TSW-U	Moderate or major TSW line break in Room C502	1.042	2.52E-06	SAMA candidate FL-06R, which provides additional NDE and inspections, detects line degradation and reduces the flooding frequency. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
TSWHUMNIC502H3LL	Operator fails to isolate moderate or major TSW leak in Room C502	1.042	1.00E+00	SAMA candidates FL-05R and FL-04R, which provide flooding detection and isolation, reduce the probability of operator failure. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
HPS-CTL-COND----	Operator fails to control RPV level using HPCS	1.041	5.00E-02	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA candidate OT-07R, this SAMA candidate proved to be cost effective. This operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPSV-MO---12P2LL	HPCS minimum flow valve HPCS-V-12 fails to open	1.04	2.43E-03	Any improvement in HPCS-V-12 reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
HPSV-MO----4P2LL	HPCS injection valve HPCS-V-4 fails to open	1.04	2.43E-03	Any improvement in HPCS-V-4 reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
ADSHUMNSTARTH3LT	Operator fails to initiate depressurization during a non-ATWS event	1.039	1.47E-04	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and actions shown to be important by the PSA. This basic event is included in SAMA OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
RHRHUMNSYS62H3LL	Operator fails to align SPC prior to loss of RCIC	1.038	1.63E-04	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this SAMA candidate proved to be cost effective. This operator action has been identified for increased training. No additional SAMA candidates are required.
TE	LOOP Initiating Event Frequency	1.036	2.98E-02	Any improvement in the frequency of LOOP will require a major hardware modification. This RRW is well below the $100K minimum value for a hardware modification. SAMA candidate AC/DC-14, which provides an additional off-site power source, reduces LOOP frequency. AC/DC-14 is evaluated in Table A-15. No additional SAMA candidates are required.
TT	Turbine Trip initiating event frequency	1.036	7.10E-01	Any improvement in turbine trip frequency will require a major hardware modification. This RRW is below the $100K minimum value for a hardware modification. Not a SAMA candidate.
CIAHUMNX-TIEH3XX	Operator fails to properly line-up CAS cross-tie manual valves when required	1.032	3.87E-02	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and actions shown to be important by the PSA. This basic event was included in SAMA OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACSM--7----W4D1	Failure of 4160 Volt bus E-SM-7	1.031	1.67E-06	Any improvement in E-SM-7 reliability will require a major hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
DMATE-----31W2LL	Failure of DMA Damper 31 temperature sensor	1.03	1.85E-03	Any improvement in DMA Damper 31 temperature sensor reliability will require a hardware modification such as installation of a redundant temperature sensor. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
DMATE-----32W2LL	Failure of DMA Damper 32 temperature sensor	1.03	1.85E-03	Any improvement in DMA Damper 32 temperature sensor reliability will require a hardware modification such as installation of a redundant temperature sensor. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate
EACTR--7-73-W4D1	Failure of transformer E-TR-7/73	1.029	2.17E-05	Any improvement in E-TR-7/73 reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
SW-HUMN-W521H3LL	Operator fails to isolate small SW leak in WMA-AH-52A/B that propagates to the Remote Shutdown Room	1.028	5.50E-01	SAMA candidates FL-05R and FL-04R, which provide flooding detection and isolation, reduce the probability of operator failure. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
XDPHUMN-W521H3LL	Operator fails to isolate small SW leak in WMA-AH-52A/B that propagates to the Division 1 Switchgear Room	1.028	3.20E-01	SAMA candidates FL-05R and FL-04R, which provide flooding detection and isolation, reduce the probability of operator failure. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHR----A----T3LL	RHR Train A unavailability due to test & maintenance (MRule data)	1.026	7.94E-03	RHR Train A has high reliability and is green on the MSPI. *Further improvement in reliability will require* hardware changes or an additional shutdown heat removal system. An example is adding a heat exchanger to LPCS with interconnecting piping similar to RHR Train A and B and a connection to SW Train A. Since the benefit from the RRW value is well below $100K, this basic event will not be considered further. SAMA candidate CP-01, which provides an additional SPC system, increases low pressure injection availability. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EAC-RHR-CCF	CCF of MOC switch assembly	1.024	4.00E-05	Any improvement will require a hardware modification such as replacing a MOC switch with a diverse component. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-9: Level 1 Internal Events Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Resolution
PP-1	Probability of SORV in the period from 12 to 24 hrs	1.025	4.90E-01	Any improvement in SRV reseat reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. SAMA candidate AT-08, which increases SRV reseat reliability, has been implemented at CGS. No additional SAMA candidates are required.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
L2-PHE-RBINEFF-F	Reactor Building ineffective in reducing source term	7.551	1.00E+00	Used to meet modeling purpose (always 1.0). SAMA candidate CP-13 was simulated by reducing the basic event to address the effects of scrubbing releases. CP-13 is evaluated in Table A-15. No additional SAMA candidates are required.
CM	Mechanical failure of scram system (NUREG/CR-5500)	2.077	2.15E-06	CGS has an aggressive CRDM replacement / rebuild program (25-29 per outage). This replaces all drives within approximately 14 years (185 total drives). A rebuilt CRDM costs on average $100K. The SAMA would be associated with increasing the maintenance to improve the reliability. Doubling the replacement program frequency to 53 per outage would result in a cost of 92.5*$100K = $9.2M over 7 years or $1.3M per year. The RRW importance measure of 1.246 corresponds to an estimated maximum benefit of $100K. Therefore, this is not cost effective. SAMA candidate AT-09 to provide alternate rod insertion is already implemented at CGS. No additional SAMA candidates are required.
GV-FAIL	Guaranteed combustible gas vent not available	1.986	1.00E+00	Used to meet modeling purpose (always 1.0). Defines support system failure states that prohibit vent operation. Not a SAMA candidate.
L2-PHE-CLIVATWAS	Large containment breach due to ATWS with continued injection or LLOCA without vapor suppression	1.986	1.00E+00	SAMA candidates AT-10 and CP-12, which provide a filtered containment vent to remove decay heat, improve containment heat removal and venting capability and reduce the probability of large containment breach. These candidates are evaluated in Table A-15. No additional SAMA candidates are required.
L2-PHE-ENV-FAILD	Environmental conditions cause loss of all RPV injection	1.986	1.00E+00	Any improvement in improving ECCS environmental capability requires multiple hardware modifications such as replacing or protecting components. This RRW is well below the cost of multiple hardware modifications that would be required. Not a SAMA candidate.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point *Estimate*	Comment/Resolution
L2-PHE-WW5-FAIL-	Wetwell failure below water line during ATWS	1.97	5.00E-01	SAMA candidate CP-21, which strengthens containment, reduces the wetwell failure probability. CP-21 is evaluated in Table A-15. SAMA candidate AT-15R, which installs modifications to make use of HPCS more likely during ATWS, may reduce the wetwell failure frequency. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-RXENV-PMP	Reactor Building environment fails RHR pumps	1.966	9.98E-01	Any improvement in improving RHR environmental capability requires multiple hardware modifications such as replacing or protecting components. This RRW is well below the cost of multiple hardware modifications that would be required. Not a SAMA candidate.
SLC-XHE-FO-LLVCT	Operator fails to prevent RPV overflow due to uncontrolled injection following depressurization	1.233	4.91E-02	SAMA OT-07R candidate evaluates improving procedures and operator training on systems and actions shown to be important by the PSA. This basic event was included in SAMA candidate OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPS-----ISLOCA-R	HPCS unavailable due to flooding from ISLOCA	1.21	1.00E+00	SAMA candidate FL-07R, which flood protects HPCS, reduces failure probability. SAMA candidates CC-01 and CC-02, which provide an additional high pressure injection system, increases high pressure injection availability. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHR-LPS-ISLOCA-R	RHR / LPCS injection valve unavailable –ISLOCA rupture in valve area	1.21	1.00E+00	SAMA candidates CB-01, CB-03, CB-08, CB-09, which provide improved ISLOCA detection and response, improve mitigation and reduce the impact. These SAMA candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
TT	Turbine Trip initiating event frequency	1.195	7.10E-01	Any improvement in turbine trip frequency requires a major hardware modification. This RRW is below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
IE-FLD-TLO--MS-U	Moderate MS leak in Turbine Building	1.135	5.61E-04	New SAMA candidate CB-10R, which evaluates additional NDE and inspections of MS piping, detects pipe degradation and reduces the flooding frequency. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
RHRS-RP---24INLL	RHR 24-inch pipe ruptures during ISLOCA	1.121	7.48E-02	SAMA candidates CB-01, CB-03, CB-08, CB-09, which provide improved ISLOCA detection and response, improve mitigation and reduce the impact. These SAMA candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-GVPHONAGA	Containment inerted, vent/purge not required	1.12	9.90E-01	Success term. Not a SAMA candidate.
MS-HUMNLOUMSH3LL	Operator fails to isolate moderate MS BOC	1.108	6.30E-05	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action will be identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2-HUMN-RCVR-SYS	Operator fails to recover RPV injection system	1.079	9.00E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action will be identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-HPST-NFAL	High primary system temperature does not cause failure	1.079	8.00E-01	Success term. Not a SAMA candidate.
L2-PHE-MSIV-S-L2	MSIVs or steam line unavailable in Level 2	1.079	1.00E+00	Used to meet modeling purpose (always 1.0). It is a conservative assessment. Not a SAMA candidate.
L2-PHE-SRV-NOPEN	SRVs do not stick open	1.079	8.00E-01	Success term. Not a SAMA candidate.
L2-PHE-WHDNCF-MS	Water hammer does not cause failure of mechanical system	1.079	7.00E-01	Success term. Not a SAMA candidate.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
TF	Loss of FW initiating event frequency	1.078	2.00E-01	SAMA candidates FW-01 and FW-04, which provide FW upgrades, reduce Loss of FW frequency. FW-01 is already implemented at CGS. FW-04 is evaluated for cost-benefit. SAMA candidate FW-05R, which provides manual control of RFW on loss of DC, reduces Loss of FW frequency. This candidate is also evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-HP-BLW-VS	High pressure blowdown overwhelms vapor suppression	1.074	1.00E-01	This is a conservative assessment of an insignificant phenomenon. Not a SAMA candidate.
IE-FLD-RLO-RWCUU	Moderate RWCU leak in Reactor Building	1.06	4.65E-04	Additional NDE and inspections were considered to detect pipe degradation and reduce the flooding frequency. At a minimum it would require a contractor analysis of pipe failure rates and inspections in high radiation areas. A similar contractor analysis cost approximately $40K. Inspection costs are estimated to be similar or greater. The estimated maximum benefit for this basic event is $28K. Additional inspections are not cost effective. Not a SAMA candidate.
TC	Loss of Condenser initiating event frequency	1.06	1.60E-01	This should focus on improving condenser reliability. Any improvement requires a major hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
RHRS-RP---18INLL	RHR 18-inch pipe ruptures during ISLOCA	1.055	6.94E-03	SAMA candidates CB-01, CB-03, CB-08, CB-09, which provide improved ISLOCA detection and response, improve mitigation and reduce the impact. These SAMA candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
HPS---------T3LL	HPCS unavailability due to test & maintenance (MRule data)	1.049	1.36E-02	HPCS is currently highly reliable. Improvement beyond this is counter-productive to total unavailability. The ability to perform on-line maintenance in a timely manner (not just in refueling outages) is necessary to maintain high reliability. SAMA candidates CC-01 and CC-02, which provide additional high pressure injection, increase high pressure injection availability. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
SLCHUMN40MINH3XX	Operator fails to initiate SLC for non-MSIV Closure during ATWS	1.046	1.89E-02	SAMA candidate AT-13, which automates SLC injection in response to ATWS, improves SLC reliability. SAMA candidate OT-07R evaluates improving procedures and operator training. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHRV-MO----8O4XX	MOV RHR-V-8 spuriously opened	1.044	3.24E-04	De-energizing RHR-V-8 was considered to reduce the risk of spuriously opening. At a minimum it would require an engineering evaluation, procedure changes, and an FSAR change. The estimated maximum benefit for this basic event is $21K. If RHR-V-9 de-energization is taken into account, the RRW is 1.025, which corresponds to an estimated maximum benefit o $12K (reference RHRV-MO----9O4XX). Therefore, de-energizing RHR-V-8 to prevent spurious opening is not cost effective. Not a SAMA candidate.
RHRV-MO----9O4XX	MOV RHR-V-9 spuriously opened	1.044	3.24E-04	RHR-V-9 is de-energized during online operations and is not susceptible to spurious opening. This basic event is conservatively retained in the model. Not a SAMA candidate.
RWCV-MO4AND1C3LL	CCF of RWCU-V-1 and RWCU-V-4	1.044	3.30E-05	Any improvement in reducing RWCU-V-1 and RWCU-V-4 CCF requires a hardware modification such as replacing a valve with a diverse component. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
RHRV-MO----8L3XX	MOV RHR-V-8 failed to hold on demand	1.036	2.70E-04	SAMA candidates CB-01, CB-03, CB-08, CB-09, which provide improved ISLOCA detection and response, improve mitigation and reduce the impact. These SAMA candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHRV-MO----9L3XX	MOV RHR-V-9 failed to hold on demand	1.036	2.70E-04	SAMA candidates CB-01, CB-03, CB-08, CB-09, which provide improved ISLOCA detection and response, improve mitigation and reduce the impact. These SAMA candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
SLCHUMN20MINH3XX	Operator fails to initiate SLC for MSIV Closure with ATWS	1.029	1.89E-02	SAMA candidate AT-13, which automates SLC injection in response to ATWS, improves SLC reliability. SAMA candidate OT-07R evaluates improving procedures and operator training. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
AIM	Operator fails to inhibit ADS for MSIV Closure with ATWS	1.027	1.66E-02	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA candidate OT-07R, this operator action will be identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-CONT-NOSI	Containment not steam inerted	1.027	5.00E-01	SAMA candidates CP-18 and CP-27, which provide containment inerting and hydrogen control system enhancements, reduce hydrogen deflagration probability. These candidates are evaluated in Table A-16. No additional SAMA candidates are required.
L2-PHE-H-DEFL-GL	Hydrogen deflagration occurs globally	1.027	1.00E+00	SAMA candidates CP-18 and CP-27, which provide containment inerting and hydrogen control system enhancements, reduce hydrogen deflagration probability. These candidates are evaluated in Table A-16. No additional SAMA candidates are required.

Table A-10: Level 2 Internal Events Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
L2-PHE-O2-INTRO-	Operation deinerted or O2 introduced	1.027	1.00E-02	SAMA candidates CP-18 and CP-27, which provide containment inerting and hydrogen control system enhancements, reduce hydrogen deflagration probability. These candidates are evaluated in Table A-16. No additional SAMA candidates are required.
ATWH-HPLPRSTH3XX	Operator fails to restart HPCS or LPCS-LPCI during ATWS	1.026	1.00E+00	SAMA candidate OT-07R evaluates improving procedures and operator training including this operator action. SAMA candidate AT-15R evaluates plant modifications that would improve the success of this operator action. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
RHRH-ATWSDC-H3XX	Operator fails to bypass RHR-SDC interlocks during ATWS	1.025	8.13E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and actions shown to be important by the PSA. This basic event was included in SAMA candidate OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

[1] RRW values are based on LERF.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
EFF	Early-Extinguish (Fixed Ignition Source) Fails	3.11	3.60E-01	Split Fraction factor (not developed). Not a SAMA candidate.
GTFF50	50% Loss Of FW Trip	1.302	5.00E-01	SAMA candidates FR-09R (area R-1D) and FR-11R (area RC-04) evaluate the installation of early detection in fire areas where fires damage can lead to a 50% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
GTFF	100% Loss of FW Trip	1.271	1.00E+00	SAMA candidates FR-12R (T-1D) and FR-11R (areas RC-02, RC-03 and RC-08) evaluate the installation of early detection in this fire area where fire damage can lead to a 100% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
ETF	Early-Extinguish (Transient Ignition Source) Fails	1.254	2.40E-01	SAMA candidates FR-09R, FR-12R, FR-11R, and FR-10R evaluate the installation of early detection in fire areas of high risk importance. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
GTFF10	10% Loss Of FW Trip	1.219	1.00E-01	SAMA candidates FR-09R (areas R-1B, R-1J) and FR-11R (areas RC-1A, RC-13) evaluate the installation of early detection in fire areas where fires damage can lead to a 10% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
NO-OFFSITE-RECOV	No Recovery Of Offsite Power (Fire)	1.191	1.00E+00	This is a conservative assumption of no offsite power recovery for the fire model. SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
GTTF50	50% Turbine Trip	1.169	5.00E-01	SAMA candidates FR-12R (area T-1A) and FR-11R (area RC-07) evaluate the installation of early detection in this fire area where fire damage can lead to a 50% turbine trip. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
CF-FAILS-INJECT	Injection Fails Due to Containment Failure	1.155	8.30E-02	This is a conditional failure of HPCS lost due to containment failure. SAMA candidates CC-01 and CC-02 evaluate the addition of a redundant train of HPCS. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FW04	IE Zone: W04	1.142	1.02E-02	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW07	IE Zone: W07	1.138	1.10E-02	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW04	Fixed Ignition Source Fraction Zone: W04	1.138	9.65E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW07	Fixed Ignition Source Fraction Zone: W07	1.136	9.68E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACENG-EDG3-S424	DG System Does Not Continue To Run For 24 Hours	1.132	3.95E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
HPS---------T3LL	HPCS Unavailability due to Test & Maintenance (MRule data)	1.118	1.36E-02	The ability to perform online maintenance in a timely manner (not just in refueling outages) is necessary to maintain high reliability. SAMA candidates CC-01 and CC-02 evaluate the addition of redundant HPCS trains. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FW14	IE Zone: W14	1.117	7.51E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
GTTF	100% Turbine Trip	1.116	1.00E+00	SAMA candidate FR-12R (area T-1C) evaluates the installation of early detection in this fire area where fires damage can lead to a 100% turbine trip. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
RHR----A----T3LL	RHR Train A Out Due to Testing & Maintenance	1.114	7.94E-03	SAMA candidate FR-08 was performed to evaluate improving fire resistance of RHR cables. This would help reduce the likelihood of failure of RHR Train B from fire while RHR Train A is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FT1C	IE Zone: T1C	1.108	7.05E-03	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFT1C	Fixed Ignition Source Fraction Zone: T1C	1.105	9.43E-01	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
RHR----B----T3LL	RHR Train B Out Due to Testing & Maintenance	1.091	7.96E-03	RHR Train B has high reliability as indicated by the basic event importance value. Further improvement in reliability would require hardware changes or an additional shutdown heat removal system. An example is added a heat exchanger to RHR Train C with interconnecting piping similar to RHR Train A and B with a connection to SW Train B. Since the benefit from the RRW value is well below $100K, this basic event will not be considered further. SAMA candidate FR-08 was performed to evaluate improving fire resistance of RHR cables. This would help reduce the likelihood of failure of RHR Train B from fire while RHR Train A is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW14	Fixed Ignition Source Fraction Zone: W14	1.087	9.53E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR1W14	Conditional Probability Fire In SM-7 Switchgear And Large Transformer	1.087	8.08E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW08	Fixed Ignition Source Fraction Zone: W08	1.077	9.50E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW08	IE Zone: W08	1.076	7.02E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW03	IE Zone: W03	1.074	2.73E-04	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
FP-FCP--------LL	Failure Of Fire Control Panel	1.068	9.00E-03	This is the local relay box that the sensors feed. These are being changed out to a more reliable local panel through a multi-year upgrade in the FP program. This is being implemented as part of an existing Appendix R upgrade program. Not a SAMA candidate.
FR1D	IE Zone: R1D	1.06	2.77E-03	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
SW-----A----T3LL	SW Train A Unavailability due to test & maintenance (MRule data)	1.058	4.12E-03	SAMA candidate FR-08 evaluates improving fire resistance of SW cables. This would help reduce the likelihood of failure of SW Train B from fire while SW Train A is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EXF	Early Extinguish Failed (Power Transformer)	1.057	3.60E-01	This requires a DG room fire damper, which is a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
NREAC4-F	Non-Recovery of Diesel in 4 Hours – Fire	1.056	1.00E+00	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional sources of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FR3W08	Conditional Probability Fire in E-SM-8 and 8/85/2	1.054	9.09E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR1J	IE Zone: R1J	1.053	1.11E-02	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
NXF	Transformer Fire Involving Oil	1.051	2.00E-01	This requires a DG room fire damper, which is a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
SW-----B----T3LL	SW Train B Out For Maintenance (MRule Data)	1.048	2.83E-03	SAMA candidate FR-08 evaluates improving fire resistance of SW cables. This would help reduce the likelihood of failure of SW Train A from fire while SW Train B is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1J	Fixed Ignition Source Fraction Zone: R1J	1.047	8.64E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR2W04	Conditional Probability Fire in TR-7A/1, TR-IN3, S1/1D, MC7A	1.046	4.61E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACTRL-S----T3--	Transformer TR-S Out For Maintenance (MRule Data)	1.046	1.46E-03	The ability to perform online maintenance in a timely manner (not just in refueling outages) is necessary to maintain high reliability. SAMA candidates AC/DC-14 and AC/DC-27, which provide additional off-site power options, increase power availability. AC/DC-14 is evaluated in Table A-15. AC/DC-27 is evaluated for cost-benefit. No additional SAMA candidates are required.
EACEDG-2----T3D2	DG-2 Out For Maintenance (MRule Data)	1.046	1.88E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
CIAHUMNX-TIEH3-F	Operator Fails To Properly Lock/Unlock CAS Cross-tie Manual Valves When Required	1.041	1.20E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This basic event was included in SAMA candidate OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPSV-MO----4P2LL	HPCS-V-4 MO Gate Valve NC-FTO	1.04	2.43E-03	Any improvement will require a hardware fix. The worth of this RRW is well below the cost of a hardware modification. Not a SAMA candidate.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
HPSV-MO---12P2LL	HPCS-V-12, Minimum Flow Protection Valve NC-FTO on Demand	1.04	2.43E-03	Any improvement will require a hardware fix. The worth of this RRW is well below the cost of a hardware modification. Not a SAMA candidate.
FW13	IE Zone: W13	1.037	2.48E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACENG-EDG2-S4D2	DG-2 Does Not Continue To Run For 6 Hours	1.036	1.00E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
HS-EAC-TRS	Hot Short Disables TR-S	1.036	3.00E-01	SAMA candidate FR-07b evaluates improving the fire resistance of cables to transformer TR-S. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW13	Fixed Ignition Source Fraction Zone: W13	1.035	8.57E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
ECF	Early Extinguish (Cabinet/electrical panel) Fails	1.035	1.90E-01	SAMA candidates FR-09R, FR-12R, FR-11R and FR-10R evaluate the installation of early detection in fire areas of high risk importance. This detection system is designed to sense fixed ignition sources sooner allowing improved early extinguishment. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1D	Fixed Ignition Source Fraction Zone: R1D	1.034	8.63E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW1A	IE Zone: W1A	1.033	4.44E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
FW02	IE Zone: W02	1.033	3.02E-04	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-CIAV-MO30A	CIA-V-30A Failure Caused By Hot Short	1.033	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches to mitigate hot shorts including CIA-V-30A. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-CIAV-MO30B	CIA-V-30B Failure Caused By Hot Short	1.032	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches to mitigate hot shorts including CIA-V-30B. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
CIAHUMNV104BH3-F	Operator Fails To Open Manual Block Valve CIA-V-104B (Fire)	1.032	2.60E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This basic event was included in SAMA candidate OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-ADS-OPEN	ADS Valve(S) Stuck Open Due To Hot Short	1.032	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches to mitigate hot shorts. HS-ADS-OPEN is not specifically addressed in FR-03, but basic events with higher RRW values are evaluated. This RRW is well below the cost of a hardware modification. No additional SAMA candidates are required.
RC2-A	Conditional Probability Not in Zone RC-2A	1.031	6.80E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
CIAHUMNV104AH3-F	Operator Fails To Open Manual Block Valve CIA-V-104a (Fire)	1.031	2.60E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This basic event was included in SAMA candidate OT-07R. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
DMATE-----32W2LL	Temperature Sensor For DMA Damper 32 Loss Of Function	1.03	1.85E-03	This basic event affects a DG room fire damper. This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
DMATE-----31W2LL	Temperature Sensor For DMA Damper 31 Loss Of Function	1.03	1.85E-03	This basic event affects a DG room fire damper. This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
FR7W14	Conditional Probability Fire in TR-7-71	1.03	1.33E-01	This requires a DG room fire damper, which is a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. No a SAMA candidate.
FR1C	IE Zone: R1C	1.029	2.72E-03	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FP-SENSOR-----LL	Failure of Fire Detection Sensor	1.029	4.00E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
RHRHUMNSYS62H3LL	Failure to Align SPC Early Prior to Loss of RCIC	1.029	1.63E-04	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in OT-07R, this operator action has been identified for increased training. SAMA candidate OT-07R has been evaluated for cost-benefit. No additional SAMA candidates are required.
FR1W04	Conditional Probability Fire In RPSMG, PP7AMG1S0001, TR7A	1.028	2.22E-01	Partitioning factor of fire source (W04). Not a SAMA candidate.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
FR2W07	Conditional Probability Fire Not in Zone RC-2B	1.027	4.27E-01	Partitioning factor of fire source (W07). Not a SAMA candidate.
NTF	Fire Propagation	1.026	4.30E-01	Assumed value (not developed). Not a SAMA candidate.
L2W14	No Propagation to Other Equipment	1.026	1.00E+00	This requires a DG room fire damper, which is a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
FW05	IE Zone: W05	1.024	1.95E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1C	Fixed Ignition Source Fraction Zone: R1C	1.023	8.61E-01	Ratio of fixed source to total source in R1C. Not a SAMA candidate.
EACENG-EDG2-R3D2	DG-2 Does Not Start	1.022	6.36E-03	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
PRAAHUS--1B-S3LL	Fan PRA-FN-1B Does Not Start on Demand	1.021	9.01E-04	Improvements in this fan would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. CGS has procedures in place to open doors and place portable fans in response to loss of HVAC in the SW pump house, which would be performed in this scenario. No additional SAMA candidates are required.
FT1A	IE Zone: T1A	1.021	2.36E-02	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACEDG-1----T3D1	DG-1 Out For Maintenance (MRule Data)	1.021	1.94E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point *Estimate*	Comment/Resolution
SW-P-MDSWP1BS3LB	Failure Of Standby SW Pump Motor To Start On Demand, Mechanical	1.021	8.84E-04	SAMA candidate CW-07 evaluates installing an additional SW pump. This candidate is evaluated for cost-benefit. Any additional improvements to increase pump start reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. It is unlikely that any hardware modification would significantly improve SW pump reliability to start. No additional SAMA candidates are required.
IFW05	Fixed Ignition Source Fraction Zone: W05	1.021	8.18E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
OP-ECCS-SW	Operator response to diagnose lack of SW for manual alignment	1.02	1.00E+00	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in OT-07R, this operator action has been identified for increased training. SAMA candidate OT-07R has been evaluated for cost-benefit. No additional SAMA candidates are required.
F-RHR-MOCSTRT	Conditional Probability of SW Start Cause by RHR Pump Start (MOC Assembly)	1.02	1.00E+00	SAMA candidate CW-07 evaluates installing an additional SW pump. This candidate is evaluated for cost-benefit. Any additional improvements to increase pump start reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. It is unlikely that any hardware modification would significantly improve SW pump reliability to start. No additional SAMA candidates are required.
EACENG-EDG1-S4D1	DG-1 Does Not Continue to Run for 6 Hrs	1.02	1.00E-02	SAMA candidates AC/DC-10 and AC/DC-15 evaluate additional emergency AC power redundant to DG-1. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
FW10	IE Zone: W10	1.02	1.30E-02	SAMA candidate FR-10R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFT1A	Fixed Ignition Source Fraction Zone: T1A	1.019	9.79E-01	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR3W07	Conditional Probability Fire Not in Zone: RC-2C	1.019	5.21E-01	Ratio of certain fixed source to total fixed source in RC07. Not a SAMA candidate.
EACENG-EDG3-R3D3	DG-3 Does Not Start	1.018	6.36E-03	SAMA candidate AC/DC-30R provides an additional diesel diverse for DG-1 and DG-2. SAMA candidate CC-24R evaluates backfeeding the HPCS system (supplied by DG-3) from SM-8 to provide an additional HPCS AC power source. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
PRAAHUS—1A-S3LL	Fan PRA-FN-1A Does Not Start On Demand	1.018	9.01E-04	CGS procedures are in place to open doors and place portable fans in response to loss of HVAC in the SW pump house, which would be performed in this scenario. SAMA candidate HV-03 evaluates enhancing procedures to respond to loss of HVAC. This candidate is already implemented at CGS. No additional SAMA candidates are required.
FP-V-CLAPPERW2LL	Failure of Deluge Valve to Open	1.018	2.49E-03	Auto Suppression – This requires a hardware modification. This RRW is well below the $100K minimum value for the hardware modification. Not a SAMA candidate.
FR1L	IE Zone: R1L	1.018	2.65E-02	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
SW-P-MDSWP1AS3LA	Failure of Standby SW Pump Motor to Start On Demand, Mechanical	1.017	8.84E-04	SAMA candidate CW-07 evaluates installing an additional SW pump. This candidate is evaluated for cost-benefit. Any additional improvements to increase pump start reliability will require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. It is unlikely that any hardware modification would significantly improve SW pump reliability to start. No additional SAMA candidates are required.
HPSV-MO---15P2LL	HPCS-V-15 NC-FTO for CST to Suppression Pool Suction Transfer	1.017	2.43E-03	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
IFR1L	Fixed Ignition Source Fraction Zone: R1L	1.017	9.43E-01	Ratio of fixed source to total source in R1L. Not a SAMA candidate.
PP-1	Probability of SORV in Period from 12-24 Hours	1.017	4.90E-01	SAMA candidate AT-08 provides increased SRV reseat reliability. This candidate has already been implemented at CGS based on the fact that CGS has an extensive SRV testing program that includes testing SRVs at plant startup for both opening and reseating. No additional SAMA candidates are required.
IFW1A	Fixed Ignition Source Fraction Zone: W1A	1.017	8.90E-01	Ratio of fixed source to total source in RC1A. Not a SAMA candidate.
FR6W14	Conditional Probability Fire in TR-7-73	1.017	1.18E-01	Ratio of certain fixed source to total fixed source in RC14. Not a SAMA candidate.
EACEDG-3----T3D3	DG-3 Out For Maintenance (MRule Data)	1.017	1.03E-02	DG-3 has high reliability as indicated by the RRW value provided. Further improvement in reliability requires hardware changes. This RRW is well below the $100K minimum value for a hardware modification. SAMA candidate CC-24R evaluates backfeeding the HPCS (powered by DG-3) from SM-8, thereby providing an additional AC power source to HPCS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPSRMS----S2W2LL	HPCS-RMS-P/1 (E22B-S2) Switch Failure	1.017	1.08E-03	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-11: Level 1 Fire Basic Events Importance List[1]

Event Label	Description	RRW	Point Estimate	Comment/Resolution
RHRP-MD---2AS3LL	RHR-P-2A Motor Driven Pump Fails to Start	1.016	8.84E-04	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
IGCCW10	Fire Starts in Critical Cabinet	1.016	1.54E-01	Ratio of critical cabinets to total cabinets in the Control Room. Not a SAMA candidate.
LTS5W14	TR-7-71 Oil Fire Spreads to TR-S	1.015	5.00E-01	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
RHRP-MD---2BS3LL	RHR-P-2B Motor Driven Pump Fails to Start	1.015	8.84E-04	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

[1] In Reference 3, the response to RAI 5.d provided a similar table of basic events important to the FPSA; the basic events were first sorted on RAW then on RRW. For Table A-11, the sorting was purely by RRW.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
EFF	Early-Extinguish (Fixed Ignition Source) Fails	4.229	3.60E-01	Split Fraction factor (not developed). Not a SAMA candidate.
L2-PHE-GVPHONAGA	Containment Inerted Vent/Purge Not Required	3.6	9.90E-01	This is a success term. Not a SAMA candidate.
L2-PHE-O2-INTRO-	Operation Deinerted or O2 Introduced	1.858	1.00E-02	SAMA candidate CP-18 evaluates post accident containment inerting capability. This candidate is evaluated in Table A-16. No additional SAMA candidates are required.
L2-PHE-H-DEFL-GL	Hydrogen Deflagration Occurs Globally	1.858	1.00E+00	Phenomenological Value (Assumed). Not a SAMA candidate.
L2-PHE-CONT-NOSI	Containment Not Steam Inerted	1.858	5.00E-01	Phenomenological Value (assumed 0.5). Not a SAMA candidate.
L2-HUMN-RCVR-SYS	Recovery of System Fails	1.732	9.00E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA candidate OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
GTFF50	50% Loss Of FW Trip	1.69	5.00E-01	SAMA candidates FR-09R (area R-1D) and FR-11R (area RC-04) evaluate the installation of early detection in fire areas where fires damage can lead to a 50% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHESM-PRXST-F	Pre-existing Failure	1.292	2.70E-01	This basic event conservatively represents a large leak in a pressurized water reactor hatch. Containment hatches are tested at CGS prior to restart to insure no latent large leak exists. In addition, O2 monitoring while the containment is inerted will reveal any significant leak in the containment. Large pre-existing containment leaks in inerted containments are considered very unlikely because of likely detection. Not a SAMA candidate.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
L2-PHE-HPST-NFAL	High Primary System Temperature Does Not Cause Failure	1.236	8.00E-01	Success term. Not a SAMA candidate.
L2-PHE-MSIV-S-L2	MSIVs or Steam Line Unavailable in Level 2	1.236	1.00E+00	Phenomenological Value (Assumed 1.0). Not a SAMA candidate.
L2-PHE-SRV-NOPEN	SRVs Do Not Stick Open	1.236	8.00E-01	SAMA candidate AT-08 evaluates improving SRV reseat reliability. This candidate has already been implemented at CGS. No additional SAMA candidates are required.
L2-PHE-WHDNCF-MS	Water Hammer Does Not Cause Failure of Mechanical System	1.236	7.00E-01	Success term. Not a SAMA candidate.
L2-PHE-HP-BLW-VS	High Pressure Blowdown Overwhelms Vapor Suppression	1.219	1.00E-01	Phenomenological Value (Vapor Suppression Failure assumed value 0.1). Not a SAMA candidate.
GTFF10	10% Loss Of FW Trip	1.211	1.00E-01	SAMA candidates FR-09R (areas R-1B, R-1J) and FR-11R (areas RC-1A, RC-13) evaluate the installation of early detection in fire areas where fires damage can lead to a 10% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
ETF	Early-Extinguish (Transient Ignition Source) Fails	1.201	2.40E-01	SAMA candidates FR-09R, FR-12R, FR-11R, and FR-10R evaluate the installation of early detection in fire areas of high risk importance. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FR1D	IE Zone: R1D	1.188	2.77E-03	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPS---------T3LL	HPCS unavailability due to test & maintenance (MRule data)	1.187	1.36E-02	SAMA candidates CC-01 and CC-02 evaluate the additions of redundant HPCS trains. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
EACENG-EDG3-SFR-11R (42)4	DG System Does Not Continue To Run For 24 hrs	1.172	3.95E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FW04	IE Zone: W04	1.16	1.02E-02	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW04	Fixed Ignition Source Fraction Zone: W04	1.159	9.65E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
GTTF	100% Turbine Trip	1.153	1.00E+00	SAMA candidate FR-12R (T-1C) evaluates the installation of early detection in this fire area where fire damage can lead to a 100% turbine trip. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FT1C	IE Zone: T1C	1.153	7.05E-03	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFT1C	Fixed Ignition Source Fraction Zone: T1C	1.149	9.43E-01	SAMA candidate FR-12R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
CIAHUMNX-TIEH3-F	Operator Fails To Properly Lock/Unlock CAS Cross-tie Manual Valves When Required	1.141	1.20E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1D	Fixed Ignition Source Fraction Zone: R1D	1.139	8.63E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
GTFF	100% Loss Of FW Trip	1.132	1.00E+00	SAMA candidates FR-12R (T-1D) and FR-11R (RC-02, RC-03, RC-08) evaluate the installation of early detection in fire areas where fires damage can lead to a 100% loss of FW. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FR1C	IE Zone: R1C	1.12	2.72E-03	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR1J	IE Zone: R1J	1.117	1.11E-02	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-CIAV-MO30A	CIA-V-30A Failure Caused By Hot Short	1.108	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches to mitigate hot shorts including CIA-V-30A. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
CIAHUMNV104BH3-F	Operator Fails To Open Manual Block Valve CIA-V-104B (Fire)	1.108	2.60E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1J	Fixed Ignition Source Fraction Zone: R1J	1.106	8.64E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
GTTF50	50% Turbine Trip	1.106	5.00E-01	SAMA candidates FR-11R (RC-07) and FR-12R (T-1A) evaluate the installation of early detection in this fire area where fire damage can lead to a 50% turbine trip. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
CIAHUMNV104AH3-F	Operator Fails To Open Manual Block Valve CIA-V-104A (Fire)	1.105	2.60E-01	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-CIAV-MO30B	CIA-V-30B Failure Caused By Hot Short	1.105	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches to mitigate hot shorts including CIA-V-30B. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2-HUMN-OPTM-RPV	Operator Fails to Depressurize in Level 2 (Conditional)	1.104	5.20E-02	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW07	IE Zone: W07	1.101	1.10E-02	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW07	Fixed Ignition Source Fraction Zone: W07	1.1	9.68E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
SW-----B----T3LL	SW Train B Out For Maintenance (Mrule Data)	1.097	2.83E-03	SAMA candidate FR-08 evaluates improving fire resistance of SW cables. This would help reduce the likelihood of failure of SW Train B from fire while SW Train A is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFR1C	Fixed Ignition Source Fraction Zone: R1C	1.093	8.61E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
EACTRL-S----T3--	Transformer TR-S Out For Maintenance (MRule Data)	1.086	1.46E-03	SAMA candidates AC/DC-14 and AC/DC-27, which provide additional off-site power options, increase power availability. AC/DC-14 is evaluated in Table A-15. AC/DC-27 was evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-CNTRODMLT	Control Rods Melt Prior to Fuel Rods	1.065	1.00E+00	Phenomenological Value (Assumed 1.0). Not a SAMA candidate.
L2-PHE-RDINTGFLD	Fuel Rod Integrity is Maintained During Reflood	1.065	1.00E-01	Phenomenological Value (Assumed 1.0). Not a SAMA candidate.
L2-HUMN-RINJ-RDM	Operator Restores Injection After Control Rods Melt	1.065	1.00E+00	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR2W04	Conditional Probability Fire In TR-7A/1, TR-IN3, S1/1D, MC7A	1.057	4.61E-01	Fraction of Fixed Source in Reactor Building 467'. Not a SAMA candidate.
FW14	IE Zone: W14	1.056	7.51E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FW03	IE Zone: W03	1.054	2.73E-04	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
SW-----A----T3LL	SW-A Unavailability From Testing and Maintenance (MRule Data)	1.05	4.12E-03	SAMA candidate FR-08 evaluates improving fire resistance of SW cables. This will help reduce the likelihood of failure of SW Train B from fire while SW Train A is OOS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FP-FCP--------LL	Failure Of Fire Control Panel	1.048	9.00E-03	This is the local relay box that the sensors feed. These are being changed out to a more reliable local panel through a multi-year upgrade in the FP program. Not a SAMA candidate.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
IFW14	Fixed Ignition Source Fraction Zone: W14	1.045	9.53E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
FR1W14	Conditional Probability Fire In SM-7 switchgear and Large transformer	1.045	8.08E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
NO-OFFSITE-RECOV	No Recovery Of Offsite Power (Fire)	1.044	1.00E+00	This is a conservative assumption of no offsite power recovery for the fire model. SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
L2-PHE-AC-RX-FS-	Failure to Recover AC Prior to Vessel Fail (Fire or Seismic)	1.043	1.00E+00	Phenomenological Value (new model). Not a SAMA candidate.
GV-FAIL	Guaranteed Combustible Gas Vent Not Available	1.043	1.00E+00	This basic event is used to meet modeling purpose (always 1.0). Defines support system failure states that prohibit vent operation. Not a SAMA candidate.
FR1R1J	Conditional Probability In MC-8B, 7B, IR72 PP7BC, FC11, TR7BC	1.043	3.55E-01	Partitioning Factor of Fixed Source in Reactor Building 471' (R1J). Not a SAMA candidate.
FR1B	IE Zone: R1B	1.042	1.17E-03	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACEDG-123FRC3LL	CCF Of All 3 DG Fail To Run	1.038	5.43E-05	SAMA candidate AC/DC-28 evaluates reducing CCF between DG-3 and DG-1/2. SAMA candidates AC/DC-10, AC/DC-29 and AC/DC-30R evaluate adding diverse diesels. SAMA candidate AC/DC-15 evaluates adding a gas turbine. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
L2-HUMN--INJ-SLC	Operator Fails to Inject SLC with Boron for Low Water Level	1.037	5.80E-03	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
PRAAHUS--1B-S3LL	Fan PRA-FN-1B Does Not Start On Demand	1.036	9.01E-04	Improvements in this fan require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. CGS procedures are in place to open doors and place portable fans in response to loss of HVAC in the SW pump house, which would be performed in this scenario. No additional SAMA candidates are required.
HS-CIAV-MO20	CIA-MO-20 Failure Caused By Hot Short	1.036	3.00E-01	SAMA candidate FR-03 evaluates installing additional transfer and isolation switches for CIA-MO-20 to mitigate any resulting hot shorts. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
SW-P-MDSWP1BS3LB	Failure Of SW Pump Motor To Start On Demand, Mechanical	1.036	8.84E-04	This term comes from Internal Events PSA and represents the SW-B Pump Motor not started on demand. Additional improvement requires a hardware modification. The RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
EACEDG-2----T3D2	DG-2 Out For Maintenance (MRule Data)	1.034	1.88E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
EACENG-EDG2-S4D2	DG-2 Does Not Continue To Run For 6 Hours	1.034	1.00E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point *Estimate*	Comment/Resolution
DEP-ADS-SLC	Operator Fails To Initiate ADS And SLC On Low RPV Water Level	1.033	2.60E-05	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L2R1D	No Propagation To Other Equipment	1.033	5.09E-01	Partitioning Factor of Fixed Source in Reactor Building 471' (R1D). Not a SAMA candidate.
L2-PHE-XVESS-EXP	Ex-Vessel Steam Explosion	1.033	1.00E-03	Phenomenological Value (Assumed 1E-3). Not a SAMA candidate.
IFR1B	Fixed Ignition Source Fraction Zone: R1B	1.032	6.76E-01	SAMA candidate FR-09R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-ADS-OPEN	ADS Valve(s) Stuck Open Due To Hot Short	1.031	3.00E-01	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
FR1W04	Conditional Probability Fire In RPSMG, PP7AMG1S0001, TR7A	1.031	2.22E-01	Partitioning Factor of Fixed Source (W04). Not a SAMA candidate.
HPSV-MO----4P2LL	HPCS-V-4 Motor Operated Gate Valve NC-FTO	1.03	2.43E-03	Any improvement requires a hardware fix. The worth of this RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate
HPSV-MO---12P2LL	HPCS-V-12, Minimum Flow Protection Valve NC-FTO on Demand	1.03	2.43E-03	Any improvement requires a hardware fix. The worth of this RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate
ECF	Early extinguish (Cabinet/electrical panel) Fails	1.028	1.90E-01	Any improvement requires a hardware fix. The worth of this RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate
FR3R1D	Conditional Probability I\in E-IR-62 MS-FN-1, H22-P009	1.027	5.69E-01	Partitioning Factor of Fixed Source in Reactor Building 471' (R1D). Not a SAMA candidate.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
EACEDG-3----T3D3	DG-3 Out For Maintenance (MRule Data)	1.026	1.03E-02	SAMA candidate CC-24R evaluates backfeeding the HPCS (powered by DG-3) from SM-8, thereby providing an additional AC power source to HPCS. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HS-RHRV-MO-27A	RHR-V-27A Failure Caused By Hot Short	1.026	3.00E-01	This requires a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
HS-RHRV-MO-17B	RHR-V-17B Failure Caused By Hot Short	1.024	3.00E-01	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
HS-RHRV-MO-16B	RHR-V-16B Failure Caused By Hot Short	1.024	3.00E-01	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
EACENG-EDG3-R3D3	DG-3 Does Not Start	1.024	6.36E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
L2-PHE-ISLOCA-F-	ISLOCA During Core Melt Progression	1.023	4.00E-04	Phenomenological Value. Not a SAMA candidate.
FW05	IE Zone: W05	1.023	1.95E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
L3R1C	No Propagation to Other Equipment	1.023	7.64E-01	Ratio of certain equipment in R1C. Not a SAMA candidate.
FW02	IE Zone: W02	1.022	3.02E-04	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
IFW05	Fixed Ignition Source Fraction Zone: W05	1.022	8.18E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
DMATE-----32W2LL	Temperature Sensor For DMA Damper 32 Loss Of Function	1.021	1.85E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
DMATE-----31W2LL	Temperature Sensor For DMA Damper 31 Loss Of Function	1.021	1.85E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
IFW08	Fixed Ignition Source Fraction Zone: W08	1.021	9.50E-01	Ratio of Fixed Source to Total Source in W08. Not a SAMA candidate
FW08	IE Zone: W08	1.02	7.02E-03	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EACEDG-1----T3D1	DG-1 Out For Maintenance (MRule Data)	1.02	1.94E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
EACENG-EDG1-S4D1	DG-1 Does Not Continue To Run For 6 Hrs	1.02	1.00E-02	SAMA candidates AC/DC-10, AC/DC-15, AC/DC-28, AC/DC-29 and AC/DC-30R evaluate additional emergency AC power or the reliability of emergency AC power. These candidates are evaluated for cost-benefit. No additional SAMA candidates are required.
FP-SENSOR-----LL	Failure Of Fire Detection Sensor	1.019	4.00E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
RC2-A	Conditional Probability Not in Zone RC-2A	1.019	6.80E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
EXF	Early Extinguish Failed (Power Transformer)	1.019	3.60E-01	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
EACENG-EDG2-R3D2	DG-2 Does Not Start	1.019	6.36E-03	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
FR3W08	Conditional Probability Fire in E-SM-8 and 8/85/2	1.018	9.09E-01	SAMA candidate FR-11R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

Table A-12: Level 2 Fire Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
DEP-ADS-HPCS	Operator Fails To Initiate ADS and HPCS	1.017	2.50E-05	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
NXF	Transformer Fire Involving Oil	1.017	2.00E-01	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
EACEDG-123FSC3LL	CCF Of All 3 DG Fail To Start	1.016	2.32E-05	This would require a hardware modification. This RRW is well below the $100K minimum value for a hardware modification. Not a SAMA candidate.
FW10	IE Zone: W10	1.015	1.30E-02	SAMA candidate FR-10R evaluates the installation of early detection in this fire area. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.
HPS-CTL-COND----	HPCS Control Required	1.015	5.00E-02	SAMA candidate OT-07R evaluates improving procedures and operator training on systems and operator actions determined to be important from PSA results. Although this basic event was not included in SAMA case OT-07R, this operator action has been identified for increased training. This candidate is evaluated for cost-benefit. No additional SAMA candidates are required.

[1] RRW values are based on LERF.

Table A-13: Level 1 Seismic Basic Events Importance List

Event Label	Description	RRW	Point Estimate	Comment/Resolution
SEIS-MITGTN-FAIL	No mitigation for seismic failure of RPV and/or Category I buildings	1.966	1.00E+00	Used to meet modeling purpose (always 1.0). Seismic failure of the RPV and key buildings is conservatively modeled as leading to core damage. See Basic Event SDS42 for applicable failures. Not a SAMA candidate.
SDS42	Failure of RPV and/or Category I buildings	1.960	2.38E-06	SAMA CP-21 - Strengthen containment would increase the seismic capability. CP-21 is evaluated in Table A-15. No additional SAMA candidates are required.
SDS41	Failure of SSEL equipment	1.509	1.64E-06	This should focus on improving SSEL seismic capability. Any improvement would require multiple hardware modifications such as replacing or strengthening components. This RRW is well below the cost of multiple hardware modifications that would be required. Not a SAMA candidate.
SEIS-LONGTERM	Probability of short-term core damage sequence for failure of SSEL equipment versus long-term core damage sequence	1.203	5.00E-01	Used to meet modeling purpose. Defines the probability of short-term versus long-term core damage sequences. See Basic Event SDS41 for applicable sequences. Not a SAMA candidate

Table A-14: Level 2 Seismic Basic Events Importance List

Event Label	Description	RRW[1]	Point Estimate	Comment/Resolution
SEIS-MITGTN-FAIL	No mitigation for seismic failure of RPV and/or Category I buildings	34.513	1.00E+00	Used to meet modeling purpose (always 1.0). Seismic failure of the RPV and key buildings is conservatively modeled as leading to core damage. See basic event SDS42 for applicable failures. Not a SAMA candidate
SDS42	Failure of RPV and/or Category I buildings	32.374	2.38E-06	SAMA candidate CP-21, which strengthens containment, increases the seismic capability. This candidate is evaluated in Table A-15. No additional SAMA candidates are required.
SEIS-CONT-BYP	Split fraction of seismic structure failures that bypass containment	22.651	7.50E-01	Used to meet modeling purpose. Defines the split fraction of seismic structure failures that bypass containment. See basic event SDS42 for applicable failures. Not a SAMA candidate.
L2-PHE-WHDNCF-MS	Water hammer does not cause failure of mechanical system	1.033	7.00E-01	Success term. Not a SAMA candidate.
L2-PHE-HPST-NFAL	High primary system temperature does not cause failure	1.033	8.00E-01	Success term. Not a SAMA candidate.
L2-PHE-SRV-NOPEN	SRVs do not stick open	1.033	8.00E-01	Success term. Not a SAMA candidate.

[1] RRW values are based on LERF.

Table A-15: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION D "EXCESSIVE IMPLEMENTATION COST")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
AC/DC-14	Install an additional buried offsite power source	D	The cost of implementing a similar SAMA candidate at Arkansas Nuclear One Unit 2 was estimated by Entergy Operations to require more than $25,000,000 in 2005. The cost associated with the implementation of this SAMA exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
AC/DC-26	Bury off-site power lines.	D	To realize a significant benefit from this SAMA candidate, the length of power lines buried must be significant. The cost of implementing a similar SAMA candidate at Arkansas Nuclear One Unit 2 was estimated by Entergy Operations to require more than $25,000,000 in 2005. The cost associated with the implementation of this SAMA exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
AT-10	Install an ATWS sized filtered containment vent to remove decay heat.	D	The conceptual design of an ATWS-sized cooling vent would require establishing a sufficiently-sized Class 1 hard pipe vent from the wetwell to a very large gravel containment tank with heat dissipation capability, filtered vents and processing drains. Current penetrations would not be suitable. Conversion of the wetwell equipment hatch would be required to provide dual function of venting and outage access. The hard piping out of the wetwell hatch and to a suitable structure outside of the reactor building would require penetration of the reactor building and strengthening of the building support system to a large gravel/tank located south of the building (only area available). Underground drainage would be required of Class 1 fill soils. Modification of security features would be necessary. Design, NRC approval of the design, material, installation, and revision of procedures and security and emergency plans would be required. A CGS cost estimate for this SAMA candidate is greater than $12,000,000. The cost associated with the implementation of this SAMA exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-15: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION D "EXCESSIVE IMPLEMENTATION COST")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CB-06	Locate RHR inside containment	A	It is unlikely that a single RHR train could be placed within a Mark II primary containment. To locate all low pressure ECCS trains within containment to avoid ISLOCA events would not be possible. Therefore, the screening criterion for this SAMA candidate is changed to A – Not Applicable. This SAMA candidate is not considered for further evaluation.
CB-07	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	E	SAMA candidate CB-01 evaluated the complete elimination of the ISLOCA scenarios and yielded a Phase 2 cost-benefit of approximately $46,800 (including uncertainty). This is less than the cost of a small design change at CGS ($100,000). Therefore, the screening criterion for this SAMA candidate is changed to E – Very Low Benefit. This SAMA candidate is not considered for further evaluation.
CP-06	Install a passive drywell spray system.	D	A completely passive drywell spray system is not possible; however a design that uses the containment vacuum breaker concept in reverse with a pressurized water tank of sufficient volume is conceptualized for cost implementation for this SAMA candidate. The existing drywell vent system or the drywell spray piping from RHR would be modified to allow an interfacing pre-charged water supply. The water volume would need to be sufficient to spray the drywell over a reasonably long period of time. Additionally, the head pressure would need to be able to overcome the maximum drywell pressure up to the containment limit. A large water tank at an elevation 300-400 feet above the drywell would be required. Tower construction is unlikely due the height required. The nearest natural elevation is an elevated bluff across the Columbia River approximately 4 miles from the site. A CGS cost estimate for this SAMA candidate is greater than $15,000,000. The cost of implementing a similar SAMA candidate at Vermont Yankee was estimated by Entergy Nuclear to require more than $5,800,000 in 2007. Assuming a 2% interest rate, the cost to implement would be $6,150,000 in 2010 dollars. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-15: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION D "EXCESSIVE IMPLEMENTATION COST")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-12	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	D	The conceptual design would be similar to AT-10 with the addition of a tank capable of sustaining an internal pressure similar to the containment maximum pressures. This is required to serve as an expansion tank prior to release through a passive filtered means. It is assumed that the release has been scrubbed by the wetwell prior to this SAMA candidate final filtering through either Option 1 or 2. The cost would be similar to AT-10 except that the tank size would be smaller reducing its estimated cost. A CGS cost estimate for this SAMA candidate is approximately $11,000,000. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
CP-13	Enhance FP system and SGT system hardware and procedures	D	Although the CGS Reactor Building design is such that the roof serves as a relief point, the pressure spike from a large ruptured containment could challenge the ability to maintain the integrity of the upper Reactor Building walls. Strengthening the walls could be necessary to have measurable effectiveness of a FP spray or an enhanced SGT system. A SAMA case was performed in which the node for mitigation failure of a release to the Reactor Building was set to 1.0E-02. The resulting RRW was 1.000 as there is no CDF benefit for this type of SAMA candidate. Reductions in release categories form the bases for the benefits. Estimated Phase 2 benefit from Cooper and Vermont Yankee yielded moderate benefits from approximately to $141,000 to $942,000 and from $1,410,000 to $2,026,000 when the 95th percentile for uncertainty is applied. The benefit results for CGS are expected to be within the range of Cooper's and Vermont Yankee's calculated cost-benefit. The estimated cost for implementing this SAMA was estimated by CGS to be much greater than $21,000,000 based on the cost for replacing the siding on the CGS Reactor Building in 2009. Therefore, this SAMA candidate is not considered for further evaluation.
CP-19	Create a large concrete crucible with heat removal potential to contain molten core debris.	D	The cost of implementing a similar SAMA candidate at Vermont Yankee was estimated by Entergy Nuclear to require more than $100,000,000 in 2007. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-15: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION D "EXCESSIVE IMPLEMENTATION COST")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-20	Create a core melt source reduction system.	D	This SAMA candidate is similar to SAMA candidate CP-06 to install a passive drywell spray system except that a larger volume of water would be necessary to achieve containment flood-up and core melt debris mitigation quickly upon detection of vessel reaching its breaching point. The cost for CP-20 would be amplified by a larger passive flooding system of similar but larger volume design. The flooding design would most likely use a lower drywell vent path to introduce the water directly to the lower portion of the drywell. This design would require consideration of steam explosion potential and the potential use of alternate fluid. A CGS estimate for this SAMA candidate is approximately $24,000,000 based on scaling up the cost estimate for CP-06. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
CP-21	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	D	The cost of implementing a similar SAMA candidate at Vermont Yankee was estimated by Entergy Nuclear to require more than $12,000,000 in 2007. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
CP-22	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	D	Increasing the depth of the containment base mat is a difficult engineering feat for an operating plant. The concept would be to tunnel under existing buildings (DG Building and pump room areas of the Reactor Building and into the area directly underneath the suppression pool) and excavate in sections. The placement of rebar and concrete would be similar to that for underground weapons defense sites or fuel storage project like Yucca Mountain. Recomposing the Class 1 soil would be required upon tunnel excavating. A CGS cost estimate for this SAMA candidate is approximately $35,000,000. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-15: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION D "EXCESSIVE IMPLEMENTATION COST")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-23	Provide a reactor vessel exterior cooling system.	D	This SAMA candidate is similar in design concept to CP-20 in that it assumes the ability to submerge the bottom of the reactor vessel head with cool water to prevent a vessel breach that potentially could expel molten core. Likewise its implementation costs would be similar, but the total volume of water injection could be less. Scaling down the cost estimated of CP-20 results in an estimated cost of approximately $17,000,000 for this SAMA candidate. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
CP-24	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	D	The free volume space in the secondary containment is approximately 3.5E06 cubic feet. Constructing a building of this size would be space and cost prohibitive at CGS. However, it would be possible to design a building or large tank that could maintain 1" vacuum or more of negative pressure similar to the condenser. A structure the size and capability of the condenser hotwell, which is maintained at 1 inch or more negative pressure by mechanical air ejectors backed by a 480 VAC commercial diesel, and connecting pipe from the Reactor Building is estimated to cost approximately $11,000,000. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.
CP-29	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	D	Significant modifications to the primary containment, if possible, are considered prohibitively expensive. The design would require adding ribbing to the containment shell and a material barrier with characteristics sufficient to withstand the molten debris. The cost of this SAMA candidate at Quad Cities was estimated to be $12,000,000. The cost associated with the implementation of this SAMA candidate exceeds the maximum attainable uncertainty benefit. Therefore, this SAMA candidate is not considered for further evaluation.

[1] The attainable uncertainty benefit for all SAMA candidates is derived from the uncertainty factor comprised from the ratio of the 95th percentile to the mean point estimate of the baseline Integrated PSA Model Rev. 7.1 for the Internal Events, Fire, and Seismic hazards. Additionally, the Internal Events maximum uncertainty benefit value is added to the RRW benefit value to conservatively account for other external events benefit.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
AC/DC-05	Provide DC bus cross-ties	E	With the ability to provide alternate power to DC buses from DG-3 or DG-4, this SAMA candidate provides little risk reduction. The CDF and LERF RRW values associated with making the cross-ties between divisional DC power sources always available are 1.021 and 1.0002, respectively (affects all hazards, but primarily Fire), and the estimated uncertainty benefit based on RRW is approximately $180,000. This benefit represents two cross-ties: one between Division 1 and 2 and the other between Division 1 or 2 to Division 3. Note: Division 3 is not of sufficient size to backfeed Division 1 or 2 loads. The individual cross-tie benefit would be about one half of the estimated benefit for this SAMA candidate, which is below the cost for a small design change at CGS ($100,000). Therefore, this SAMA candidate is not considered for further evaluation.
AC/DC-06	Provide additional DC power to the 120/240V vital AC system	E	120/240V AC is not risk significant at CGS. The CDF and LERF RRW values associated with making the buses perfect are 1.002 and 1.000, respectively (affects primarily Fire). The estimated uncertainty benefit based on RRW is less than $15,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is determined to have a very low benefit and is not considered for further evaluation.
AC/DC-08	Increase training on a response to a loss of two 120V AC buses that cause inadvertent actuation signals	E	120/240V AC is not risk significant at CGS. The estimated uncertainty benefit based on RRW associated with AC/DC-06 provides a very small benefit when making the120V AC sources perfect. Abnormal procedures currently exist at CGS for loss of 120V AC, which contain detailed information on lost indication and specific restoration actions. The operators receive periodic operator training on these procedures. Improving operator response associated with the loss of a 120V AC bus would not be likely to yield a SAMA candidate with real benefit. Therefore, this SAMA candidate is determined to have a very low benefit and will not be considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
AC/DC-21	Use fire water system as a backup source for diesel cooling	E	The DG cooling water source is SW. This SAMA candidate only addresses loss of SW to the DG and not to other equipment (since this SAMA candidate is attempting to increase DG availability.) The CDF and LERF RRW values associated with doubling the DG cooling reliability are 1.005 and 1.000, respectively (affects primarily Fire). The estimated uncertainty benefit based on RRW is less than $70,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
AC/DC-22	Add a new backup source of diesel cooling	E	This SAMA candidate is similar in intent to AC/DC-21. The RRW associated with doubling the DG cooling reliability calculated for AC/DC-21 also applies to this SAMA candidate, and the estimated uncertainty benefit is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
AT-04	Increase boron concentration in the SLC system	B	A change to the CGS Technical Specifications has been submitted to the NRC for increasing the SLC boron concentration (i.e., use of boron enriched in the isotope B-10). This TS change achieves the intent of this SAMA candidate. Therefore, the screening criterion for this SAMA candidate is changed to Criterion B – Already Implemented.
CB-02	Add redundant and diverse limit switches on each CIV	E	Isolation at CGS is considered quite reliable. CGS CIVs that only provide a containment isolation function (V-Sequence related) are air-operated. The CDF and LERF RRW values associated with eliminating containment isolation failures (except pre-existing and flooding) and reducing ISLOCA failures by one half are 1.002 and 1.018, respectively (primarily Internal Events LERF), and the estimated uncertainty benefit based on RRW is approximately $260,000. The uncertainty benefit for one MS line penetration improvement (modification of two MSIVs) would be approximately $65,000, which is below the cost of a small design change. If the benefit is further reduced to a per-valve basis for the other CIVs, this SAMA candidate is of very low benefit. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CB-05	Install self-actuating CIVs	E	Containment isolation at CGS is considered very reliable. CGS CIVs that are normally open and have a containment isolation function are air-operated and are self-actuating. The estimated uncertainty benefit based on RRW that was calculated for SAMA candidate CB-02 ($260,000) also applies to this SAMA candidate. The modification of the ECCS, RWCI and RCC penetration pathways involve seven lines and the conversion of fourteen MOVs. (The MS lines and containment atmosphere lines have air-operated self-actuating CIVs.) The estimated uncertainty benefit based on RRW of each line would be approximately $35,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
CC-08	Modify ADS components to improve reliability	E	The ADS at CGS is very reliable and not risk significant. The CDF and LERF RRW values associated with doubling the ADS valves' reliability are calculated to both be 1.000, indicating no risk improvement, and the estimated uncertainty benefit is well below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
CC-09	Add signals to open SRVs automatically in an MSIV closure transient	E	For an MSIV closure event, one or more SRVs may open briefly. Opening of SRVs is very reliable and not a significant contributor to risk. The CDF and LERF RRW values associated with making the SRV pressure relief function perfect are 1.0041 and 1.000, respectively (affects Internal Events only), and the estimated uncertainty benefit based on RRW is less than $10,000, which is well below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CC-12	Add a diverse low pressure injection system	D	CGS has significant redundancy of low pressure systems; thus these systems have low to moderate risk significance. The CDF and LERF RRW values associated with reducing the unavailability of the low pressure ECCS injection function by 3 orders of magnitude are 1.046 and 1.007, respectively (affects Internal Events and Fire), and the estimated uncertainty benefit based on RRW is approximately $1,000,000. The implementation cost for this SAMA was evaluated by Vermont Yankee to be greater than $3,900,000. With the significant difference in estimated RRW uncertainty benefit and the implementation cost, the screening criterion for this SAMA candidate is changed to D – Excessive Implementation Cost. This SAMA candidate is not considered for further evaluation.
CC-13	Increase flowrate of suppression pool cooling	E	The increase in flowrate for CGS adds little benefit. Cooling is provided by RHR Trains A and B. Once SPC is activated, additional cooling will not provide additional mitigating benefit. Significant time currently exists for this operator action. However, a potential benefit to ATWS sequences is to provide additional operator time to place SLC in service. The CDF and LERF RRW values associated with making the operator action perfect for initiating SLC during an MSIV closure ATWS are 1.001 and 1.007, respectively. The estimated uncertainty benefit based on RRW is approximately $110,000. Modification of both RHR Trains A and B pump impellers, increasing the horsepower of the pump motors and redesigning the distribution system would be required to achieve this benefit. The estimated uncertainty benefit based on RRW for each RHR train is approximately $55,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CC-15	Provide capability for alternate injection via RWCU	E	RWCU has no source of water other than the RPV. It receives cooling from TSW. Therefore, if other sources of injection are unavailable, it is likely that RCWU will also be unavailable. The CDF and LERF RRW values associated with making an alternate injection system more reliable by a factor of 2 are 1.006 and 1.000, respectively (affects primarily Internal Events). The estimated uncertainty benefit based on RRW is approximately $40,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
CC-23	Replace two of the four electric safety injection pumps with diesel-powered pumps	D	CGS has ample diversity of coolant injection systems that have multiple offsite power supplies and are backed up by independent diesels. The modeling approach for SAMA candidate CC-12, reducing the unavailability of low pressure ECCS injection, bounds this SAMA candidate. SAMA candidate CC-23 adds diversity to the existing injection systems. However the improvement in CCF provided by this SAMA candidate would not reach the improvement of an additional coolant injection system proposed by SAMA candidate CC-12. Additionally, diesel-driven injection pumps most likely will require a separate building and piping to the reactor since the pump rooms at CGS are not compatible with diesel-driven pumps which could introduce additional fire risks that offset improvement in diversity. The implementation cost exceeds the implementation costs of SAMA candidate CC-12 since separate structures would be required for divisional separation. With the significant difference in estimated RRW uncertainty benefit and the implementation cost of SAMA candidate CC-12, an even larger difference would occur with this SAMA candidate. Therefore, the screening criterion for this SAMA candidate is changed to D – Excessive Implementation Cost. This SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-04	Enable flooding of the drywell head seal	D	For containment overpressure or over-temperature, failure at four locations is considered credible for scenarios that do not result in effective pool or spray scrubbing. Three of the locations: 1) upper cylinder-cone junction, 2) equipment hatch, and 3) wetwell above the water line are all considered the most likely failure points with equal probability. The drywell head, although possible, is considered less likely. The RRW associated with loss of injection caused by containment failure was reduced to zero to assess this SAMA candidate's benefit. This modeling is very conservative in that loss of injection is primarily driven by failure sites much lower in the containment that would not be improved by this SAMA candidate. The calculated CDF and LERF RRW values are both 1.126 (affects all hazards), and the estimated uncertainty benefit based on RRW is approximately $500,000. A cost-benefit analysis performed by Vermont Yankee produced a much lower benefit through a Phase 2 analysis which also included the uncertainty factor. Vermont Yankee reported a cost for implementation of greater than $1,000,000. Similar results would occur for CGS, and this SAMA would not be cost-beneficial. Therefore, the screening criterion for this SAMA candidate is changed to D – Excessive Implementation Cost. This SAMA candidate is not considered for further evaluation.
CP-08	Enhance procedures to refill CST from demineralized water or SW system	E	CST level is a Technical Specification parameter that requires action to refill the CST within a limited time period. The SAMA candidate assumes that sufficient volume is not available and that a refill would provide additional volume for injection. Only HPCS and RCIC take suction from the CST for accident mitigation purposes. Therefore, this SAMA candidate would only support sequences that require high pressure injection (i.e. loss of depressurization capability). Additionally, CGS has two full capacity CSTs and additional make-up would not add significant risk improvement. The model was modified to provide an unavailability of one CST at 1.0E-04 assuming that sufficient inventory was not available and one CST would be required to be refilled to support high pressure injection risk mitigation. The CDF and LERF RRW values associated with this condition are 1.001 and 1.000, respectively (Internal Events). The estimated uncertainty benefit based on RRW is below $1000, which is well below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-09	Enhance procedures to maintain ECCS suction on CST as long as possible	B	RCIC and HPCS are the only ECCS pumps that can take suction from the CST. Specific guidance is included in operating procedures for both RCIC and HPCS to avoid low water level conditions in CST or suppression pool lineups to avoid conditions that potentially could result in loss of NPSH. During events when containment venting is necessary, the suppression pool level will lower, resulting in lower NPSH for the HPCS and RCIC pumps. However, the level does not lower enough to cause the pumps to lose NPSH within the pumps' 24-hour mission time. Vortex limits, in terms of suppression pool level, are clearly indicated in procedures. The vortex limits are low relative to normal suppression pool level (5.5' and 17.5', respectively, for HPCS and RCIC relative to the ~30' normal level). Therefore, the screening criteria of this SAMA candidate is changed to Criterion B – Already Implemented.
CP-11	Install an unfiltered hardened containment vent	D	A sensitivity study performed as part of the CGS IPE concluded that a hardened vent would not significantly reduce off-site releases following core damage. Venting currently is an option for decay heat removal following loss of SPC. A SAMA case was performed in which the containment vent unavailability was low (1.0E-09) and free from fire damage. The resulting integrated model CDF and LERF RRW values are 1.275 and 1.000, respectively (affects Internal Events and Fire). The estimated uncertainty benefit based on RRW is approximately $1,500,000, which is higher than cost-benefit Phase 2 cost-benefit results reported by other BWRs. Estimates of installation cost from other BWRs range from greater than $2,500,000 to greater than $5,000,000. An actual cost for the existing hardened pipe vent at Hope Creek installed in 1993 was between $5,000,000 and $6,000,000. A CGS cost estimate is $6,850,000, which is similar to the Hope Creek estimate adjusted for inflation. This SAMA candidate would not be cost-beneficial for CGS. Therefore, the screening criterion for this SAMA is changed to D – Excessive Implementation Cost. This SAMA is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
CP-17	Improve wetwell to drywell vacuum breaker reliability by installing redundant valves in each line	B	The wetwell-to-drywell vacuum breakers are dual seat: each relief valve assembly consists of two discs with two seats, which operate independently. Each valve disc is equipped with a positive closure mechanism, a magnetic latch, an exercising mechanism, and redundant limit switches. Therefore, the screening criterion for this SAMA candidate is changed to Criterion B – Already Implemented.
CP-18	Provide post-accident containment inerting capability	E	The CGS containment is inert at power conditions. The PSA quantifies hydrogen combustion as 5.0E-03. The CDF and LERF RRW values associated with making the probability for de-inerting or oxygen introduction equal to zero are both 1.000. There is no estimated uncertainty benefit for CGS. Therefore, this SAMA candidate is not considered for further evaluation.
CP-26	Improve leak detection procedures	Subsumed by FL-05R, FL-04R, FL-06R	The Control Building area was identified for additional leak detection improvement by the Integrated PSA Model Rev. 7.1. SAMA candidates FL-05R, FL-04R, and FL-06R address this area of improvement and are evaluated for cost-benefit. These SAMA candidates replace SAMA candidate CP-26.
CP-27	Install independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	A	CGS has a Mark II containment and does not have a hydrogen control system. The CGS containment is inerted at power conditions. As such, the screening criterion for this SAMA candidate is changed to A – Not Applicable to CGS.
CW-08	Enhance the screen wash system	E	The SW ponds at CGS are a semi-closed system and screen clogging is highly unlikely. Also, the screens are excessively oversized for the SW flow rates. The CDF and LERF RRW values associated with reducing the SW screens' unavailability by a factor of two are 1.009 and 1.0002, respectively (affects Internal Events and Fire). The estimated uncertainty benefit based on RRW is approximately $70,000, which is below the cost for a small design change at CGS Therefore, this SAMA candidate is not considered for further evaluation

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
FR-01	Replace mercury switches in FP system	B	The original diesel fire pump controllers were designed with mercury switches. The diesel fire pump controllers have been evaluated and are approved as part of the CGS obsolescence program. One diesel fire pump controller remains to be replaced as part of this existing program. Therefore, the screening criterion for this SAMA candidate is changed to Criterion B – Already Implemented. This SAMA candidate is not considered for further evaluation.
FR-02	Upgrade fire compartment barriers	E	The CGS IPEEE conclusions cited no weaknesses in compartment fire barriers that contributed to any significant risk. A potential SAMA candidate associated with providing fire barriers for the two oil-filled transformers in each of the critical switchgear rooms was identified. Although a portion of the 480V distribution would be lost due to the transformer failure, the protected switchgear, the other 480V oil-filled transformer, and other components in the division would still receive power. Special HVAC cooling and ducting is also required to preserve the effectiveness of the fire barrier and to provide adequate transformer cooling. This SAMA candidate was modeled by setting the accident sequences involving ignition of oil-filled transformer fires in switchgear rooms to zero. The CDF and LERF RRW values for addition of four fire barriers to separate each of the oil filed transformers from the switchgear, inverter, and other electrical panels in both the Division 1 and Division 2 electrical switchgear rooms are 1.034 and 1.0003, respectively (affects Fire only). The estimated uncertainty benefit based on RRW is $180,000. The estimated uncertainty benefit per transformer is roughly $45,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
FW-03	Install an independent diesel for the CST makeup pumps	E	CGS has the ability to connect the diesel driven fire water pump to the suction of a condensate booster pump for RPV makeup. The CDF RRW associated with making the uncertainty of one CST very low (see SAMA candidate CP-08) is 1.001 (affects Internal Events, no LERF contribution). The estimated uncertainty based on the RRW value of SAMA candidate CP-08 represents the uncertainty benefit expected of this SAMA candidate and is well below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
FW-04	Add a motor-driven FW pump	C	SAMA Candidate FW-04 is evaluated for cost-benefit using the Integrated PSA Model Rev. 7.1. The screening criterion was revised to Criterion C – Considered for Further Evaluation.
HV-05	Create ability to switch HPCS and RCIC room fan power supply to DC in an SBO event	E	This SAMA candidate is intended to increase the availability of RCIC and high pressure coolant injection in an SBO event. The need for RCIC fan cooling during an SBO has already been analyzed and found to not be required. The other high pressure injection pump at CGS is a motor driven pump (HPCS). HPCS fan cooling is supplied during an SBO by its own diesel and separate electrical division. In the event that the power is lost only to the fan, operators can open doors to the HPCS pump room for alternate room cooling until the cause can be corrected. The CDF and LERF RRW values associated with providing a batter-backed inverter supply to the HPCS fan are both 1.0000 indicating the RRW value is not sufficiently high enough to generate a benefit value. Therefore, this SAMA candidate is not considered for further evaluation.
HV-06	Enhance procedures to trip unneeded RHR or core spray pumps on loss of room ventilation	A	Each ECCS pump is located in a separate room. Each room has a room cooler with fans powered from the associated division and cooling water supplied by the respective division of SW. Failures of the HVAC in one ECCS subsystem would not impact the operability of the other subsystem within the division or redundant trains in the other divisions. Therefore, the criterion for this SAMA is changed to A – Not Applicable. This SAMA candidate is not considered for further evaluation.
IA-02	Modify procedure to provide ability to align diesel power to more air compressors	E	Two of three CAS compressors are backed up by DGs. The only safety-related components supplied directly from CAS are the outboard MSIV solenoids. CAS is backup for inboard MSIVs and SRVs. On a LOOP, opening of the MSIVs is not an option since the BOP systems are unavailable. The CDF and LERF RRW values associated with making the CAS system perfectly reliable are 1.002 for both. To implement this SAMA candidate, the third CAS compressor would require the installation of a manual transfer switch to transfer the power from the diesel-backed compressor to the third compressor assuming the first compressor failed. The estimated uncertainty benefit based on RRW is approximately $20,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
IA-03	Replace service and instrument air compressors with more compressors that have self-contained air cooling by shaft driven fans	E	The CAS compressors are cooled by the TSW system, which is backed up by the DGs. In the event that TSW fails, the compressors can be cooled by fire water. The CDF and LERF RRW values associated with removing the TSW dependency are 1.000 and 1.001, respectively. The estimated uncertainty benefit based on RRW is less than $5,000, which is below the cost for a procedure change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
IA-05	Improve SRV and MSIV pneumatic components	E	SRVs and MSIVs are very reliable and further improvement would not contribute significantly to plant risk. The CDF and LERF RRW values associated with reducing the unavailability of SRV, MSIV, pneumatic components by a factor of 2 are 1.001 and 1.0003, respectively. The estimated uncertainty benefit based on RRW is approximately $15,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
OT-01	Install digital large break LOCA protection system	E	LLOCA is not a large risk contributor at CGS, and this modification is not considered to significantly reduce the risk of a LLOCA. The CDF and LERF RRW values associated with making the probability of a LLOCA very low (5.0E-10) are both 1.0001. The estimated uncertainty benefit based on RRW is less than $1,000, which is below the cost for a small design change at CGS. Therefore, this SAMA candidate is not considered for further evaluation.
OT-02	Enhance procedures to mitigate large break LOCA	E	Large break LOCAs are dominated by automatic initiation of mitigating systems. SAMA Candidate OT-01 addresses making the probability of a LLOCA very small. Operator actions associated with a LLOCA would be similarly very low benefit. Therefore, this SAMA is not considered for further evaluation.
OT-04	Improve maintenance procedures	Subsumed by OT-07R	This SAMA is subsumed by SAMA candidate OT-07R which is evaluated for cost-benefit. Improvement to maintenance procedures has been added as an attribute of SAMA candidate OT-07R.

Table A-16: QUALITATIVE SCREENING OF SAMA CANDIDATES (ORIGINALLY SCREENED AS CRITERION E "VERY LOW BENEFIT")

SAMA ID	Modification (Potential Enhancement)	Revised Criteria	Basis for Screening/ Modification Enhancements [1]
OT-05	Increase training and operating experience feedback to improve operator response	B	Plant training or feedback issues are identified and their significance to plant risk assessed through the Operating Experience program. Improvement in this program is an ongoing element within the CGS process. This program is effective and receives continual management oversight and emphasis. Therefore, the screening criterion for this SAMA candidate is changed to B – Already Implemented. This SAMA candidate is not considered for further evaluation.
SR-01	Increase seismic ruggedness of standby SW pumps and RHR heat exchangers	D	The CDF and LERF RRW values associated with reducing the seismic failure for RHR heat exchangers and SW pumps to zero for the seismic sequence SDS41S01 are 1.032 and 1.0000, respectively (affects Seismic only). This sequence contributes 87% of the seismic CDF – 35% of which is related to the RHR system and 65% to the SW system. The estimated uncertainty benefit of making the RHR and SW components impervious to seismic failure (before Reactor Building collapse) based on RRW is approximately $380,000. Increasing the seismic ruggedness of the RHR pumps, heat exchangers, and piping would also be necessary. The work on the heat exchangers and their piping would be in a high radiation area, which complicates this modification. For the benefit to be realized, both SW systems would be required to be modified. A CGS cost estimate is approximately $10,000,000. This SAMA candidate would not be cost-beneficial for CGS. Therefore, the screening criterion for this SAMA candidate is changed to D – Excessive Implementation Cost. This SAMA candidate is not considered for further evaluation.

[1] Where RRW benefit values are provided, the value listed represents the SAMA candidate's combined RRW value from Internal Events, Fire and Seismic Level 1 and Level 2 (CDF and LERF). To calculate the candidate's estimated uncertainty benefit based on RRW, the formula provided in Section 3.1 is used to derive an estimated benefit for each hazard based on the SAMA candidate's RRW for that hazard and then it is multiplied by the uncertainty factor associated with the PSA hazard provided in Section 4.1. All hazards with a benefit are summed. This is duplicated for determining the estimated uncertainty benefit associated with LERF. Conservatively, CDF and LERF RRWs use the same formula from Section 3.1, potentially doubling the SAMA candidate's estimated uncertainty value based on RRW. The uncertainty benefit from the CDF and LERF based on RRW are then summed.

APPENDIX B

COST-BENEFIT RESULTS FROM REV. 7.1 OF THE PSA

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
	Maximum benefit.		7.50E-06	1.37E-05	4.86E-06	2.61E-05
AC/DC-01	Provide additional DC battery capacity.	Period for off-site/onsite recovery of power extended to 10 hours during SBO when RCIC successfully starts and runs on dc power.	7.46E-06	1.37E-05	4.86E-06	2.60E-05
AC/DC-02	Replace lead-acid batteries with fuel cells.	Period for off-site / onsite recovery of power extended to 10 hours during SBO when RCIC successfully starts and runs on dc power.	7.46E-06	1.37E-05	4.86E-06	2.60E-05
AC/DC-03	Add a portable, diesel-driven battery charger to existing DC system.	Period for off-site / onsite recovery of power extended to 10 hours during SBO when RCIC successfully starts and runs on dc power.	7.46E-06	1.37E-05	4.86E-06	2.60E-05
AC/DC-10	Provide an additional DG.	DG-1 was selected due to RCIC dependency on DG-1. Gate G1AC544 was set to a low value.	7.37E-06	1.24E-05	4.83E-06	2.46E-05
AC/DC-15	Install a gas turbine generator.	DG-1 was selected due to RCIC dependency on DG-1. Gate G1AC544 was set to a low value.	7.37E-06	1.24E-05	4.83E-06	2.46E-05
AC/DC-16	Install tornado protection on gas turbine generator.	DG-1 was selected due to RCIC dependency on DG-1. Gate G1AC544 was set to a low value.	7.37E-06	1.24E-05	4.83E-06	2.46E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
AC/DC-23	Develop procedures to repair or replace failed 4 kV breakers. In the event of a loss of bus due to a failed breaker, this SAMA candidate would provide the ability to repair or replace 4 kV breakers in a timely manner to restore AC power to the affected division.	BED data will be changed as noted in attached spreadsheet (4 kV AC breakers tab).	7.09E-06	1.35E-05	4.86E-06	2.55E-05
AC/DC-27	Install permanent hardware changes that make it possible to establish 500 kV backfeed through the main step-up transformer.	An unavailability of 1E-02 is assumed for the 500 kV backfeed basic event: EAC----500KVFEED. Assumed to not be available for seismic analysis. For the fire analysis, EAC----500KVFEED is conservatively assumed to be fire-protected (maximum risk benefit).	6.73E-06	8.50E-06	4.86E-06	2.01E-05
AC/DC-28	Reduce CCFs between DG-3 and DG-1/2.	Combinations of DG-1 and DG-3 as well as DG-2 and DG-3 were reduced, in addition to CCF of all three. The values were reduced by a factor of 2.	7.47E-06	1.36E-05	4.86E-06	2.59E-05
AC/DC-29	Replace DG-3 with a diesel diverse from DG-1 and DG-2.	Only the CCFs for DG-1 and DG-2 common cause group of two will be used. All others will be set to zero.	7.44E-06	1.34E-05	4.86E-06	2.57E-05
AT-05	Add an independent boron injection system.	C(3) functions set to a low value (1E-09) for Internal Events. For Seismic, damage state 40 (SDS40) is set to zero. No change to the FPSA results (ATWS sequences associated with fire are not risk significant and are not modeled by the PSA).	7.36E-06	1.37E-05	4.86E-06	2.59E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
AT-07	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	SRV failures set to zero, including failure of one valve when 7 of 7 ADS valves must open. There was no change in CDF. The SRV failures have no risk importance due to the high likelihood for success of the function.	7.50E-06	1.37E-05	4.86E-06	2.61E-05
CB-01	Install additional pressure or leak monitoring instruments for detection of interfacing system loss of coolant accidents (ISLOCAs).	ISLOCA contribution to PSA results (Internal Events) will be removed.	7.39E-06	1.37E-05	4.86E-06	2.60E-05
CB-03	Increase leak testing of valves in ISLOCA paths.	ISLOCA contribution to PSA results (Internal Events) will be removed.	7.39E-06	1.37E-05	4.86E-06	2.60E-05
CB-08	Revise EOPs to improve ISLOCA identification.	ISLOCA contribution to PSA results (Internal Events) will be removed.	7.39E-06	1.37E-05	4.86E-06	2.60E-05
CB-09	Improve operator training on ISLOCA coping.	ISLOCA contribution to PSA results (Internal Events) will be removed.	7.39E-06	1.37E-05	4.86E-06	2.60E-05
CC-01	Install an independent active or passive high pressure injection system.	HPCS event tree functions set to a low value (1E-09).	3.01E-06	3.55E-06	4.74E-06	1.13E-05
CC-02	Provide an additional high pressure injection pump with independent diesel.	HPCS event tree functions set to a low value (1E-09).	3.01E-06	3.55E-06	4.74E-06	1.13E-05
CC-03b	Raise RCIC backpressure trip set points.	The various RCIC failure to run events are reduced by a factor of 3.	7.49E-06	1.37E-05	4.86E-06	2.61E-05
CC-20	Improve ECCS suction strainers.	ECCS suction strainer plugging events set to zero.	7.45E-06	1.37E-05	4.86E-06	2.60E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
CP-01	Install an independent method of SPC.	The W(1) functions (SPC) were modeled as perfectly reliable. Operator action to align W(1) assumed to be necessary.	5.01E-06	6.36E-06	4.82E-06	1.62E-05
CW-02	Add redundant DC control power for pumps.	Control power dependencies associated with gates GHPS852, GRHR652, GRHR1552, GRHR3452, GLPS372, control power gates for RCIC were set to a low value.	6.74E-06	1.30E-05	4.86E-06	2.46E-05
CW-03	Replace ECCS pump motors with air-cooled motors.	Pump cooling dependencies modeled under GRHR520, GRHR1420, GRHR3320 and GLPS402 set to a low value. No external pump cooling modeled for RCIC or HPCS, so no change for these pumps.	7.30E-06	1.33E-05	4.86E-06	2.55E-05
CW-04	Provide self-cooled ECCS seals.	Pump cooling dependencies modeled under GRHR520, GRHR1420, GRHR3320 and GLPS402 set to a low value. No external pump cooling modeled for RCIC or HPCS, so no change for these pumps.	7.30E-06	1.33E-05	4.86E-06	2.55E-05
CW-07	Add a SW pump.	GSWB123, GXWB123, GYWB123 and GZWB123 set to a low value.	6.70E-06	1.20E-05	4.86E-06	2.36E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
FR-03	Install additional transfer and isolation switches.	Circuits downstream of the isolation switch/transfer switch will be susceptible to hot short/ spurious operation. Such switches, to be effective, would need to be installed very near the components in question. The hot short probability was reduced to zero for the most risk significant hot shorts: HS-EAC-TRS HS-CIAV-MO20 HS-CIAV-MO30A HS-ADS-OPEN HS-RHRV-MO-6B	7.50E-06	1.29E-05	4.86E-06	2.53E-05
FR-07a	Improve the fire resistance of critical cables.	Protect cables for containment vent (valves, containment air and power supplies).	7.50E-06	9.60E-06	4.86E-06	2.20E-05
FR-07b	Improve the fire resistance of critical cables.	Protect cables for that would disable TR-S due to hot short.	7.50E-06	1.33E-05	4.86E-06	2.57E-05
HV-02	Provide a redundant train or means of ventilation.	GXWA1112, GXWB1112, GYWA1112, GYWB1112, GZWA1112, GZWB1112 set to a low value.	7.48E-06	1.37E-05	4.86E-06	2.60E-05
SR-03	Modify safety related CST.	Basic events HPSV-CH----2P2LL and RCIV-CH---11P2LL were removed from S-BASE.BED to credit CST availability.	7.50E-06	1.37E-05	4.82E-06	2.60E-05
AT-13	Automate SLC injection in response to ATWS event.	Set SLCHUMN20MINH3XX and SLCHUMN40MINH3XX to zero.	7.46E-06	1.37E-05	4.86E-06	2.60E-05
AT-14	Diversify SLC explosive valve operation.	Set SLCV-SQ--4ABC2XX to zero.	7.50E-06	1.37E-05	4.86E-06	2.61E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
SR-05R	Improve seismic ruggedness of MCC-7F and MCC-8F.	Given a seismic event, MCC-7F and MCC-8F are likely to fail whenever Division 3 electrical power fails, based on component fragilities. The loss of these MCCs causes loss of Division 1 and Division 2 switchgear room cooling. No credit is assigned for alternate ventilation of the switchgear rooms due to the occurrence of a seismic-LOCA (no credit is given in the internal events PSA for alternate ventilation for LOCAs, due to the higher electrical heat loads), and potential challenges to obtain electrical power for portable fans, given a seismic event. The model was modified to represent failing room cooling for Division 1 and Division 2 switchgear rooms for the seismic damage states indicated. NOTE: The quantification result becomes the Base Case in the Phase 2 calculations for this candidate. The CDF produced from base case PSA then becomes the benefit case.	7.50E-06	1.37E-05	5.76E-06	2.70E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
OT-08R	Install explosion protection around CGS transformers. The CGS startup transformer and backup transformer are not in close proximity. However, there are the step up main transformers and auxiliary transformers that separate them. Although CGS transformers are protected with sudden pressure relays to mitigate rapid pressure increases from resulting in explosion, should they fail, there is a possibility that missiles generated from a transformer explosion could impact other transformers and potentially their incoming associated power lines. Although the cost for explosion protection is expected to be significantly greater than the maximum benefit, a SAMA case will be considered.	Plant-centered LOOP and switchyard-centered LOOP account for 37.2% of the Columbia LOOP frequency (NUREG/CR-6890). Reduce the LOOP frequency by this amount. The LOOP frequency, TE was changed to 1.87E-02, which is a 37.2% reduction from the LOOP frequency of 2.98E-02/ reactor-year.	7.39E-06	1.37E-05	4.86E-06	2.60E-05
FL-05R	Install three clamp-on flow instruments to certain drain	The control building flood isolation HEPs were reduced to 1E-02 to represent the	6.27E-06	1.37E-05	4.86E-06	2.48E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
	lines in the Control Building area of the Radwaste Building and alarm in the Control Room. The new flooding sources do not have a means to detect a flood. These flow instruments would alarm in the Control Room to alert operators that a large flow of water was coming from area drains. These drains are normally dry, so any alarm would be cause for immediate investigation.	improvement in operator timing response due to prompt flooding identification provided by the additional instrumentation. This list of HEPs consists of the following: FP-HUMNIC205H3LL FP-HUMNIC304H3LL SW-HUMN-W511H3LL SW-HUMN-W521H3LL SW-HUMN-W523H3LL SW-HUMN-W531H3LL SW-HUMN-W532H3LL SW-HUMNIC212H3LL SW-HUMNIC502H3LL SW-HUMNIC525H3LL TSWHUMNIC502H3LL TSWHUMNIC525H3LL XDPHUMN-W521H3LL XDPHUMN-W523H3LL XDPHUMN-W532H3LL XDPHUMNIC502H3LL				
FL-04R	Install one isolation valve in each of the SW, TSW, and FP lines in the Control Building area of the Radwaste Building to	The Control Building flood isolation HEPs were reduced to represent the improvement in flooding isolation capability by the addition of isolation valves in the piping branch lines that could result in	6.26E-06	1.37E-05	4.86E-06	2.48E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
	facilitate rapid isolation by the operators upon receipt of a high flow alarm.	Control Building flooding. Specifically, the Control Building flood isolation HEPs were reduced to 0.0: FP-HUMNIC205H3LL FP-HUMNIC304H3LL SW-HUMN-W511H3LL SW-HUMN-W521H3LL SW-HUMN-W523H3LL SW-HUMN-W531H3LL SW-HUMN-W532H3LL SW-HUMNIC212H3LL SW-HUMNIC502H3LL SW-HUMNIC525H3LL TSWHUMNIC502H3LL TSWHUMNIC525H3LL XDPHUMN-W521H3LL XDPHUMN-W523H3LL XDPHUMN-W532H3LL XDPHUMNIC502H3LL				
FL-06R	Perform additional NDE and inspections to the three lines identified in SAMA candidate FL-04R to verify that degradation is not occurring in these lines. The specific locations of the NDE would	The increased testing intervals and locations of critical piping in the Control Building are expected to improve detection and timely corrective maintenance. To model this improvement, the control building flood isolation HEPs were reduced by a factor of 2 to represent early detection	6.87E-06	1.37E-05	4.86E-06	2.54E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
	be selected from potentially susceptible areas using similar methods as used in the risk-informed in-service inspection program to detect wall thinning.	of degrading piping. The specific HEPs are: IE-FLD-C205-FP-U IE-FLD-C212SSWAU IE-FLD-C212SSWBU IE-FLD-C304-FP-U IE-FLD-C502SSWAU IE-FLD-C502SSWBU IE-FLD-C502TSW-U IE-FLD-C507SSWAM IE-FLD-C507SSWAS IE-FLD-C507SSWAU IE-FLD-C507TSW-M IE-FLD-C507TSW-S IE-FLD-C507TSW-U IE-FLD-C507WCH-S IE-FLD-C508SSWBM IE-FLD-C508SSWBS IE-FLD-C508SSWBU IE-FLD-C508TSW-M IE-FLD-C508TSW-S IE-FLD-C508TSW-U IE-FLD-C508WCH-S IE-FLD-W51ASSWAS IE-FLD-W52ASSWAS IE-FLD-W52ASSWAU IE-FLD-W52BSSWBS IE-FLD-W52BSSWBU IE-FLD-W53ASSWAS IE-FLD-W53ASSWAU IE-FLD-W53BSSWBS IE-FLD-W53BSSWBU				

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
CC-24R	CGS can cross-tie DG-3 to either SM-7 or SM-8 by procedure. Using DG-3 hardware to cross-tie Division 1 and Division 2 is possible but overload potential of the DG would reduce risk value. This pathway is not of high benefit when the DG-3 cross-connect is available. Prior NRC approval would be required. Backfeeding the HPCS system with SM-8 would provide a third power source for HPCS. A SAMA candidate to evaluate this is proposed for use in the EOP/SAGs.	To represent the additional power supply to the HPCS system, the HPCS AC power dependency was removed. This removes all power dependency (offsite power and onsite power) to HPCS. The PSA model was modified to accomplish this by adding a house event gate to remove this dependency. Specifically, the power dependency of SM-4 supply to the HPCS system was removed.	6.94E-06	1.24E-05	4.86E-06	2.42E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
CC-25R	Enhance alternate injection reliability by including RHRSW and fire water cross-tie in the maintenance program.	This SAMA candidate examines a PSA modeling incompleteness. Examine the risk increase to the PSA for this incompleteness, assuming a 10-year mean time between tests for the subject valves. Change the following to failure type 2, with a 10-year mean time between tests: CONV-MA-1062F2LL now equals 5.7E-04 RHRV-MO-115-P3LL now equals 9.9E-02 RHRV-MO-116-P3LL now equals 9.9E-02 NOTE: The quantification result becomes the Base Case in the Phase 2 calculations for this candidate. The CDF produced from base case PSA then becomes the benefit case.	7.55E-06	1.38E-05	4.86E-06	2.62E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
OT-07R	Improve procedures and operator training to identify systems and operator actions determined to be important from the PSA.	The model was revised by reducing the top 10 most risk-significant HEPs by a factor of 10. Based on an importance evaluation of the integrated CDF results, these top ten will represent the potential risk improvement for other important HEPs. Specifically, the following HEP basic events were chosen as representative and were reduced: ATWH-HPLPRSTH3XX RHRH-ATWSDC-H3XX CIAHUMNX-TIEH3-F CIAHUMNV104BH3-F CIAHUMNV104AH3-F ADSHUMNSTARTH3LT CIAHUMNX-TIEH3XX SLC-XHE-FO-LLVCT ADS-XHE-FO-S2W RHRHUMN-SDC-H3XX	5.61E-06	1.30E-05	4.86E-06	2.35E-05
FW-05R	CGS loss of DC power from DC Bus E-DP-S1/7 will result in potential tripping of both the turbine-driven RFW pumps resulting in a low low reactor water level which closes the MSIVs. This SAMA candidate examines the potential for operators to control RFW and avoid a reactor trip.	The model was revised to remove loss of E-DP-S1/7 from the RFW initiating event equation, and set the unavailability of E-DP-S1/7 to a very low value (1E-09). This was accomplished by inserting a house event to remove bus loss from the loss of RFW initiating event logic and setting the unavailability of E-DP-S1/7 to 1E-09 through existing house events XHOS0--S17--SRVC, XHOS1--S17--SRVC and EDCDP--S17---OOS = 1E-09.	7.25E-06	1.28E-05	4.86E-06	2.49E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
FR-09R	Install early fire detection in the following Reactor Building analysis units: R-1B, R-1D, R-1J, R-1L, R-1C, R-1K.	The model was revised to simulate the improvement in detection and mitigation of a fire due to early detection in the most important fire areas of the Reactor Building. The ignition frequencies were reduced by factor of 10 to simulate that potential fires would be detected and arrested before becoming a damaging fire. The following fire area fixed initiating event frequencies were reduced: FR1B, NE Reactor bldg 471', RRW = 1.01 FR1D RB 471', RRW = 1.06 FR1J RB 522', RRW = 1.05 FR1L, RRW = 1.02 FR1C, RRW = 1.03 FR1K, RRW = 1.01	7.50E-06	1.16E-05	4.86E-06	2.40E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
FR-08	Protect RHR and SW cables from fires.	The unavailability for each of two trains of RHR is set to the value for random unavailability for each train. The FPSA was quantified assuming an unavailability of 2.7E-02 or RHR train A and an unavailability of 2.7E-02 for RHR train B. The 2.7E-02 unavailability is the square root of the base unavailability for the suppression pool cooling function: SQRT(7.22E-04)=2.7E-02. Thus, the FPSA is quantified assuming only the random unavailabilities of RHR train A and B (both SPC function and the injection function) apply. The specific model changes were to quantify the PSA using the following surrogate basic events for the unavailability of RHR A and B: RHR----TRN_A-OOS = 2.7E-02 RHR----TRN_B-OOS = 2.7E-02	7.50E-06	6.02E-06	4.86E-06	1.84E-05
AT-15R	Modifications to make use of HPCS more likely for ATWS (use of auto bypass, installing throttle valve).	The model was revised to provide added crediting of the manual use of the HPCS system by operators during ATWS conditions. This was accomplished by setting the HPCS control operator action for ATWS to 1E-3: Set ATWH-HPLPRSTH3XX to 1E-03.	6.41E-06	1.37E-05	4.86E-06	2.59E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
OT-09R	For the non-LOCA initiating events, credit the Z (PCS recovery) function.	Remove the MSIV trip on high steam tunnel temperature for transient initiators. House event xhos0-cs40 was used in the PCS.lgc fault tree to turn off the trip of MSIVs on high steam tunnel temperature.	7.22E-06	1.26E-05	4.86E-06	2.47E-05
FR-12R	Install early fire detection in the following physical analysis units: T-1A, T-12, T-1C, and T-1D.	The model was revised to simulate the improvement in detection and mitigation of a fire due to early detection in the most important fire areas of the Turbine Building. The ignition frequencies were reduced by factor of 10 to simulate that potential fires would be detected and arrested before becoming a damaging fire. The following fire area fixed initiating event frequencies were reduced: FT12 Turbine Building S Corridors, RRW = 1.01 FT1A Turbine Building W 441', RRW = 1.02 FT1C Turbine Building E 441', RRW = 1.11 FT1D Turbine building W 471', RRW = 1.01	7.50E-06	1.20E-05	4.86E-06	2.44E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
FR-11R	Install early fire detection in the following analysis units: RC-02, RC-03, RC-05, RC-04, RC-07, RC-08, RC-11, RC-14, RC-13, and RC-1A.	The model was revised to simulate the improvement in detection and mitigation of a fire due to early detection in the most important fire areas of the Control Building. The ignition frequencies were reduced by factor of 10 to simulate that potential fires would be detected and arrested before becoming a damaging fire. The following fire area fixed initiating event frequencies were reduced: FW02-Cable Spreading Room, RRW=1.03 FW03-Cable Chase, RRW=1.07 FW05-Battery room 1, RRW=1.02 FW04-Div 1 Electrical Equipment Room, RRW=1.14 FW07-Div 2 Electrical Equipment Room, RRW=1.14 FW08-Div 2 Switchgear Room, RRW=1.08 FW14-Div 1 Switchgear room, RRW=1.12 FW13,Emergency chiller room, RRW=1.04 FW1A, Radwaste Building 437' RRW=1.03	7.50E-06	6.05E-06	4.86E-06	1.84E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
FR-10R	Install early fire detection in the Main Control Room: RC-10.	The model was revised to simulate the improvement in detection and mitigation of a fire due to early detection in the Main Control Room. The ignition frequencies were reduced by factor of 10 to simulate that potential fires would be detected and arrested before becoming a damaging fire. The Main Control Room fire area fixed initiating event frequency was reduced: FW10 - Control room, RRW = 1.02	7.50E-06	1.35E-05	4.86E-06	2.59E-05
FL-07R	Flood protect HPCS, based on LERF RRW of 1.21, for HPCS unavailable due to flooding from ISLOCA rupture.	Set - HPS-----ISLOCA-R, "HPCS UNAVAILABLE DUE TO FLOODING FROM ISLOCA RUPT" to 0.0. This modeling is such that HPCS is assumed to be perfectly protected from flooding due to ISLOCA (i.e., the likelihood is set to zero).	7.50E-06	1.37E-05	4.86E-06	2.61E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
AC/DC-30R	SAMA candidate AC/DC-10 "provide an additional diesel generator" address DG-1 unavailability. Since DG-2 is more important to fire risk, an additional SAMA candidate to examine risk improvement for DG-2 will be considered.	This SAMA candidate adds an additional diesel generator that could be aligned to either 4.16 KV bus SM-7 or SM-8. The diesel generator would differ in design from DG-1 and DG-2 to minimize the likelihood of diesel generator CCF events. The PSA was modified to make DG-2 perfectly reliable to start and run (a different case, AC/DC-10, examined risk benefit from making DG-1 perfectly reliable). To accomplish this, gate G2AC544 was set to a low value. Additionally, any loss of DG-1 and DG-2 was transferred to the SBO event trees, as this is the definition of SBO at CGS, and produces realistic modeling for this SAMA candidate.	7.77E-06	1.09E-05	4.75E-06	2.34E-05
CC-26R	Install hard pipe from diesel fire pump to vessel.	The existing method of providing the fire water injection includes hookup of hoses from the FP system to the condensate system. By eliminating human errors in the model, the hard pipe system effectiveness can be simulated. Set to zero the human failure events for alignment of diesel fire pump to vessel. To accomplish this, set the following HEPs to zero: FP-HUMN-SBOLH3LL FP-HUMNSYS62H3LL	7.48E-06	1.37E-05	4.86E-06	2.60E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
OT-10R	Increase fire pump house building integrity to withstand higher winds so the fire system will be capable of withstanding a severe weather event.	For Internal Events, assume a 1.37E-04 probability for high wind during a plant initiating event (represents a 20 year wind occurring during the 24 hour mission time, 1/20/365) and a 1.0 probability for high wind given LOOP (conservative). To the FPW fault tree, add house event XHOS1-CS47 to the FPW fault tree to activate these modeling conditions.	7.51E-06	1.37E-05	4.86E-06	2.61E-05
FW-04	Add a third RFW pump.	Reduced the RFW unavailability by 1E-03 to account for a third train of RFW. No common dependencies are assumed. Reduce the TF initiating event frequency by at least 3 orders of magnitude. To accomplish this, house event XHOS0-CS48 was used in the RFW.lgc to credit a third RFW train. Event TF and INIT-RY-TF were set to low values.	4.50E-06	1.03E-05	4.86E-06	1.97E-05

Table B-1: Summary of PSA Cases[1]

SAMA Candidate	Description	Model Approach	Risk Reduction CDF (1/yr)			Total CDF (1/yr)
			Internal	Fire	Seismic	
CB-10R	Provide additional NDE and inspections of MS pipe in turbine building.	The increased testing intervals and locations of critical sections of MS piping outside containment expected to improve detection and timely corrective maintenance. To model this improvement, the MS piping break initiating event was reduced by a factor of two to represent early detection of degrading piping. Reduce the MS LOCA outside containment initiating event frequencies by a factor of 2: IE-FLD-TLO--MS-S IE-FLD-TLO--MS-U IE-FLD-TLO--MS-M	7.34E-06	1.37E-05	4.86E-06	2.59E-05

[1]The modeling approach for SAMA candidates that were evaluated in Table E.11-1 of the ER was not changed for this sensitivity study.

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Maximum Benefit	Case 01 (AC/DC-01)	Case 01 (AC/DC-02)	Case 01 (AC/DC-03)	Case 02 (AC/DC-10)	Case 02 (AC/DC-15)
Off-site Annual Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.48E+00	5.48E+00
Off-site Annual Property Loss ($)	$7,079	$7,075	$7,075	$7,075	$7,061	$7,061
Comparison CDF	----	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	----	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	----	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	----	7.46E-06	7.46E-06	7.46E-06	7.37E-06	7.37E-06
Reduction in CDF	----	**0.53%**	**0.53%**	**0.53%**	**1.73%**	**1.73%**
Reduction in Off-site Dose	----	**0.00%**	**0.00%**	**0.00%**	**0.18%**	**0.18%**
Immediate Dose Savings (On-site)	$646	$3	$3	$3	$11	$11
Long Term Dose Savings (On-site)	$2,816	$15	$15	$15	$49	$49
Total Accident Related Occupational Exposure **(AOE)**	$3,462	$18	$18	$18	$60	$60
Cleanup/Decontamination Savings (On-site)	$105,582	$563	$563	$563	$1,830	$1,830
Replacement Power Savings (On-site)	$155,733	$831	$831	$831	$2,699	$2,699
Averted Costs of On-site Property Damage **(AOSC)**	$261,315	$1,394	$1,394	$1,394	$4,529	$4,529
Total On-site Benefit	**$264,776**	**$1,412**	**$1,412**	**$1,412**	**$4,589**	**$4,589**
Averted Public Exposure **(APE)**	$143,289	$0	$0	$0	$261	$261
Averted Off-site Damage Savings **(AOC)**	$92,381	$52	$52	$52	$235	$235
Total Off-site Benefit	**$235,670**	**$52**	**$52**	**$52**	**$496**	**$496**
Total Benefit (On-site + Off-site)	**$500,446**	**$1,464**	**$1,464**	**$1,464**	**$5,085**	**$5,085**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 02 (AC/DC-16)	Case 03 (AC/DC-23)	Case 04 (AC/DC-27)	Case 05 (AC/DC-28)	Case 06 (AC/DC-29)	Case 07 (AT-05)
Off-site Annual Dose (rem)	5.48E+00	5.16E+00	5.00E+00	5.49E+00	5.48E+00	5.13E+00
Off-site Annual Property Loss ($)	$7,061	$6,659	$6,470	$7,076	$7,073	$6,620
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.37E-06	7.09E-06	6.73E-06	7.47E-06	7.44E-06	7.36E-06
Reduction in CDF	**1.73%**	**5.47%**	**10.27%**	**0.40%**	**0.80%**	**1.87%**
Reduction in Off-site Dose	**0.18%**	**6.01%**	**8.93%**	**0.00%**	**0.18%**	**6.56%**
Immediate Dose Savings (On-site)	$11	$35	$66	$3	$5	$12
Long Term Dose Savings (On-site)	$49	$154	$289	$11	$23	$53
Total Accident Related Occupational Exposure **(AOE)**	$60	$189	$355	$14	$28	$65
Cleanup/Decontamination Savings (On-site)	$1,830	$5,772	$10,840	$422	$845	$1,971
Replacement Power Savings (On-site)	$2,699	$8,513	$15,989	$623	$1,246	$2,907
Averted Costs of On-site Property Damage **(AOSC)**	$4,529	$14,285	$26,828	$1,045	$2,091	$4,878
Total On-site Benefit	**$4,589**	**$14,474**	**$27,184**	**$1,059**	**$2,118**	**$4,942**
Averted Public Exposure **(APE)**	$261	$8,613	$12,789	$0	$261	$9,396
Averted Off-site Damage Savings **(AOC)**	$235	$5,481	$7,947	$39	$78	$5,990
Total Off-site Benefit	**$496**	**$14,094**	**$20,736**	**$39**	**$339**	**$15,386**
Total Benefit (On-site + Off-site)	**$5,085**	**$28,568**	**$47,920**	**$1,098**	**$2,458**	**$20,328**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 08 (AT-07)	Case 09 (CB-01)	Case 09 (CB-03)	Case 10 (CC-01)	Case 11 (CC-02)	Case 12 (CC-03b)
Off-site Annual Dose (rem)	5.49E+00	5.35E+00	5.35E+00	2.40E+00	2.40E+00	5.49E+00
Off-site Annual Property Loss ($)	$7,079	$6,881	$6,881	$3,267	$3,267	$7,081
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.50E-06	7.39E-06	7.39E-06	3.01E-06	3.01E-06	7.49E-06
Reduction in CDF	**0.00%**	**1.47%**	**1.47%**	**59.87%**	**59.87%**	**0.13%**
Reduction in Off-site Dose	**0.00%**	**2.55%**	**2.55%**	**56.28%**	**56.28%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$9	$9	$387	$387	$1
Long Term Dose Savings (On-site)	$0	$41	$41	$1,686	$1,686	$4
Total Accident Related Occupational Exposure **(AOE)**	$0	$51	$51	$2,072	$2,072	$5
Cleanup/Decontamination Savings (On-site)	$0	$1,549	$1,549	$63,209	$63,209	$141
Replacement Power Savings (On-site)	$0	$2,284	$2,284	$93,232	$93,232	$208
Averted Costs of On-site Property Damage **(AOSC)**	$0	$3,833	$3,833	$156,440	$156,440	$348
Total On-site Benefit	**$0**	**$3,883**	**$3,883**	**$158,513**	**$158,513**	**$353**
Averted Public Exposure **(APE)**	$0	$3,654	$3,654	$80,649	$80,649	$0
Averted Off-site Damage Savings **(AOC)**	$0	$2,584	$2,584	$49,747	$49,747	($26)
Total Off-site Benefit	**$0**	**$6,238**	**$6,238**	**$130,396**	**$130,396**	**($26)**
Total Benefit (On-site + Off-site)	**$0**	**$10,121**	**$10,121**	**$288,908**	**$288,908**	**$327**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 13 (CC-20)	Case 15 (CP-01)	Case 18 (CW-02)	Case 19 (CW-03)	Case 19 (CW-04)	Case 20 (CW-07)
Off-site Annual Dose (rem)	5.45E+00	2.42E+00	4.78E+00	5.45E+00	5.45E+00	4.85E+00
Off-site Annual Property Loss ($)	$7,026	$3,267	$6,211	$7,068	$7,068	$6,317
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.45E-06	5.01E-06	6.74E-06	7.30E-06	7.30E-06	6.70E-06
Reduction in CDF	**0.67%**	**33.20%**	**10.13%**	**2.67%**	**2.67%**	**10.67%**
Reduction in Off-site Dose	**0.73%**	**55.92%**	**12.93%**	**0.73%**	**0.73%**	**11.66%**
Immediate Dose Savings (On-site)	$4	$214	$65	$17	$17	$69
Long Term Dose Savings (On-site)	$19	$935	$285	$75	$75	$300
Total Accident Related Occupational Exposure **(AOE)**	$23	$1,149	$351	$92	$92	$369
Cleanup/Decontamination Savings (On-site)	$704	$35,053	$10,699	$2,816	$2,816	$11,262
Replacement Power Savings (On-site)	$1,038	$51,703	$15,781	$4,153	$4,153	$16,611
Averted Costs of On-site Property Damage **(AOSC)**	$1,742	$86,757	$26,480	$6,968	$6,968	$27,874
Total On-site Benefit	**$1,765**	**$87,906**	**$26,831**	**$7,061**	**$7,061**	**$28,243**
Averted Public Exposure **(APE)**	$1,044	$80,127	$18,531	$1,044	$1,044	$16,704
Averted Off-site Damage Savings **(AOC)**	$692	$49,747	$11,327	$144	$144	$9,944
Total Off-site Benefit	**$1,736**	**$129,874**	**$29,858**	**$1,188**	**$1,188**	**$26,648**
Total Benefit (On-site + Off-site)	**$3,501**	**$217,779**	**$56,689**	**$8,248**	**$8,248**	**$54,891**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 21 (FR-03)	Case 22 (FR-07a)	Case22a (FR-07b)	Case 23 (HV-02)	Case 25 (SR-03)	Case 26 (AT-13)
Off-site Annual Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.48E+00	5.49E+00	5.41E+00
Off-site Annual Property Loss ($)	$7,079	$7,079	$7,079	$7,069	$7,079	$6,975
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.50E-06	7.50E-06	7.50E-06	7.48E-06	7.50E-06	7.46E-06
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**0.27%**	**0.00%**	**0.53%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**0.18%**	**0.00%**	**1.46%**
Immediate Dose Savings (On-site)	$0	$0	$0	$2	$0	$3
Long Term Dose Savings (On-site)	$0	$0	$0	$8	$0	$15
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$9	$0	$18
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$282	$0	$563
Replacement Power Savings (On-site)	$0	$0	$0	$415	$0	$831
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$697	$0	$1,394
Total On-site Benefit	**$0**	**$0**	**$0**	**$706**	**$0**	**$1,412**
Averted Public Exposure **(APE)**	$0	$0	$0	$261	$0	$2,088
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$131	$0	$1,357
Total Off-site Benefit	**$0**	**$0**	**$0**	**$391**	**$0**	**$3,445**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$1,098**	**$0**	**$4,857**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 27 (AT-14)	Case 28 (SR-05R)	Case 29 (OT-08R)	Case 30 (FL-05R)	Case 31 (FL-04R)	Case 32 (FL-06R)
Off-site Annual Dose (rem)	5.49E+00	5.49E+00	5.47E+00	3.56E+00	3.55E+00	4.51E+00
Off-site Annual Property Loss ($)	$7,079	$7,079	$7,057	$4,506	$4,490	$5,771
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.50E-06	7.50E-06	7.39E-06	6.27E-06	6.26E-06	6.87E-06
Reduction in CDF	**0.00%**	**0.00%**	**1.47%**	**16.40%**	**16.53%**	**8.40%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.36%**	**35.15%**	**35.34%**	**17.85%**
Immediate Dose Savings (On-site)	$0	$0	$9	$106	$107	$54
Long Term Dose Savings (On-site)	$0	$0	$41	$462	$466	$237
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$51	$568	$572	$291
Cleanup/Decontamination Savings (On-site)	$0	$0	$1,549	$17,315	$17,456	$8,869
Replacement Power Savings (On-site)	$0	$0	$2,284	$25,540	$25,748	$13,082
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$3,833	$42,856	$43,204	$21,950
Total On-site Benefit	**$0**	**$0**	**$3,883**	**$43,423**	**$43,776**	**$22,241**
Averted Public Exposure **(APE)**	$0	$0	$522	$50,373	$50,634	$25,578
Averted Off-site Damage Savings **(AOC)**	$0	$0	$287	$33,578	$33,786	$17,069
Total Off-site Benefit	**$0**	**$0**	**$809**	**$83,951**	**$84,420**	**$42,647**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$4,692**	**$127,374**	**$128,197**	**$64,889**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 33 (CC-24R)	Case 34 (CC-25R)	Case 35 (OT-07R)	Case 36 (FW-05R)	Case 37 (FR-09R)	Case 38 (FR-08)
Off-site Annual Dose (rem)	5.10E+00	5.53E+00	5.05E+00	5.38E+00	5.49E+00	5.49E+00
Off-site Annual Property Loss ($)	$6,588	$7,130	$6,512	$6,951	$7,079	$7,079
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	6.94E-06	7.55E-06	5.61E-06	7.25E-06	7.50E-06	7.50E-06
Reduction in CDF	**7.47%**	**0.67%**	**25.20%**	**3.33%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**7.10%**	**0.73%**	**8.01%**	**2.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$48	$4	$163	$22	$0	$0
Long Term Dose Savings (On-site)	$210	$19	$710	$94	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$258	$23	$872	$115	$0	$0
Cleanup/Decontamination Savings (On-site)	$7,883	$704	$26,607	$3,519	$0	$0
Replacement Power Savings (On-site)	$11,628	$1,038	$39,245	$5,191	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$19,512	$1,742	$65,851	$8,710	$0	$0
Total On-site Benefit	**$19,770**	**$1,765**	**$66,724**	**$8,826**	**$0**	**$0**
Averted Public Exposure **(APE)**	$10,179	$1,044	$11,484	$2,871	$0	$0
Averted Off-site Damage Savings **(AOC)**	$6,408	$666	$7,399	$1,670	$0	$0
Total Off-site Benefit	**$16,587**	**$1,710**	**$18,883**	**$4,541**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$36,357**	**$3,475**	**$85,607**	**$13,367**	**$0**	**$0**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 39 (AT-15R)	Case 40 (OT-09R)	Case 41 (FR-12R)	Case 42 (FR-11R)	Case 43 (FR-10R)	Case 44 (FL-07R)
Off-site Annual Dose (rem)	5.46E+00	5.22E+00	5.49E+00	5.49E+00	5.49E+00	5.37E+00
Off-site Annual Property Loss ($)	$7,033	$6,731	$7,079	$7,079	$7,079	$6,905
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	6.41E-06	7.22E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Reduction in CDF	**14.53%**	**3.73%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.55%**	**4.92%**	**0.00%**	**0.00%**	**0.00%**	**2.19%**
Immediate Dose Savings (On-site)	$94	$24	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$409	$105	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$503	$129	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$15,345	$3,942	$0	$0	$0	$0
Replacement Power Savings (On-site)	$22,633	$5,814	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$37,978	$9,756	$0	$0	$0	$0
Total On-site Benefit	**$38,481**	**$9,885**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$783	$7,047	$0	$0	$0	$3,132
Averted Off-site Damage Savings **(AOC)**	$600	$4,541	$0	$0	$0	$2,271
Total Off-site Benefit	**$1,383**	**$11,588**	**$0**	**$0**	**$0**	**$5,403**
Total Benefit (On-site + Off-site)	**$39,864**	**$21,473**	**$0**	**$0**	**$0**	**$5,403**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 45 (AC/DC-30R)	Case 46 (CC-26R)	Case 47 (OT-10R)	Case 48 (FW-04)	Case 49 (CB-10R)	Case 09 (CB-08)
Off-site Annual Dose (rem)	5.54E+00	5.48E+00	5.50E+00	3.20E+00	5.39E+00	5.35E+00
Off-site Annual Property Loss ($)	$7,098	$7,062	$7,087	$4,213	$6,947	$6,881
Comparison CDF	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06	7.50E-06
Comparison Dose (rem)	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00	5.49E+00
Comparison Cost ($)	$7,079	$7,079	$7,079	$7,079	$7,079	$7,079
Enhanced CDF	7.77E-06	7.48E-06	7.51E-06	4.50E-06	7.34E-06	7.39E-06
Reduction in CDF	**-3.60%**	**0.27%**	**0.13%**	**40.00%**	**2.13%**	**1.47%**
Reduction in Off-site Dose	**-0.91%**	**0.18%**	**0.18%**	**41.71%**	**1.82%**	**2.55%**
Immediate Dose Savings (On-site)	($23)	$2	$1	$258	$14	$9
Long Term Dose Savings (On-site)	($101)	$8	$4	$1,126	$60	$41
Total Accident Related Occupational Exposure **(AOE)**	($125)	$9	$5	$1,385	$74	$51
Cleanup/Decontamination Savings (On-site)	($3,801)	$282	$141	$42,233	$2,252	$1,549
Replacement Power Savings (On-site)	($5,606)	$415	$208	$62,293	$3,322	$2,284
Averted Costs of On-site Property Damage **(AOSC)**	($9,407)	$697	$348	$104,526	$5,575	$3,833
Total On-site Benefit	**($9,532)**	**$706**	**$353**	**$105,911**	**$5,649**	**$3,883**
Averted Public Exposure **(APE)**	($1,305)	$261	$261	$59,769	$2,610	$3,654
Averted Off-site Damage Savings **(AOC)**	($248)	$222	$104	$37,401	$1,723	$2,584
Total Off-site Benefit	**($1,553)**	**$483**	**$365**	**$97,170**	**$4,333**	**$6,238**
Total Benefit (On-site + Off-site)	**($11,085)**	**$1,189**	**$718**	**$203,081**	**$9,981**	**$10,121**

Table B-2: Internal Events Benefit Results for Analysis Cases

Case	Case 09 (CB-09)
Off-site Annual Dose (rem)	5.35E+00
Off-site Annual Property Loss ($)	$6,881
Comparison CDF	7.50E-06
Comparison Dose (rem)	5.49E+00
Comparison Cost ($)	$7,079
Enhanced CDF	7.39E-06
Reduction in CDF	**1.47%**
Reduction in Off-site Dose	**2.55%**
Immediate Dose Savings (On-site)	$9
Long Term Dose Savings (On-site)	$41
Total Accident Related Occupational Exposure **(AOE)**	$51
Cleanup/Decontamination Savings (On-site)	$1,549
Replacement Power Savings (On-site)	$2,284
Averted Costs of On-site Property Damage **(AOSC)**	$3,833
Total On-site Benefit	**$3,883**
Averted Public Exposure **(APE)**	$3,654
Averted Off-site Damage Savings **(AOC)**	$2,584
Total Off-site Benefit	**$6,238**
Total Benefit (On-site + Off-site)	**$10,121**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Maximum Benefit	Case 01 (AC/DC-01)	Case 01 (AC/DC-02)	Case 01 (AC/DC-03)	Case 02 (AC/DC-10)	Case 02 (AC/DC-15)
Off-site Annual Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.32E+00	8.32E+00
Off-site Annual Property Loss ($)	$11,168	$11,168	$11,168	$11,168	$10,370	$10,370
Comparison CDF	----	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	----	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	----	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	----	1.37E-05	1.37E-05	1.37E-05	1.24E-05	1.24E-05
Reduction in CDF	----	**0.00%**	**0.00%**	**0.00%**	**9.49%**	**9.49%**
Reduction in Off-site Dose	----	**0.00%**	**0.00%**	**0.00%**	**7.14%**	**7.14%**
Immediate Dose Savings (On-site)	$1,180	$0	$0	$0	$112	$112
Long Term Dose Savings (On-site)	$5,143	$0	$0	$0	$488	$488
Total Accident Related Occupational Exposure **(AOE)**	$6,323	$0	$0	$0	$600	$600
Cleanup/Decontamination Savings (On-site)	$192,864	$0	$0	$0	$18,301	$18,301
Replacement Power Savings (On-site)	$284,471	$0	$0	$0	$26,994	$26,994
Averted Costs of On-site Property Damage **(AOSC)**	$477,335	$0	$0	$0	$45,295	$45,295
Total On-site Benefit	**$483,658**	**$0**	**$0**	**$0**	**$45,895**	**$45,895**
Averted Public Exposure **(APE)**	$233,856	$0	$0	$0	$16,704	$16,704
Averted Off-site Damage Savings **(AOC)**	$145,742	$0	$0	$0	$10,414	$10,414
Total Off-site Benefit	**$379,598**	**$0**	**$0**	**$0**	**$27,118**	**$27,118**
Total Benefit (On-site + Off-site)	**$863,256**	**$0**	**$0**	**$0**	**$73,012**	**$73,012**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 02 (AC/DC-16)	Case 03 (AC/DC-23)	Case 04 (AC/DC-27)	Case 05 (AC/DC-28)	Case 06 (AC/DC-29)	Case 07 (AT-05)
Off-site Annual Dose (rem)	8.32E+00	8.80E+00	5.69E+00	8.94E+00	8.91E+00	8.96E+00
Off-site Annual Property Loss ($)	$10,370	$10,967	$7,123	$11,149	$11,107	$11,168
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.24E-05	1.35E-05	8.50E-06	1.36E-05	1.34E-05	1.37E-05
Reduction in CDF	**9.49%**	**1.46%**	**37.96%**	**0.73%**	**2.19%**	**0.00%**
Reduction in Off-site Dose	**7.14%**	**1.79%**	**36.50%**	**0.22%**	**0.56%**	**0.00%**
Immediate Dose Savings (On-site)	$112	$17	$448	$9	$26	$0
Long Term Dose Savings (On-site)	$488	$75	$1,952	$38	$113	$0
Total Accident Related Occupational Exposure **(AOE)**	$600	$92	$2,400	$46	$138	$0
Cleanup/Decontamination Savings (On-site)	$18,301	$2,816	$73,204	$1,408	$4,223	$0
Replacement Power Savings (On-site)	$26,994	$4,153	$107,975	$2,076	$6,229	$0
Averted Costs of On-site Property Damage **(AOSC)**	$45,295	$6,968	$181,178	$3,484	$10,453	$0
Total On-site Benefit	**$45,895**	**$7,061**	**$183,578**	**$3,530**	**$10,591**	**$0**
Averted Public Exposure **(APE)**	$16,704	$4,176	$85,347	$522	$1,305	$0
Averted Off-site Damage Savings **(AOC)**	$10,414	$2,623	$52,787	$248	$796	$0
Total Off-site Benefit	**$27,118**	**$6,799**	**$138,134**	**$770**	**$2,101**	**$0**
Total Benefit (On-site + Off-site)	**$73,012**	**$13,860**	**$321,712**	**$4,300**	**$12,692**	**$0**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 08 (AT-07)	Case 09 (CB-01)	Case 09 (CB-03)	Case 10 (CC-01)	Case 11 (CC-02)	Case 12 (CC-03b)
Off-site Annual Dose (rem)	8.96E+00	8.96E+00	8.96E+00	3.08E+00	3.08E+00	8.96E+00
Off-site Annual Property Loss ($)	$11,168	$11,168	$11,168	$3,869	$3,869	$11,174
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.37E-05	1.37E-05	1.37E-05	3.55E-06	3.55E-06	1.37E-05
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**74.09%**	**74.09%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**65.63%**	**65.63%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$874	$874	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$3,810	$3,810	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$4,685	$4,685	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$142,888	$142,888	$0
Replacement Power Savings (On-site)	$0	$0	$0	$210,758	$210,758	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$353,646	$353,646	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$358,331**	**$358,331**	**$0**
Averted Public Exposure **(APE)**	$0	$0	$0	$153,468	$153,468	$0
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$95,252	$95,252	($78)
Total Off-site Benefit	**$0**	**$0**	**$0**	**$248,720**	**$248,720**	**($78)**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$607,051**	**$607,051**	**($78)**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 13 (CC-20)	Case 15 (CP-01)	Case 18 (CW-02)	Case 19 (CW-03)	Case 19 (CW-04)	Case 20 (CW-07)
Off-site Annual Dose (rem)	8.95E+00	1.52E+00	9.81E+00	9.79E+00	9.79E+00	8.44E+00
Off-site Annual Property Loss ($)	$11,159	$1,743	$12,301	$12,298	$12,298	$10,602
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.37E-05	6.36E-06	1.30E-05	1.33E-05	1.33E-05	1.20E-05
Reduction in CDF	**0.00%**	**53.58%**	**5.11%**	**2.92%**	**2.92%**	**12.41%**
Reduction in Off-site Dose	**0.11%**	**83.04%**	**-9.49%**	**-9.26%**	**-9.26%**	**5.80%**
Immediate Dose Savings (On-site)	$0	$632	$60	$34	$34	$146
Long Term Dose Savings (On-site)	$0	$2,755	$263	$150	$150	$638
Total Accident Related Occupational Exposure **(AOE)**	$0	$3,388	$323	$185	$185	$785
Cleanup/Decontamination Savings (On-site)	$0	$103,330	$9,854	$5,631	$5,631	$23,932
Replacement Power Savings (On-site)	$0	$152,410	$14,535	$8,306	$8,306	$35,299
Averted Costs of On-site Property Damage **(AOSC)**	$0	$255,740	$24,389	$13,937	$13,937	$59,231
Total On-site Benefit	**$0**	**$259,128**	**$24,712**	**$14,121**	**$14,121**	**$60,016**
Averted Public Exposure **(APE)**	$261	$194,184	($22,185)	($21,663)	($21,663)	$13,572
Averted Off-site Damage Savings **(AOC)**	$117	$122,996	($14,786)	($14,747)	($14,747)	$7,386
Total Off-site Benefit	**$378**	**$317,180**	**($36,971)**	**($36,410)**	**($36,410)**	**$20,958**
Total Benefit (On-site + Off-site)	**$378**	**$576,308**	**($12,258)**	**($22,288)**	**($22,288)**	**$80,974**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 21 (FR-03)	Case 22 (FR-07a)	Case22a (FR-07b)	Case 23 (HV-02)	Case 25 (SR-03)	Case 26 (AT-13)
Off-site Annual Dose (rem)	8.78E+00	4.79E+00	8.56E+00	8.96E+00	8.96E+00	8.96E+00
Off-site Annual Property Loss ($)	$10,955	$5,872	$10,665	$11,166	$11,168	$11,168
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.29E-05	9.60E-06	1.33E-05	1.37E-05	1.37E-05	1.37E-05
Reduction in CDF	**5.84%**	**29.93%**	**2.92%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**2.01%**	**46.54%**	**4.46%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$69	$353	$34	$0	$0	$0
Long Term Dose Savings (On-site)	$300	$1,539	$150	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$369	$1,892	$185	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$11,262	$57,718	$5,631	$0	$0	$0
Replacement Power Savings (On-site)	$16,611	$85,134	$8,306	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$27,874	$142,852	$13,937	$0	$0	$0
Total On-site Benefit	**$28,243**	**$144,744**	**$14,121**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$4,698	$108,837	$10,440	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$2,780	$69,113	$6,564	$26	$0	$0
Total Off-site Benefit	**$7,478**	**$177,950**	**$17,004**	**$26**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$35,720**	**$322,694**	**$31,126**	**$26**	**$0**	**$0**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 27 (AT-14)	Case 28 (SR-05R)	Case 29 (OT-08R)	Case 30 (FL-05R)	Case 31 (FL-04R)	Case 32 (FL-06R)
Off-site Annual Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Off-site Annual Property Loss ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$0	$0	$0
Replacement Power Savings (On-site)	$0	$0	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$0	$0	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$0	$0	$0	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$0	$0	$0
Total Off-site Benefit	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 33 (CC-24R)	Case 34 (CC-25R)	Case 35 (OT-07R)	Case 36 (FW-05R)	Case 37 (FR-09R)	Case 38 (FR-08)
Off-site Annual Dose (rem)	7.80E+00	8.93E+00	8.92E+00	8.64E+00	8.31E+00	3.25E+00
Off-site Annual Property Loss ($)	$9,711	$11,174	$11,120	$10,788	$10,387	$4,056
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.24E-05	1.38E-05	1.30E-05	1.28E-05	1.16E-05	6.02E-06
Reduction in CDF	**9.49%**	**0.73%**	**5.11%**	**6.57%**	**15.33%**	**56.06%**
Reduction in Off-site Dose	**12.95%**	**0.33%**	**0.45%**	**3.57%**	**7.25%**	**63.73%**
Immediate Dose Savings (On-site)	$112	$9	$60	$78	$181	$661
Long Term Dose Savings (On-site)	$488	$38	$263	$338	$788	$2,883
Total Accident Related Occupational Exposure **(AOE)**	$600	$46	$323	$415	$969	$3,545
Cleanup/Decontamination Savings (On-site)	$18,301	$1,408	$9,854	$12,670	$29,563	$108,116
Replacement Power Savings (On-site)	$26,994	$2,076	$14,535	$18,688	$43,605	$159,470
Averted Costs of On-site Property Damage **(AOSC)**	$45,295	$3,484	$24,389	$31,358	$73,168	$267,586
Total On-site Benefit	**$45,895**	**$3,530**	**$24,712**	**$31,773**	**$74,137**	**$271,131**
Averted Public Exposure **(APE)**	$30,276	$783	$1,044	$8,352	$16,965	$149,031
Averted Off-site Damage Savings **(AOC)**	$19,014	$78	$626	$4,959	$10,192	$92,812
Total Off-site Benefit	**$49,290**	**$861**	**$1,670**	**$13,311**	**$27,157**	**$241,843**
Total Benefit (On-site + Off-site)	**$95,184**	**$4,392**	**$26,383**	**$45,084**	**$101,294**	**$512,974**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 39 (AT-15R)	Case 40 (OT-09R)	Case 41 (FR-12R)	Case 42 (FR-11R)	Case 43 (FR-10R)	Case 44 (FL-07R)
Off-site Annual Dose (rem)	8.96E+00	7.81E+00	7.90E+00	3.33E+00	8.80E+00	8.96E+00
Off-site Annual Property Loss ($)	$11,168	$9,716	$9,831	$4,140	$10,976	$11,168
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.37E-05	1.26E-05	1.20E-05	6.05E-06	1.35E-05	1.37E-05
Reduction in CDF	**0.00%**	**8.03%**	**12.41%**	**55.84%**	**1.46%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**12.83%**	**11.83%**	**62.83%**	**1.79%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$95	$146	$659	$17	$0
Long Term Dose Savings (On-site)	$0	$413	$638	$2,872	$75	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$508	$785	$3,531	$92	$0
Cleanup/Decontamination Savings (On-site)	$0	$15,485	$23,932	$107,694	$2,816	$0
Replacement Power Savings (On-site)	$0	$22,841	$35,299	$158,847	$4,153	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$38,326	$59,231	$266,541	$6,968	$0
Total On-site Benefit	**$0**	**$38,834**	**$60,016**	**$270,072**	**$7,061**	**$0**
Averted Public Exposure **(APE)**	$0	$30,015	$27,666	$146,943	$4,176	$0
Averted Off-site Damage Savings **(AOC)**	$0	$18,949	$17,448	$91,715	$2,506	$0
Total Off-site Benefit	**$0**	**$48,964**	**$45,114**	**$238,658**	**$6,682**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$87,797**	**$105,130**	**$508,730**	**$13,742**	**$0**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 45 (AC/DC-30R)	Case 46 (CC-26R)	Case 47 (OT-10R)	Case 48 (FW-04)	Case 49 (CB-10R)	Case 09 (CB-08)
Off-site Annual Dose (rem)	7.32E+00	8.88E+00	8.96E+00	6.64E+00	8.96E+00	8.96E+00
Off-site Annual Property Loss ($)	$9,156	$11,070	$11,170	$8,262	$11,168	$11,168
Comparison CDF	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05	1.37E-05
Comparison Dose (rem)	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
Comparison Cost ($)	$11,168	$11,168	$11,168	$11,168	$11,168	$11,168
Enhanced CDF	1.09E-05	1.37E-05	1.37E-05	1.03E-05	1.37E-05	1.37E-05
Reduction in CDF	**20.44%**	**0.00%**	**0.00%**	**24.82%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**18.30%**	**0.89%**	**0.00%**	**25.89%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$241	$0	$0	$293	$0	$0
Long Term Dose Savings (On-site)	$1,051	$0	$0	$1,276	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$1,292	$0	$0	$1,569	$0	$0
Cleanup/Decontamination Savings (On-site)	$39,417	$0	$0	$47,864	$0	$0
Replacement Power Savings (On-site)	$58,140	$0	$0	$70,599	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$97,558	$0	$0	$118,463	$0	$0
Total On-site Benefit	**$98,850**	**$0**	**$0**	**$120,032**	**$0**	**$0**
Averted Public Exposure **(APE)**	$42,804	$2,088	$0	$60,552	$0	$0
Averted Off-site Damage Savings **(AOC)**	$26,257	$1,279	$26	$37,923	$0	$0
Total Off-site Benefit	**$69,061**	**$3,367**	**$26**	**$98,475**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$167,910**	**$3,367**	**$26**	**$218,507**	**$0**	**$0**

Table B-3: Fire Benefit Results for Analysis Cases

Case	Case 09 (CB-09)
Off-site Annual Dose (rem)	8.96E+00
Off-site Annual Property Loss ($)	$11,168
Comparison CDF	1.37E-05
Comparison Dose (rem)	8.96E+00
Comparison Cost ($)	$11,168
Enhanced CDF	1.37E-05
Reduction in CDF	**0.00%**
Reduction in Off-site Dose	**0.00%**
Immediate Dose Savings (On-site)	$0
Long Term Dose Savings (On-site)	$0
Total Accident Related Occupational Exposure **(AOE)**	$0
Cleanup/Decontamination Savings (On-site)	$0
Replacement Power Savings (On-site)	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0
Total On-site Benefit	**$0**
Averted Public Exposure **(APE)**	$0
Averted Off-site Damage Savings **(AOC)**	$0
Total Off-site Benefit	**$0**
Total Benefit (On-site + Off-site)	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Maximum Benefit	Case 01 (AC/DC-01)	Case 01 (AC/DC-02)	Case 01 (AC/DC-03)	Case 02 (AC/DC-10)	Case 02 (AC/DC-15)
Off-site Annual Dose (rem)	5.91E+00	5.90E+00	5.90E+00	5.90E+00	5.82E+00	5.82E+00
Off-site Annual Property Loss ($)	$8,444	$8,436	$8,436	$8,436	$8,311	$8,311
Comparison CDF	----	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	----	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	----	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	----	4.86E-06	4.86E-06	4.86E-06	4.83E-06	4.83E-06
Reduction in CDF	----	**0.00%**	**0.00%**	**0.00%**	**0.62%**	**0.62%**
Reduction in Off-site Dose	----	**0.17%**	**0.17%**	**0.17%**	**1.52%**	**1.52%**
Immediate Dose Savings (On-site)	$419	$0	$0	$0	$3	$3
Long Term Dose Savings (On-site)	$1,824	$0	$0	$0	$11	$11
Total Accident Related Occupational Exposure **(AOE)**	$2,243	$0	$0	$0	$14	$14
Cleanup/Decontamination Savings (On-site)	$68,417	$0	$0	$0	$422	$422
Replacement Power Savings (On-site)	$100,915	$0	$0	$0	$623	$623
Averted Costs of On-site Property Damage **(AOSC)**	$169,332	$0	$0	$0	$1,045	$1,045
Total On-site Benefit	**$171,575**	**$0**	**$0**	**$0**	**$1,059**	**$1,059**
Averted Public Exposure **(APE)**	$154,251	$261	$261	$261	$2,349	$2,349
Averted Off-site Damage Savings **(AOC)**	$110,194	$104	$104	$104	$1,736	$1,736
Total Off-site Benefit	**$264,445**	**$365**	**$365**	**$365**	**$4,085**	**$4,085**
Total Benefit (On-site + Off-site)	**$436,020**	**$365**	**$365**	**$365**	**$5,144**	**$5,144**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 02 (AC/DC-16)	Case 03 (AC/DC-23)	Case 04 (AC/DC-27)	Case 05 (AC/DC-28)	Case 06 (AC/DC-29)	Case 07 (AT-05)
Off-site Annual Dose (rem)	5.82E+00	5.91E+00	5.91E+00	5.90E+00	5.90E+00	5.89E+00
Off-site Annual Property Loss ($)	$8,311	$8,444	$8,444	$8,441	$8,437	$8,429
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.83E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**0.62%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**1.52%**	**0.00%**	**0.00%**	**0.17%**	**0.17%**	**0.34%**
Immediate Dose Savings (On-site)	$3	$0	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$11	$0	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$14	$0	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$422	$0	$0	$0	$0	$0
Replacement Power Savings (On-site)	$623	$0	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$1,045	$0	$0	$0	$0	$0
Total On-site Benefit	**$1,059**	**$0**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$2,349	$0	$0	$261	$261	$522
Averted Off-site Damage Savings **(AOC)**	$1,736	$0	$0	$39	$91	$196
Total Off-site Benefit	**$4,085**	**$0**	**$0**	**$300**	**$352**	**$718**
Total Benefit (On-site + Off-site)	**$5,144**	**$0**	**$0**	**$300**	**$352**	**$718**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 08 (AT-07)	Case 09 (CB-01)	Case 09 (CB-03)	Case 10 (CC-01)	Case 11 (CC-02)	Case 12 (CC-03b)
Off-site Annual Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.80E+00	5.80E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,444	$8,444	$8,444	$8,309	$8,309	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	4.86E-06	4.86E-06	4.74E-06	4.74E-06	4.86E-06
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**2.47%**	**2.47%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**1.86%**	**1.86%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$10	$10	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$45	$45	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$55	$55	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$1,689	$1,689	$0
Replacement Power Savings (On-site)	$0	$0	$0	$2,492	$2,492	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$4,181	$4,181	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$4,236**	**$4,236**	**$0**
Averted Public Exposure **(APE)**	$0	$0	$0	$2,871	$2,871	$0
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$1,762	$1,762	$0
Total Off-site Benefit	**$0**	**$0**	**$0**	**$4,633**	**$4,633**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$8,869**	**$8,869**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 13 (CC-20)	Case 15 (CP-01)	Case 18 (CW-02)	Case 19 (CW-03)	Case 19 (CW-04)	Case 20 (CW-07)
Off-site Annual Dose (rem)	5.91E+00	5.85E+00	5.91E+00	5.91E+00	5.91E+00	5.90E+00
Off-site Annual Property Loss ($)	$8,444	$8,370	$8,444	$8,444	$8,444	$8,434
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	4.82E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**0.00%**	**0.82%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**1.02%**	**0.00%**	**0.00%**	**0.00%**	**0.17%**
Immediate Dose Savings (On-site)	$0	$3	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$0	$15	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$18	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$0	$563	$0	$0	$0	$0
Replacement Power Savings (On-site)	$0	$831	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$1,394	$0	$0	$0	$0
Total On-site Benefit	**$0**	**$1,412**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$0	$1,566	$0	$0	$0	$261
Averted Off-site Damage Savings **(AOC)**	$0	$966	$0	$0	$0	$131
Total Off-site Benefit	**$0**	**$2,532**	**$0**	**$0**	**$0**	**$391**
Total Benefit (On-site + Off-site)	**$0**	**$3,944**	**$0**	**$0**	**$0**	**$391**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 21 (FR-03)	Case 22 (FR-07a)	Case22a (FR-07b)	Case 23 (HV-02)	Case 25 (SR-03)	Case 26 (AT-13)
Off-site Annual Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.87E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,444	$8,444	$8,444	$8,444	$8,395	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.82E-06	4.86E-06
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.82%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.68%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$0	$3	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$0	$15	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$0	$18	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$0	$563	$0
Replacement Power Savings (On-site)	$0	$0	$0	$0	$831	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$0	$1,394	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$0**	**$1,412**	**$0**
Averted Public Exposure **(APE)**	$0	$0	$0	$0	$1,044	$0
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$0	$639	$0
Total Off-site Benefit	**$0**	**$0**	**$0**	**$0**	**$1,683**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$0**	**$3,096**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 27 (AT-14)	Case 28 (SR-05R)	Case 29 (OT-08R)	Case 30 (FL-05R)	Case 31 (FL-04R)	Case 32 (FL-06R)
Off-site Annual Dose (rem)	5.91E+00	6.52E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,444	$9,165	$8,444	$8,444	$8,444	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	5.76E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**0.00%**	**18.52%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**10.32%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$78	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$0	$338	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$415	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$0	$12,670	$0	$0	$0	$0
Replacement Power Savings (On-site)	$0	$18,688	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$31,358	$0	$0	$0	$0
Total On-site Benefit	**$0**	**$31,773**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$0	$15,921	$0	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$0	$9,409	$0	$0	$0	$0
Total Off-site Benefit	**$0**	**$25,330**	**$0**	**$0**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$57,103**	**$0**	**$0**	**$0**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 33 (CC-24R)	Case 34 (CC-25R)	Case 35 (OT-07R)	Case 36 (FW-05R)	Case 37 (FR-09R)	Case 38 (FR-08)
Off-site Annual Dose (rem)	5.91E+00	5.90E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,444	$8,445	$8,444	$8,444	$8,444	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.17%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$0	$0	$0
Replacement Power Savings (On-site)	$0	$0	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$0	$0	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$0	$261	$0	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$0	$13	$0	$0	$0	$0
Total Off-site Benefit	**$0**	**$274**	**$0**	**$0**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$274**	**$0**	**$0**	**$0**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 39 (AT-15R)	Case 40 (OT-09R)	Case 41 (FR-12R)	Case 42 (FR-11R)	Case 43 (FR-10R)	Case 44 (FL-07R)
Off-site Annual Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$0	$0	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$0	$0	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$0	$0	$0	$0	$0	$0
Replacement Power Savings (On-site)	$0	$0	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0	$0	$0	$0	$0	$0
Total On-site Benefit	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$0	$0	$0	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$0	$0	$0	$0	$0	$0
Total Off-site Benefit	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 45 (AC/DC-30R)	Case 46 (CC-26R)	Case 47 (OT-10R)	Case 48 (FW-04)	Case 49 (CB-10R)	Case 09 (CB-08)
Off-site Annual Dose (rem)	5.77E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Off-site Annual Property Loss ($)	$8,241	$8,444	$8,444	$8,444	$8,444	$8,444
Comparison CDF	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Comparison Dose (rem)	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Comparison Cost ($)	$8,444	$8,444	$8,444	$8,444	$8,444	$8,444
Enhanced CDF	4.75E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06	4.86E-06
Reduction in CDF	**2.26%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Reduction in Off-site Dose	**2.37%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**
Immediate Dose Savings (On-site)	$9	$0	$0	$0	$0	$0
Long Term Dose Savings (On-site)	$41	$0	$0	$0	$0	$0
Total Accident Related Occupational Exposure **(AOE)**	$51	$0	$0	$0	$0	$0
Cleanup/Decontamination Savings (On-site)	$1,549	$0	$0	$0	$0	$0
Replacement Power Savings (On-site)	$2,284	$0	$0	$0	$0	$0
Averted Costs of On-site Property Damage **(AOSC)**	$3,833	$0	$0	$0	$0	$0
Total On-site Benefit	**$3,883**	**$0**	**$0**	**$0**	**$0**	**$0**
Averted Public Exposure **(APE)**	$3,654	$0	$0	$0	$0	$0
Averted Off-site Damage Savings **(AOC)**	$2,649	$0	$0	$0	$0	$0
Total Off-site Benefit	**$6,303**	**$0**	**$0**	**$0**	**$0**	**$0**
Total Benefit (On-site + Off-site)	**$10,187**	**$0**	**$0**	**$0**	**$0**	**$0**

Table B-4: Seismic Benefit Results for Analysis Cases

Case	Case 09 (CB-09)
Off-site Annual Dose (rem)	5.91E+00
Off-site Annual Property Loss ($)	$8,444
Comparison CDF	4.86E-06
Comparison Dose (rem)	5.91E+00
Comparison Cost ($)	$8,444
Enhanced CDF	4.86E-06
Reduction in CDF	**0.00%**
Reduction in Off-site Dose	**0.00%**
Immediate Dose Savings (On-site)	$0
Long Term Dose Savings (On-site)	$0
Total Accident Related Occupational Exposure **(AOE)**	$0
Cleanup/Decontamination Savings (On-site)	$0
Replacement Power Savings (On-site)	$0
Averted Costs of On-site Property Damage **(AOSC)**	$0
Total On-site Benefit	**$0**
Averted Public Exposure **(APE)**	$0
Averted Off-site Damage Savings **(AOC)**	$0
Total Off-site Benefit	**$0**
Total Benefit (On-site + Off-site)	**$0**

Table B-5: Total Benefit Results for Analysis Cases

	Maximum Benefit	Case 01 (AC/DC-01)	Case 01 (AC/DC-02)	Case 01 (AC/DC-03)	Case 02 (AC/DC-10)	Case 02 (AC/DC-15)	Case 02 (AC/DC-16)	Case 03 (AC/DC-23)
Internal Events	$500,446	$1,464	$1,464	$1,464	$5,085	$5,085	$5,085	$28,568
Fire	$863,256	$0	$0	$0	$73,012	$73,012	$73,012	$13,860
Seismic	$436,020	$365	$365	$365	$5,144	$5,144	$5,144	$0
Other	$500,446	$1,464	$1,464	$1,464	$5,085	$5,085	$5,085	$28,568
Total Benefit	$2,300,169	$3,294	$3,294	$3,294	$88,327	$88,327	$88,327	$70,997

	Case 04 (AC/DC-27)	Case 05 (AC/DC-28)	Case 06 (AC/DC-29)	Case 07 (AT-05)	Case 08 (AT-07)	Case 09 (CB-01)	Case 09 (CB-03)	Case 10 (CC-01)
Internal Events	$47,920	$1,098	$2,458	$20,328	$0	$10,121	$10,121	$288,908
Fire	$321,712	$4,300	$12,692	$0	$0	$0	$0	$607,051
Seismic	$0	$300	$352	$718	$0	$0	$0	$8,869
Other	$47,920	$1,098	$2,458	$20,328	$0	$10,121	$10,121	$288,908
Total Benefit	$417,553	$6,797	$17,959	$41,375	$0	$20,243	$20,243	$1,193,736

Table B-5: Total Benefit Results for Analysis Cases

	Case 11 (CC-02)	Case 12 (CC-03b)	Case 13 (CC-20)	Case 15 (CP-01)	Case 18 (CW-02)	Case 19 (CW-03)	Case 19 (CW-04)	Case 20 (CW-07)
Internal Events	$288,908	$327	$3,501	$217,779	$56,689	$8,248	$8,248	$54,891
Fire	$607,051	($78)	$378	$576,308	($12,258)	($22,288)	($22,288)	$80,974
Seismic	$8,869	$0	$0	$3,944	$0	$0	$0	$391
Other	$288,908	$327	$3,501	$217,779	$56,689	$8,248	$8,248	$54,891
Total Benefit	$1,193,736	$576	$7,380	$1,015,810	$101,120	($5,792)	($5,792)	$191,148

	Case 21 (FR-03)	Case 22 (FR-07a)	Case 22a (FR-07b)	Case 23 (HV-02)	Case 25 (SR-03)	Case 26 (AT-13)	Case 27 (AT-14)	Case 28 (SR-05R)
Internal Events	$0	$0	$0	$1,098	$0	$4,857	$0	$0
Fire	$35,720	$322,694	$31,126	$26	$0	$0	$0	$0
Seismic	$0	$0	$0	$0	$3,096	$0	$0	$57,103
Other	$0	$0	$0	$1,098	$0	$4,857	$0	$0
Total Benefit	$35,720	$322,694	$31,126	$2,221	$3,096	$9,715	$0	$57,103

	Case 29 (OT-08R)	Case 30 (FL-05R)	Case 31 (FL-04R)	Case 32 (FL-06R)	Case 33 (CC-24R)	Case 34 (CC-25R)	Case 35 (OT-07R)	Case 36 (FW-05R)
Internal Events	$4,692	$127,374	$128,197	$64,889	$36,357	$3,475	$85,607	$13,367
Fire	$0	$0	$0	$0	$95,184	$4,392	$26,383	$45,084
Seismic	$0	$0	$0	$0	$0	$274	$0	$0
Other	$4,692	$127,374	$128,197	$64,889	$36,357	$3,475	$85,607	$13,367
Total Benefit	$9,385	$254,748	$256,394	$129,777	$167,897	$11,615	$197,597	$71,819

Table B-5: Total Benefit Results for Analysis Cases

	Case 37 (FR-09R)	Case 38 (FR-08)	Case 39 (AT-15R)	Case 40 (OT-09R)	Case 41 (FR-12R)	Case 42 (FR-11R)	Case 43 (FR-10R)	Case 44 (FL-07R)
Internal Events	$0	$0	$39,864	$21,473	$0	$0	$0	$5,403
Fire	$101,294	$512,974	$0	$87,797	$105,130	$508,730	$13,742	$0
Seismic	$0	$0	$0	$0	$0	$0	$0	$0
Other	$0	$0	$39,864	$21,473	$0	$0	$0	$5,403
Total Benefit	$101,294	$512,974	$79,728	$130,744	$105,130	$508,730	$13,742	$10,805

	Case 45 (AC/DC-30R)	Case 46 (CC-26R)	Case 47 (OT-10R)	Case 48 (FW-04)	Case 49 (CB-10R)	Case 09 (CB-08)	Case 09 (CB-09)
Internal Events	($11,085)	$1,189	$718	$203,081	$9,981	$10,121	$10,121
Fire	$167,910	$3,367	$26	$218,507	$0	$0	$0
Seismic	$10,187	$0	$0	$0	$0	$0	$0
Other	($11,085)	$1,189	$718	$203,081	$9,981	$10,121	$10,121
Total Benefit	$155,927	$5,745	$1,463	$624,669	$19,962	$20,243	$20,243

Table B-6: Implementation Cost Estimates

SAMA ID	Potential Enhancement	Cost Estimate	Date of Cost Estimate	Present Day Estimate (2008)
AC/DC-01	Provide additional DC battery capacity.	$1,730,000	2007	$1,799,200
AC/DC-02	Replace lead-acid batteries with fuel cells.	$1,000,000	2007	$1,040,000
AC/DC-03	Add a portable, diesel-driven battery charger to existing DC system.	$500,000	2008	$500,000
AC/DC-10	Provide an additional DG.	$10,000,000	2006	$10,816,000
AC/DC-15	Install a gas turbine generator.	$2,000,000	2007	$2,080,000
AC/DC-16	Install tornado protection on gas turbine generator.	>$2,000,000 (cost gas turbine + cost tornado protection)	2007	$2,080,000
AC/DC-23	Develop procedures to repair or replace failed 4 kV breakers.	$375,000	2008	$375,000
AC/DC-27	Install permanent hardware changes that make it possible to establish 500 kV backfeed through the main set-up transformer.	$1,700,000	2008	$1,700,000
AC/DC-28	Reduce CCFs between DG-3 and DG-1/2.	$100,000	2008	$100,000
AC/DC-29	Replace DG-3 with a diesel diverse from DG-1 and DG-2.	$4,200,000	2008	$4,200,000
AT-05	Add an independent boron injection system.	$800,000	2008	$800,000
AT-07	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	$1,000,000	2005	$1,124,864
AT-13	Automate SLC injection in response to ATWS event.	$660,000	2008	$660,000
AT-14	Diversify SLC explosive valve operation.	$370,000	2008	$370,000
CB-01	Install an additional pressure or leak monitoring instruments for detection of ISLOCAs.	$5,600,000	2008	$5,600,000
CB-03	Increase leak testing of valves in ISLOCA paths.	$400,000	2008	$400,000
CB-08	Revise EOPs to improve ISLOCA identification. The cost estimate includes the instrumentation cost (CB-01, $5,600,000) and $20,000 for revising procedures.	$5,620,000	2008	$5,620,000

Table B-6: Implementation Cost Estimates

SAMA ID	Potential Enhancement	Cost Estimate	Date of Cost Estimate	Present Day Estimate (2008)
CB-09	Improve operator training on ISLOCA coping. The cost estimate includes the instrumentation cost (CB-01, $5,600,000) and $30,000 for revising procedures.	$5,630,000	2008	$5,630,000
CC-01	Install an independent active or passive high pressure injection system.	$28,000,000	2007	$29,120,000
CC-02	Provide an additional high pressure injection pump with independent diesel.	$5,000,000	2007	$5,200,000
CC-03b	Raise RCIC backpressure trip set points.	$82,000	2008	$82,000
CC-20	Improve ECCS suction strainers or replace insulation in containment.	$10,000,000	2008	$10,000,000
CP-01	Install an independent method of SPC.	$6,000,000	2008	$6,000,000
CW-02	Add redundant DC control power for pumps.	$650,000	2008	$650,000
CW-03	Replace ECCS pump motors with air-cooled motors.	$1,000,000	2005	$1,124,864
CW-04	Provide self-cooled ECCS seals.	$675,000	2008	$675,000
CW-07	Add a SW pump.	$5,900,000	2007	$6,136,000
FR-03	Install additional transfer and isolation switches.	$2,000,000	2008	$2,000,000
FR-07a	Improve the fire resistance of cables to the containment vent valve.	$400,000	2008	$400,000
FR-07b	Improve the fire resistance of cables to transformer E-TR-S.	$100,000	2008	$100,000
FR-08	Improve the fire resistance of cables to RHR and SW.	$1,250,000	2010	$1,250,000[1]
HV-02	Provide a redundant train or means of ventilation.	$480,000	2008	$480,000
SR-03	Modify safety related CST.	$980,000	2008	$980,000
SR-05R	Improve seismic ruggedness of MCC-7F and MCC-8F.	$152,000	2010	$152,000[1]
OT-08R	Install explosion protection around CGS transformers.	$700,000	2010	$700,000[2]

[1] This cost estimate was determined in 2010 in response to a RAI from the NRC. The 2010 cost estimate was used in the cost-benefit analysis for SAMA candidates FR-08 and SR-05R.

Table B-6: Implementation Cost Estimates

SAMA ID	Potential Enhancement	Cost Estimate	Date of Cost Estimate	Present Day Estimate (2008)
FL-05R	Install clamp-on flow instruments to certain drain lines in the Control Building area of the Radwaste Building with alarms in the Control Room.	$250,000	2010	$250,000[2]
FL-04R	Add one isolation valve in the SW, TSW, and FP lines in the Control Building area of the Radwaste Building.	$377,000	2010	$377,000[2]
FL-06R	Perform additional NDE and inspections of the SW, TSW, and FP lines in the Control Building area of the Radwaste Building.	$13,500	2010	$13,500[2]
CC-24R	Backfeed the HPCS system with SM-8 to provide a third power source for HPCS.	$105,000	2010	$105,000[2]
CC-25R	Enhance alternate injection reliability by including RHRSW and fire water cross-tie in the maintenance program.	$13,000	2010	$13,000[2]
OT-07R	Improve procedures and operator training to identify systems and operator actions determined to be important from the PSA.	$40,000	2010	$40,000[2]
FW-05R	Examine the potential for operators to control RFW and avoid a reactor trip.	$29,000	2010	$29,000[2]
FR-09R	Install early fire detection in the following Reactor Building analysis units: R-1B, R-1D, and R-1J.	$680,000	2010	$680,000[2]
AT-15R	Install modifications to make use of HPCS more likely for ATWS.	$2,825,000	2010	$2,825,000[2]
OT-09R	For the non-LOCA initiating events, credit the Z (PCS recovery) function.	$130,000	2010	$130,000[2]
FR-12R	Install early fire detection in the following physical analysis units: T-1A, T-12, T-1C, and T-1D.	$725,000	2010	$725,000[3]

[2] This cost estimate was determined in 2010 in response to a request for additional information (RAI) from the NRC. The 2010 cost estimate was used in the cost-benefit analysis for SAMA candidates OT-08R, FL-05R, FL-04R, FL-06R, CC-24R, CC-25R, OT-07R, FW-05R, FR-09R, AT-15R, and OT-09R.

[3] This cost estimate was determined in 2010 in response to a request for additional information (RAI) from the NRC. The 2010 cost estimate was used in the cost-benefit analysis for SAMA candidates FR-12R, FR-11R, FR-10R, FL-07R, AC/DC-30R, CC-26R, OT-10R, FW-04, and CB-10R.

Table B-6: Implementation Cost Estimates

SAMA ID	Potential Enhancement	Cost Estimate	Date of Cost Estimate	Present Day Estimate (2008)
FR-11R	Install early fire detection in the following analysis units: RC-02, RC-03, RC-04, RC-05, RC-07, RC-08, RC-11, RC-13, RC-14, and RC-1A.	$1,035,000	2010	$1,035,000[3]
FR-10R	Install early fire detection in the Main Control Room: RC-10.	$535,000	2010	$535,000[3]
FL-07R	Protect the HPCS from flooding resulting from ISLOCA events.	$1,050,000	2010	$1,050,000[3]
AC/DC-30R	Provide an additional DG diverse from DG-1 and DG-2.	$10,000,000	2010	$10,000,000[3]
CC-26R	Install hard pipe from diesel fire pump to vessel.	$710,000	2010	$710,000[3]
OT-10R	Increase fire pump house building integrity to withstand higher winds so the fire system will be capable of withstanding a severe weather event.	$735,000	2010	$735,000[3]
FW-04	Add a motor-driven feedwater pump.	$10,000,000	2010	$10,000,000[3]
CB-10R	Provide additional NDE and inspections of MS pipe in Turbine Building.	$125,000	2010	$125,000[3]

Table B-7: Final Results of the Cost-Benefit Evaluation

SAMD ID	Modification	Analysis Case	Estimated Benefit	Cost of Implementation	Conclusion
AC/DC-01	Provide additional DC battery capacity.	Case 01	$3,294	$1,799,200	Not Cost Effective
AC/DC-02	Replace lead-acid batteries with fuel cells.	Case 01	$3,294	$1,040,000	Not Cost Effective
AC/DC-03	Add a portable, diesel-driven battery charger to existing DC system.	Case 01	$3,294	$500,000	Not Cost Effective
AC/DC-10	Provide an additional DG.	Case 02	$88,327	$10,816,000	Not Cost Effective
AC/DC-15	Install a gas turbine generator.	Case 02	$88,327	$2,080,000	Not Cost Effective
AC/DC16	Install tornado protection on gas turbine generator.	Case 02	$88,327	$2,080,000	Not Cost Effective
AC/DC-23	Develop procedures to repair or replace failed 4 KV breakers.	Case 03	$70,997	$375,000	Not Cost Effective
AC/DC-27	Install permanent hardware changes that make it possible to establish 500 kV backfeed through the main set-up transformer.	Case 04	$417,553	$1,700,000	Not Cost Effective
AC/DC-28	Reduce CCFs between DG-3 and DG-1/2.	Case 05	$6,797	$100,000	Not Cost Effective
AC/DC-29	Replace DG-3 with a diesel diverse from DG-1 and DG-2.	Case 06	$17,959	$4,200,000	Not Cost Effective
AT-05	Add an independent boron injection system.	Case 07	$41,375	$800,000	Not Cost Effective
AT-07	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Case 08	$0	$1,124,864	Not Cost Effective
AT-13	Automate SLC injection in response to ATWS event.	Case 26	$9,715	$660,000	Not Cost Effective
AT-14	Diversify SLC explosive valve operation.	Case 27	$0	$370,000	Not Cost Effective
CB-01	Install an additional pressure or leak monitoring instruments for detection of ISLOCAs.	Case 09	$20,243	$5,600,000	Not Cost Effective
CB-03	Increase leak testing of valves in ISLOCA paths.	Case 09	$20,243	$400,000	Not Cost Effective
CB-08	Revise EOPs to improve ISLOCA identification.	Case 09	$20,243	$5,620,000	Not Cost Effective
CB-09	Improve operator training on ISLOCA coping.	Case 09	$20,243	$5,630,000	Not Cost Effective
CC-01	Install an independent active or passive high pressure injection system.	Case 10	$1,193,736	$29,120,000	Not Cost Effective
CC-02	Provide an additional high pressure injection pump with independent diesel.	Case 11	$1,193,736	$5,200,000	Not Cost Effective
CC-03b	Raise RCIC backpressure trip set points.	Case 12	$576	$82,000	Not Cost Effective

Table B-7: Final Results of the Cost-Benefit Evaluation

SAMD ID	Modification	Analysis Case	Estimated Benefit	Cost of Implementation	Conclusion
CC-20	Improve ECCS suction strainers or replace insulation in containment.	Case 13	$7,380	$10,000,000	Not Cost Effective
CP-01	Install an independent method of SPC.	Case 15	$1,015,810	$6,000,000	Not Cost Effective
CW-02	Add redundant DC control power for pumps.	Case 18	$101,120	$650,000	Not Cost Effective
CW-03	Replace ECCS pump motors with air-cooled motors.	Case 19	($5,792)	$1,124,864	Not a viable SAMA candidate.
CW-04	Provide self-cooled ECCS seals.	Case 19	($5,792)	$675,000	Not a viable SAMA candidate.
CW-07	Add a SW pump.	Case 20	$191,148	$6,136,000	Not Cost Effective
FR-03	Install additional transfer and isolation switches.	Case 21	$35,720	$2,000,000	Not Cost Effective
FR-07a	Improve the fire resistance of cable to the containment vent valve.	Case 22	$322,694	$400,000	Not Cost Effective
FR-07b	Improve the fire resistance of cable to transformer E-TR-S.	Case 22a	$31,126	$100,000	Not Cost Effective
FR-08	Improve the fire resistance of cables to RHR and SW.	Case 38	$512,974	$1,250,000	Not Cost Effective
HV-02	Provide a redundant train or means of ventilation.	Case 23	$2,221	$480,000	Not Cost Effective
SR-03	Modify safety-related CST.	Case 25	$3,096	$980,000	Not Cost Effective
SR-05R	Improve seismic ruggedness of MCC-7F and MCC-8F.	Case 28	$57,103	$152,000	Not Cost Effective
OT-08R	Install explosion protection around CGS transformers.	Case 29	$9,385	$700,000	Not Cost Effective
FL-05R	Install clamp-on flow instruments to certain drain lines in the Control Building area of the Radwaste Building with alarms in the Control Room.	Case 30	$254,748	$250,000	Cost Effective
FL-04R	Add one isolation valve in the SW, TSW, and FP lines in the Control Building area of the Radwaste Building.	Case 31	$256,394	$377,000	Not Cost Effective
FL-06R	Perform additional NDE and inspections of the SW, TSW, and FP lines in the Control Building area of the Radwaste Building.	Case 32	$129,777	$13,500	Cost Effective
CC-24R	Backfeed the HPCS system with SM-8 to provide a third power source for HPCS.	Case 33	$167,897	$105,000	Cost Effective
CC-25R	Enhance alternate injection reliability by including RHRSW and fire water cross-tie in the maintenance program.	Case 34	$11,615	$13,000	Not Cost Effective

Table B-7: Final Results of the Cost-Benefit Evaluation

SAMD ID	Modification	Analysis Case	Estimated Benefit	Cost of Implementation	Conclusion
OT-07R	Improve procedures and operator training to identify systems and operator actions determined to be important from the PSA.	Case 35	$197,597	$40,000	Cost Effective
FW-05R	Examine the potential for operators to control RFW and avoid a reactor trip.	Case 36	$66,860	$29,000	Cost Effective
FR-09R	Install early fire detection in the following Reactor Building analysis units: R-1B, R-1D, and R-1J.	Case 37	$101,294	$680,000	Not Cost Effective
AT-15R	Install modifications to make use of HPCS more likely for ATWS.	Case 39	$79,728	$2,825,000	Not Cost Effective
OT-09R	For the non-LOCA initiating events, credit the Z (PCS recovery) function.	Case 40	$130,744	$130,000	Cost Effective
FR-12R	Install early fire detection in the following physical analysis units: T-1A, T-12, T-1C, and T-1D.	Case 41	$105,130	$725,000	Not Cost Effective
FR-11R	Install early fire detection in the following analysis units: RC-02, RC-03, RC-04, RC-05, RC-07, RC-08, RC-11, RC-13, RC-14, and RC-1A.	Case 42	$508,730	$1,035,000	Not Cost Effective
FR-10R	Install early fire detection in the Main Control Room: RC-10.	Case 43	$13,742	$535,000	Not Cost Effective
FL-07R	Protect the HPCS from flooding resulting from ISLOCA events.	Case 44	$10,805	$1,050,000	Not Cost Effective
AC/DC-30R	Provide an additional DG diverse from DG-1 and DG-2.	Case 45	$155,927	$10,000,000	Not Cost Effective
CC-26R	Install hard pipe from diesel fire pump to vessel.	Case 46	$5,745	$710,000	Not Cost Effective
OT-10R	Increase fire pump house building integrity to withstand higher winds so the fire system will be capable of withstanding a severe weather event.	Case 47	$1,463	$735,000	Not Cost Effective
FW-04	Add a motor-driven feedwater pump.	Case 48	$624,669	$10,000,000	Not Cost Effective
CB-10R	Provide additional NDE and inspections of MS pipe in Turbine Building.	Case 49	$19,962	$125,000	Not Cost Effective

Table B-8: Final Results of the Sensitivity Cases

SAMA ID	Sensitivity Case #1	Sensitivity Case #2[1]	Estimated Cost (2008/2010)	Conclusion
AC/DC-01	$4,338	$8,125	$1,799,200	Not Cost Effective
AC/DC-02	$4,338	$8,125	$1,040,000	Not Cost Effective
AC/DC-03	$4,338	$8,125	$500,000	Not Cost Effective
AC/DC-10	$124,168	$229,673	$10,816,000	Not Cost Effective
AC/DC-15	$124,168	$229,673	$2,080,000	Not Cost Effective
AC/DC-16	$124,168	$229,673	$2,080,000	Not Cost Effective
AC/DC-23	$103,456	$173,164	$375,000	Not Cost Effective
AC/DC-27	$597,972	$1,066,469	$1,700,000	Not Cost Effective
AC/DC-28	$9,022	$17,353	$100,000	Not Cost Effective
AC/DC-29	$23,879	$45,853	$4,200,000	Not Cost Effective
AT-05	$64,739	$99,730	$800,000	Not Cost Effective
AT-07	$0	$0	$1,124,864	Not Cost Effective
AT-13	$14,999	$23,315	$660,000	Not Cost Effective
AT-14	$0	$0	$370,000	Not Cost Effective
CB-01	$30,499	$48,582	$5,600,000	Not Cost Effective
CB-03	$30,499	$48,582	$400,000	Not Cost Effective
CB-08	$30,499	$48,582	$5,620,000	Not Cost Effective
CB-09	$30,499	$48,582	$5,630,000	Not Cost Effective
CC-01	$1,709,802	$2,991,699	$29,120,000	Not Cost Effective
CC-02	$1,709,802	$2,991,699	$5,200,000	Not Cost Effective
CC-03b	$673	$1,366	$82,000	Not Cost Effective
CC-20	$10,840	$17,788	$10,000,000	Not Cost Effective
CP-01	$1,511,838	$2,555,573	$6,000,000	Not Cost Effective
CW-02	$136,498	$240,236	$650,000	Not Cost Effective
CW-03	($20,934)	($18,357)	$1,124,864	Not Cost Effective
CW-04	($20,934)	($18,357)	$675,000	Not Cost Effective
CW-07	$270,705	$475,184	$6,136,000	Not Cost Effective
FR-03	$47,994	$92,873	$2,000,000	Not Cost Effective
FR-07a	$477,812	$839,005	$400,000	Cost Effective–Sensitivity Cases 1 & 2
FR-07b	$46,023	$80,926	$100,000	Not Cost Effective
FR-08	$743,114	$1,333,731	$1,250,000	Cost Effective–Sensitivity Case 2
HV-02	$3,122	$5,336	$480,000	Not Cost Effective
SR-03	$4,574	$9,287	$980,000	Not Cost Effective
SR-05R	$82,084	$171,310	$152,000	Cost Effective–Sensitivity Case 2
OT-08R	$12,471	$22,524	$700,000	Not Cost Effective
FL-05R	$388,192	$611,395	$250,000	Cost Effective

Table B-8: Final Results of the Sensitivity Cases

SAMA ID	Sensitivity Case #1	Sensitivity Case #2[1]	Estimated Cost (2008/2010)	Conclusion
FL-04R	$390,642	$615,345	$377,000	Cost Effective–Sensitivity Cases 1 & 2
FL-06R	$197,662	$311,465	$13,500	Cost Effective
CC-24R	$244,548	$421,991	$105,000	Cost Effective
CC-25R	$16,457	$28,919	$13,000	Cost Effective – Sensitivity Cases 1 & 2
OT-07R	$264,720	$479,509	$40,000	Cost Effective
FW-05R	$99,445	$181,382	$29,000	Cost Effective
FR-09R	$138,485	$263,365	$680,000	Not Cost Effective
AT-15R	$101,544	$191,348	$2,825,000	Not Cost Effective
OT-09R	$193,609	$331,346	$130,000	Cost Effective
FR-12R	$150,512	$273,337	$725,000	Not Cost Effective
FR-11R	$736,493	$1,322,699	$1,035,000	Cost Effective – Sensitivity Case 2
FR-10R	$19,989	$35,730	$535,000	Not Cost Effective
FL-07R	$17,942	$25,933	$1,050,000	Not Cost Effective
AC/DC-30R	$225,380	$413,919	$10,000,000	Not Cost Effective
CC-26R	$8,973	$14,461	$710,000	Not Cost Effective
OT-10R	$2,146	$3,516	$735,000	Not Cost Effective
FW-04	$904,245	$1,542,907	$10,000,000	Not Cost Effective
CB-10R	$28,619	$47,910	$125,000	Not Cost Effective

[1] The replacement power component for Sensitivity Case 1 (3% Discount Rate) is calculated using the replacement power net present value for a 1% and 5% discount rate and interpolating for the 3% discount rate.

Table E.4-4 Fire LERF Contribution for Each Plant Damage State (continued)

PDS	Description	PDS Frequency	LERF Split Fraction	Total LERF Contribution (per year)
1HB	LOOP sequences with no high or low pressure injection, but RPV depressurization is successful. This results in core damage before containment failure, with the reactor at low pressure. HPCS is not recoverable.	7.7E-8	7.8E-4	5.97E-11
2B	Transient with stuck-open SRV or LOCA with loss of containment heat removal. Containment failure occurs prior to core damage with the reactor vessel at low pressure.	2.8E-8	0.0	0.0E+0
~~2C~~	~~Transient with stuck open SRV or LOCA with loss of containment heat removal. Containment failure occurs prior to core damage with the reactor vessel at low pressure.~~	~~1.5E-6~~	~~0.0~~	~~0.0E+0~~
2D	Transient with loss of containment heat removal. Containment fails prior to core damage with the reactor vessel at high pressure.	~~0.0E+0~~ 1.5E-6	~~n/a~~ 0.0	0.0E+0
4BA	ATWS with vessel intact at time of core uncovery, which indicates high pressure core damage with containment failed.	2.7E-10	1.0	2.7E-10
4BL	ATWS with vessel failed at time of core uncovery, which indicates low pressure core damage with containment failed.	0.0E+0	n/a	0.0E+0
5	LOCA outside containment with failure to isolate the break. The sequences indicate low reactor pressure at the time of core damage, with the containment bypassed.	0.0E+0	n/a	0.0E+0
6A1A	SBO sequences with early failure of HPCS and RCIC. The sequences indicate high reactor pressure at the time of core damage, with the containment intact. HPCS is recoverable after core damage occurs.	0.0E+0	n/a	0.0E+0
6A1B	SBO sequences with early failure of HPCS and RCIC. The sequences indicate high reactor pressure at the time of core damage, with the containment intact. HPCS is not recoverable.	3.7E-7	6.8E-2	2.5E-8
6A2	SBO sequences with a SORV, no containment heat removal, but successful injection until containment failure. Injection fails at containment failure, resulting in core damage at low reactor pressure with containment failed.	7.6E-8	0.0	0.0E+0
6B1	SBO sequences with initial success of HPCS. If HPCS operation is lost due to HPCS diesel failure, operation is recoverable if AC power is restored. Containment heat removal is unavailable. Core damage occurs at high pressure with containment intact.	2.7E-7	0.0	0.0E+0