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

Dresden Nuclear Power Station, Units 2 and 3
Facility Operating License Nos. DPR-19 and DPR-25
NRC Docket Nos. 50-237 and 50-249

Subject: Response to Request for Additional Information – License Renewal Environmental Report for Dresden Nuclear Power Station, Units 2 and 3

References:

(1) Letter from J. A. Benjamin (Exelon Generation Company, LLC) to U. S. NRC, "Application for Renewed Operating Licenses," dated January 3, 2003

(2) Letter from Louis L. Wheeler (USNRC) to John Skolds (Exelon Generation Company, LLC), "Request for Additional Information (RAI) Related to the Staff's Review of the License Renewal Environmental Report for the Dresden Nuclear Power Station, Unit 2 and 3 (TAC NOS. MB6843 and MB6844)," dated May 30, 2003

Exelon Generation Company, LLC (EGC) is providing the information requested in Reference 2. This additional information is provided to support the Staff in its review of the License Renewal Application submitted in Reference 1.

Should you have any questions, please contact Al Fulvio at 610-765-5936.

Respectfully,

Patrick R. Simpson

Patrick R. Simpson
Manager – Licensing
Mid-West Regional Operating Group

Attachments:
Affidavit
Attachment 1: RAI Responses Related to Severe Accident Mitigation Alternatives

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station
Office of Nuclear Facility Safety – Illinois Department of Nuclear Safety

A097

STATE OF ILLINOIS	**)**	
COUNTY OF DUPAGE	**)**	
IN THE MATTER OF	**)**	
EXELON GENERATION COMPANY, LLC	**)**	**Docket Numbers**
Dresden Nuclear Power Station - Units 2 and 3	**)**	**50-237 and 50-249**

SUBJECT: **Response to Request for Additional Information – License Renewal Environmental Report for Dresden Nuclear Power Station, Units 2 and 3**

AFFIDAVIT

I affirm that the content of this transmittal is true and correct to the best of my knowledge, information, and belief.

Patrick R. Simpson
Manager - Licensing
Mid-West Regional Operating Group

Subscribed and sworn to before me, a Notary Public in and for the State above named, this 23rd day of July, 2003

"OFFICIAL SEAL"
TIMOTHY A. BYAM
COMMISSION EXPIRES 12/04/05

Notary Public

Attachment 1

RAI Responses Related to Severe Accident Mitigation Alternatives

RAI 1

The SAMA analysis is based on the most recent version of the Dresden Nuclear Power Station (DNPS) Probabilistic Safety Assessment (PSA) for internal events, i.e., 2002 Update, which is a modification to the modified IPE submittal transmitted to the NRC in June 1996. Please provide the following information regarding this PSA model:

a. a summary description of any peer reviews of the level 1 and level 2 portions of this PSA beyond the normally-performed internal second checker reviews (e.g., DNPS BWROG Peer Review),

b. a characterization of the findings of these internal and external peer reviews (if any), and the impact of any identified weaknesses on the SAMA identification and evaluation process,

c. a breakdown of the internal events core damage frequency (CDF) by major contributors, initiators and accident classes, such as loss of offsite power (LOOP), station blackout (SBO), transients, anticipated transient without scram (ATWS), loss-of-coolant accident (LOCA), ISLOCA, internal floods, and other, and

d. a description of the major differences from the updated IPE submittal, including the plant and/or modeling changes that have resulted in the new core damage frequency (CDF), along with the corresponding CDF.

Response 1(a):

"[Provide] a summary description of any peer reviews of the level 1 and level 2 portions of this PSA beyond the normally-performed internal second checker reviews (e.g., DNPS BWROG Peer Review)[.]"

Three external peer reviews of the Dresden Probabilistic Risk Assessment (PRA) models were conducted.

<u>BWROG Peer Review/Certification</u>

Boiling Water Reactor Owner's Group (BWROG) PRA Certification Peer Review was conducted in January 1998. (Note, Level 2 analysis of Large, Early release frequency (LERF) was not included in this review). A six-member industry team following the latest BWROG guidance available at the time performed this review.

<u>Independent External Review</u>

Robert Schmidt performed the independent review with support from Jeff Julius (HRA area). This review was performed in late 1998 and early 1999.

NEI/BWROG Peer Review

A six-member industry team performed this review in January 2000 with a report published in March 2000. The review used the Nuclear Energy Institute (NEI) draft, "Probabilistic Risk Assessment Peer Review Process Guidance." This peer review process was adapted from the review process originally developed and used by the BWROG.

Response 1(b):

"[Provide] a characterization of the findings of these internal and external peer reviews (if any), and the impact of any identified weaknesses on the SAMA identification and evaluation process[.]"

BWROG Peer Review/Certification

This review evaluated all PSA elements except Level 2 analysis. The evaluation found that all elements were consistently graded as sufficient to support meaningful rankings for the assessment of systems, structures, and components, when combined with deterministic insights. Enhancements were recommended in the following areas:

- Completion of Level 2 analysis
- Treatment of Special Initiators (some special initiators were missing or treatment through the Accident Sequence Evaluation (Event Trees) was judged to require improvements)
- Accident Sequence Evaluation (Event Trees) were overly simplified and needed further development to support higher applications
- Dependency Analysis (Common Cause Factors)
- Human Reliability Analysis (HRA) (Operator dependency analysis was judged to require improvement and operator input was necessary).

There is judged to be no impact to the SAMA identification and evaluation process as weaknesses were corrected since the review. Insights were developed and evaluated using the upgraded PRA models. Enhancements included addition of special initiators, upgrading Event Tree Analysis, revision of human reliability analysis (including dependency analysis and operator interviews), update of Common Cause Factors, and completion of Level 2 analysis.

Independent External Review

This review, primarily performed by Robert Schmidt, was limited to the Level 1, at power, internal events portion of the PSA, excluding the internal flooding analysis. The review was performed on the 1999 rev. 0 model. The review focused on Initiating Events, Event Trees, Success Criteria, System Analysis (3 systems; Isolation Condenser (IC), High Pressure Coolant Injection (HPCI), and Service Water (SW)), Human Reliability Analysis, and Quantification. The review found the Dresden Updated PRA to be a high quality Level 1 PSA. All technical elements reviewed meet or exceed general industry practice. The reviewer found the update process to be well documented in analysis notebooks. No deficiencies were found in the analyses that needed to be corrected immediately. Mr. Schmidt provided 28 comments ranging from clarifications to documentation to potential model changes. Exelon responded to all of Mr. Schmidt's comments and made model and documentation changes where appropriate.

The following lists the weaknesses judged to be the most significant and resolution of those weaknesses.

- Initiating Events: Loss of a single DC bus was not included in the 99 model., Interfacing System Loss of Coolant Accident (ISLOCA) frequency calculation was deficient and IE frequency was based on poor availability. Plant availability had recently improved and the reviewer recommended updating the plant availability calculations.
- Data: RAW water and clean water system check valve failure rates used the same rates. The reviewer recommended a higher failure rate be considered for RAW water systems.
- Event Tree: Depressurization was not required prior to using the Shutdown Cooling (SDC) System following use of HPCI (Note, Dresden has a SDC system in addition to a Residual Heat Removal (RHR) system. The RHR system is referred to as the Low Pressure Coolant Injection (LPCI/CCSW) system at Dresden). Several ATWS Event Tree changes were recommended including adding Failure to inhibit ADS was noted as missing in several ATWS sequences. A manual scram following an Inadvertent Open Relief Valve (IORV) event was not included in the ATWS Event Tree logic. Recovery of containment vents following loss of Instrument air (0.9 failure probability) was recommended.
- HRA: A change to a HEP associated with controlling injection following boron injection was recommended. An operator action dependency for Operator failure to initiate IC makeup, SPC, SDC, and Containment vent was not found in the final cutset.

To address the above weaknesses, the following changes were incorporated in the 2002A revision 0 PRA model:

- Included Loss of a single DC bus, updated ISLOCA frequency calculation and initiating event frequency reflects improved plant availability.
- RAW water and clean water failure rates are treated separately in the 2002A model. RAW water failure rates are now greater, reflecting harsher environmental conditions.
- Failure to inhibit ADS was added to several ATWS sequences.
- A manual scram following IORV was added to the ATWS Event Tree logic. Recovery of containment vents following loss of Instrument air (0.9 failure probability) was added.
- Modified HEP (based on Operator interviews) associated with controlling injection following boron injection. Increased HEP to 0.1 for an operator action to assure dependency was picked up in the cutset recovery process (HEP is returned to normal value following recovery process).

There is judged to be no impact to the SAMA identification and evaluation process as weaknesses (all considered relatively minor) were corrected since the Independent reviewer evaluation. Insights were developed and evaluated using the upgraded PRA models.

NEI/BWROG Peer Review

The NEI Peer Review team gave high marks to the Dresden PRA. The team specifically noted, "The Dresden PSA is consistent with state of the art technology PRAs in scope, methods, data usage, and results. The PSA does not have unique PSA features." Of the eleven "elements" evaluated by the team, a Summary Score of "4" was received for the Maintenance and Update element, and Summary Scores of "3" were assigned to the ten other elements. In the words of the review team, "These grades are consistent with a very solid PSA program with no major weaknesses." There were no "A" level Facts & Observations (F&Os). There were eight "B" level F&Os. The 2002 Dresden Update resolved all "B" F&Os and a number of "C" F&Os as well.

The most significant recommendations identified weaknesses in the area of Level 2 (LERF) analysis, internal flooding and thermal hydraulic analysis. Special efforts to enhance the PRA model in these three areas have been completed. Further discussion on Level 2 enhancements can be found in response to RAI 3.

In the area of flooding, two Facts and Observations (F&Os) were written. Under Initiating Events (IE) it was noted, "The consideration of internal event initiators do not give adequate exposition of possible flooding events." Under Structural Response (ST), it was noted, "Internal flooding is no longer considered in the Level 1 quantification. This is non-conservative." These observations were not considered significant by the review team, as the IPE walk downs did not identify significant flooding initiators. Exelon performed a new internal flooding study in 2001. This internal flooding study was incorporated into the 2002A PRA model fully addressing the Peer Review team F&Os.

The certification team noted under the Quantification (QU) element that there were limited sets of uncertainty analyses performed and no parametric uncertainty analysis had been performed. The Peer Review report recommended that ComEd "Consider additional uncertainty analysis as appropriate." At this time, a parametric uncertainty analysis has not been performed. (see response 7(a) for additional discussion on uncertainty).

It is judged that the improvements made since the Peer reviews and the independent review have corrected any significant weaknesses identified and the 2002A PRA model fully supports the SAMA identification and evaluation process.

Response 1(c):

"[Provide] a breakdown of the internal events core damage frequency (CDF) by major contributors, initiators and accident classes, such as loss of offsite power (LOOP), station blackout (SBO), transients, anticipated transient without scram (ATWS), loss-of-coolant accident (LOCA), ISLOCA, internal floods, and other [contributors.]"

Table 1-1 provides a breakdown of the internal events CDF by initiator type, and Table 1-2 provides a breakdown of the internal events CDF by accident class. Note that ATWS and SBO scenarios are not represented by individual initiators but are determined as consequences from an initiating event. The ATWS contribution from the 2002 update model is estimated at 10% of the total CDF, and the SBO contribution is estimated at 22% of the total CDF.

Table 1-1
Contribution to Dresden 2002 PRA CDF by Initiator
(Truncation Limit = 1E-10/yr)

Description	% of Base CDF
Single Unit Loss of Offsite Power Initiating Event (LOOP)	26%
Transient With Feedwater (FW) Unavailable and Main Condenser (MC) Available	22%
Dual Unit Loss of Offsite Power (DLOOP)	15%
Transient With FW And MC Available	11%
Loss of Multiple DC Buses	8%
Medium LOCA Initiator (MLOCA)	3%
Large LOCA Initiator (LLOCA)	3%
Manual Shutdown Initiating Event	3%
Internal Flooding	3%
Loss of Service Water Initiating Event	2%
Loss of Turbine Building Closed Cooling Water (TBCCW)	0.9%
ISLOCA	0.1%
All other initiators	3%
Total:	100%

Table 1-2
Contribution to CDF by Accident Class
(Truncation Limit = 1E-10/yr)

Accident Class	Short Description	2002 Update CDF	2002 Update CDF(%)
IA/IE	Loss of Makeup at High Reactor Pressure Vessel (RPV)Pressure	1.06E-06 / yr	56.1%
IBE	Early Station Blackout (less than 4 hours)	3.01E-07 / yr	15.9%
IBL	Late Station Blackout (greater than 4 hours)	1.08E-07 / yr	5.7%
IC	Loss of Makeup (ATWS)	1.79E-08 / yr	0.9%
ID	Loss of Makeup at Low RPV Pressure (transient Initiators)	2.56E-08 / yr	1.4%
II	Loss of Decay Heat Removal	8.15E-08 / yr	4.3%
IIIB	Loss of Makeup at High RPV Pressure (LOCA Initiators)	1.53E-08 / yr	0.8%
IIIC	Loss of Makeup at Low RPV Pressure (LOCA Initiators)	8.20E-08 / yr	4.3%
IIID	Loss of Vapor Suppression	1.18E-08 / yr	0.6%
IVA	Loss of Reactivity Control (ATWS)	1.86E-07 / yr	9.8%
V	Containment Bypass	1.74E-09 / yr	0.1%
	Total:	**1.89E-06 / yr**	**100.0%**

Response 1(d):

"[Provide] a description of the major differences from the updated IPE submittal, including the plant and/or modeling changes that have resulted in the new core damage frequency (CDF), along with the corresponding CDF."

A summary of the total calculated CDF for each of the relevant models is provided in Table 1-3. As can be seen, the Dresden CDF has been reduced from the Modified IPE CDF to the present. The total reduction in CDF is approximately 44%. Table 1-4 provides the change in CDF contribution from the Modified IPE to the 2002 Update. Here, it can be seen that the Dresden risk profile has also changed significantly.

Also provided is information that relates modeling methodology, plant data and plant configuration changes to changes in Core Damage Frequency. Examples of each type of change are listed below. These examples are changes made during the 1999 Upgrade.

- PRA Methodology Change: Calculating Medium LOCA frequency using the latest EPRI methodology increased the MLOCA frequency.
- Plant Operating Experience: The General Transient Frequency was reduced based on operating experience. This caused a decrease in ATWS contribution by ~60%.

- Plant Configuration Changes: Installation of Station Blackout Diesel Generators and the Division 1 4kV cross-tie reduced Loss of Off-Site Power contribution by 75%.

It is apparent from this information that the present PRA results are significantly different from the Modified IPE. One could conclude that insights from the present model are more valuable than IPE insights at this time.

Table 1-3
Dresden CDF History

Model	Date	CDF (Per Yr) (1)
• Modified IPE	1996	3.4E-06/yr
• Upgraded PRA	1999	2.6E-06/yr
• 2002 Updated PRA	2002	1.9E-06/yr (2)

Notes to Table 1-3

(1) Results shown are for Unit 2. The Unit 3 results are the same except for the Modified IPE. The Modified IPE Unit 3 CDF was 5E-06/yr. The difference in the CDF estimates between the two units was due to a hardware modification that eliminated a FW trip on loss of DC power as an initiating event at Unit 2. The modification was later installed on Unit 3.

(2) The most recent version of the Dresden 2002 PRA model is Revision 3. However, the SAMA calculations were performed using Revision 0 of the 2002 PRA. For consistency with the SAMA evaluations, the results of the Revision 0 model are reported for the RAI responses. The Revision 3 results are not significantly different than for Revision 0. Model changes were the following:

Revision 1:

1) Minor modifications to the U2 Database to correct Common Cause Factors for failure of both Emergency Diesel Generators and SBO Diesel Generators, and common cause failures of combinations of 2 of 4 CCSW Pumps. (Impacted cutsets with values less than 1E-08/yr.)
2) Incorporated the U3 2002A Model.

Revision 2:

Units 2 and 3 combined CDF/LERF models were developed.

Revision 3:

Credited Standby Coolant Supply (SBCS) for Large and Medium LOCAs with a top-peaked core.

Table 1-4
Dresden Risk Profile History

Initiator	Modified IPE [1]	1999 Upgrade [2]	2002 Update
MLOCA	39%	21%	3%
DLOOP	24%	23% [3]	15% [4]
LOOP	8%	3%	26% [4]
General Transient	27%	27%	33%
Loss of Service Water	1%	11%	2%
ISLOCA	<0.1%	0.4%	0.1%
Loss of Instrument Air	<0.1%	7%	0.9%
Large LOCA	<0.1%	2%	3%
Excessive LOCA	N/A	0.2%	0.3%
Loss of Multiple 125 VDC Buses	N/A	3%	8%
Loss of TBCCW	N/A	0.9%	0.9%
Manual Shutdown	N/A	0.6%	2%
Service Water Flood	N/A	N/A	3%
All Others	<1%	<1%	<3%

Notes to Table 1-4

(1) The Modified IPE report gave a separate ATWS result that included contributions from many initiators, but mainly due to General Transients. Therefore, for risk profile comparison purposes, the ATWS contribution is included with the General Transient results above in the Modified IPE column. Unit 2 results are reported (see note 1 of previous table).

(2) The third and fourth columns contain the 1999 and 2002 PRA Model Update results with ATWS contributions included with the results for each initiator. For example, the table shows that General Transients contribute 27% of the total CDF in the 1999 Upgrade. General Transients evolving into ATWS events contributed 14.4% of the total CDF.

(3) Of the 23% contribution of Dual Unit LOOPs in the 1999 Upgrade, approximately two-thirds is due to Station Blackout (SBO) sequences. No other initiators (including Single Unit LOOPs) include any significant CDF contribution to SBO sequences.

(4) Of the 41% CDF contribution of Single and Dual Unit LOOPs in the 2002 Update, approximately one-half is due to Station Blackout (SBO) sequences.

RAI 2

The CDF cited and used in the SAMA analysis is based on the risk profile for internal events at DNPS Unit 2. Provide the internal events CDF for Unit 3, and a discussion of the reasons for any differences from Unit 2. Discuss the impact on the SAMA analysis, including the impacts of external events, and results if the analysis were based on Unit 3 rather than Unit 2.

Response 2

Internal Events

<u>*Unit 2 CDF*</u>

The Unit 2 internal events CDF is identical to that of Unit 3: 1.9E-06/yr.

<u>*Unit 2 Differences from Unit 3*</u>

There are asymmetries between Unit 2 and Unit 3 related to the 125V DC System bus configuration, AC Bus Initiating Event Frequency difference due to water spray, AC power supplies to the SDC pumps, HPCI room cooler and LPCI cooling (Containment Cooling Service Water System (CCSW). These asymmetries involve highly reliable components, such as Electric Power Busses. Thus, there is a minimal impact on baseline CDF.

- Loss of AC Bus Initiator Frequency: The Loss of AC Bus Initiator Frequencies includes loss of bus due to water spray. The water spray contributions vary by unit. This asymmetry is not significant.

- 125V DC System Bus Configuration: The 125V DC System is essentially a plant distribution system: normally supporting equipment on both units in order to provide divisional separation for safety related systems. Divisional separation is accomplished by having Division I equipment on a unit supplied by the Unit's own 125V DC System while the opposite unit's 125V DC system supplies the Division II loads. For example, the 125V DC battery located in Unit 2 is considered "Division I" power supply for Unit 2 and "Division II" power supply for Unit 3. The two battery divisions have asymmetries in the bus configurations. The electric busses and cable connections are highly reliable and the 125 V DC system Bus asymmetries have an insignificant impact to baseline CDF.

- Shutdown Cooling (SDC) SYSTEM: The power supplies to the SDC pumps are not symmetric. There are three SDC pumps for each unit. The Unit 2 2A and 2C SDC pumps obtain power from Bus 23-1 and the 2B pump obtains power from Bus 24-1. The Unit 3 3A SDC pump obtains power from Bus 33-1 and the 3B and 3C pumps obtain power from Bus 34-1. The impact of this asymmetry is insignificant.

- HPCI Room Cooler: The power supply for the HPCI room cooler is not symmetric. The Unit 2 HPCI room cooler is powered from MCC 29-4 and the Unit 3 HPCI room cooler is powered from MCC 39-1. These MCCs are powered from symmetric sources and therefore, this asymmetry is not significant.

- LPCI Containment Cooling (CCSW System): The CCSW System for each unit is comprised of two loops with 2 pumps per loop. The Unit 2 CCSW Loop A is partially dependent on MCC 28-2 and the Unit 3 CCSW Loop A is partially dependent on MCC 38-3. The Unit 2 CCSW Loop B is partially dependent on MCC 29-4 and the Unit 3 CCSW Loop B is partially dependent on MCC 39-1. These asymmetries are not significant.

The Unit 3 model uses the same event trees as the Unit 2 model. The Unit 3 model uses the same system logic and database, except as impacted by the items above. While these differences do appear in low-frequency cutsets, the effects of the fault tree differences are small enough that they do not affect the total internal events CDF. Therefore, the differences do not affect the SAMA analyses for internal events.

External Events

<u>*Unit 2 Fire CDF*</u>

The Unit 2 fire CDF is 1.7E-05/yr compared to a Unit 3 fire CDF of 3.1E-05/yr.

<u>*Fire-Related Unit 3 Differences from Unit 2*</u>

A review of the dominant risk contributors shows a few notable asymmetries in the risk profiles.

Self-Initiated Cable Fires Due to Cable Routing Differences

The risk contribution from self-initiated cable fires is much higher in Unit 3 (25%) than in Unit 2 (2%). Two thirds (5.0E-06/yr) of the Unit 3 self-initiated cable fire contribution results from Cable Tunnel fire scenarios. Since Unit 2 cables are generally not routed through this area, a similar exposure does not exist for Unit 2. Of the remaining Unit 3 contribution, one half (1.0E-06/yr) results from fires on the second floor of the Reactor Building. These fires also affect cables whose fire-induced failure disable Suppression Pool Cooling, Shutdown Cooling, and one or more trains of Core Spray and LPCI, depending on the scenario being considered, which increases the significance of these fires. It should also be noted that safe shutdown procedures were not credited in the Dresden fire analysis. Recovery of the Isolation Condenser is addressed in the Safe Shutdown Procedures. Crediting this recovery would reduce the difference in CDF from unit asymmetries.

The common control room is located adjacent to Unit 2. Unit 3 is located on the opposite side of Unit 2, thus requiring a Unit 3 cable tunnel to the control room area. The SAMA analysis would not be impacted as rerouting sufficient number of cables to significantly reduce fire risk in Unit 3 is judged not to be cost effective. Crediting safe shutdown procedures in the Dresden fire analysis would reduce the contribution from these scenarios.

Loss of 125 VDC in Unit 2

A large oil fire involving Unit 2 Reactor Feedwater Pump C or a fire involving MCC 26-1 is a dominant contributor to the Unit 2 CDF. This is because of the location of the cables needed for the Unit 2 DC power system. The Unit 3 DC power feed to one train of the Unit 2 DC system and the Unit 2 AC power cable to the battery charger for the redundant DC train are exposed to a common hazard. Although the circuits are located in separate trays, they are stacked vertically. The occurrence of a postulated large fire event requires an operator action to either align the spare battery charger or to connect the spare Unit 2 battery bank. An option also exists to use the safe shutdown procedures, which specify manual actions to operate the Isolation Condenser. The safe shutdown procedures were not credited in the Dresden Fire PRA model. Fires involving the Unit 2 Reactor Feedwater Pump C and MCC 26-1 contribute approximately 4.0E-06/yr (with no credit given to the safe shutdown procedures).

RWCU pump fires in Unit 2

Fires originating from the Unit 2 RWCU pumps contribute 8.5% (1.0E-06/yr) to the Unit 2 CDF, while Unit 3 RWCU pump fires contribute less than 1% to the Unit 3 CDF. The difference between the two scenarios is primarily due to a fire-induced loss of the Isolation Condenser in the Unit 2 analysis. In particular, the trays affected by the Unit 2 pump fire contain cables whose fire-induced failure disables Reactor Building 250VDC MCC #2. Such an exposure does not exist in the Unit 3 analysis. Crediting the safe shutdown procedures would allow for recovery of the Isolation Condenser.

<u>Seismic-Related Unit 3 Differences from Unit 2</u>

With modifications to each unit in response to the Seismic Margins Analysis, there is no significant difference in seismic vulnerabilities between the two units.

RAI 3

In the Extended Power Uprate (EPU) Amendment application, Exelon indicates that the Level 2 analysis is based on NUREG/CR-6595. However, there is no such indication in the SAMA portion of the Environmental Report (ER). Based on the above, provide a description of the following:

a. *the changes in the Level 2 methodology since the modified IPE submittal, including major modeling assumptions, containment event tree (CET) structure, and binning of endstates.*

b. *the methodology and criteria for binning CET endstates into release categories used in the Level 3 analysis. Include the definitions of the release characteristics listed in Column 2 of Table 4-5.*

c. *each release (consequence) category used in the Level 3 analysis (as listed in Column 1 of Table 4-5), the specific source terms used to represent each release category, and a containment matrix describing the mapping of Level 1 results (plant damage state frequencies) into the various release categories.*

Response 3(a):

"[Provide] the changes in the Level 2 methodology since the modified IPE submittal, including major modeling assumptions, containment event tree (CET) structure, and binning of endstates."

The IPE and modified IPE employed what some would call a simplistic Level 2 methodology. Many accident progression phenomena or failure modes were eliminated from consideration, based on experiments, MAAP calculations, or judgments concerning the likelihood of various phenomena. Core damage end states were coded for sequence characteristics that would affect the remaining phenomena affecting containment performance. Based on those characteristics, it was determined in what time range the vessel would fail, whether the pedestal area was dry or wet, whether containment sprays were operating, whether liner melt-through was likely, and whether containment vent was operated. Based on this information, it was determined which core damage end states resulted in containment failure, and which resulted in LERF.

Because of the limitations of the IPE Level 2 model, the model was revised for the 1999 Dresden PRA Upgrade. It was decided to use a simplified LERF model in the style of NUREG/CR-6595. The 1999 Dresden PRA was used for the Extended Power Uprate (EPU) submittal.

The submittal for License Renewal required Level 3 calculations. Therefore, Exelon decided to develop a full Level 2 PRA model for Dresden that meets standard industry practices. The full Level 2 model was used for the License Renewal analyses, and that model also has now been incorporated in the 2002 Dresden PRA model. It is also the basis for LERF calculations for risk assessment.

A brief summary of the current Level 2 model compared to the 1999 Level 2 model that was used for the EPU submittal follows:

- No changes in modeling assumptions
- CET structure has been enhanced to include more top event nodes
- Old CET had LERF and non-LERF end states whereas the updated model has several release category bins (see Responses 3(b) and 3(c))

Response 3(b):

"[Provide] the methodology and criteria for binning CET endstates into release categories used in the Level 3 analysis. Include the definitions of the release characteristics listed in Column 2 of Table 4-5."

Each CET end state can be associated with a radionuclide source term bin, which covers a spectrum of similar potential scenarios and timing. Theoretically, it would be desirable in determining the point estimates of risk to evaluate the source terms for each sequence of each accident plant damage state. However, for purposes of risk presentation, the CET end states can also be characterized in such a manner as to combine similar "consequence impact" sequences within a CET end state.

The discrete nature of the radionuclide release categories means that the severe accident spectrum is divided up into bins, which then represent a group of severe accidents that have similar characteristics. These characteristics would imply similar public health consequences. It has been found in the past that the public health consequences are affected by a large number of governing features. The following portrays the radionuclide release category characterization used for Dresden.

<u>Radionuclide Release Categories (CET End States)</u>

The spectrum of possible radionuclide release scenarios is represented by a discrete set of categories or bins. The end states of the containment and phenomenological event sequences may be characterized according to certain key quantitative attributes that affect offsite consequences. These attributes include two important factors:

- Timing (e.g., early or late releases); and,
- Total quantity of fission products released.

Therefore, the containment event tree end states represent the source term magnitude and relative timing of the radionuclide release. The number of categories used for Dresden (i.e., 13) in the source term characterization offers a level of discrimination similar to that included in numerous published PRAs.

Timing Bins

Three timing categories are used, as follows:

• Early (E)	Less than time when evacuation is effective
• Intermediate (I)	Greater than or equal to Early, but less than 24 hrs
• Late (L)	Greater than or equal to 24 hours.

The definition of the categories is based upon past experience concerning offsite accident response:

- Early is conservatively assumed to include cases in which minimal offsite protective measures have been observed to be performed in non-nuclear accidents.
- Intermediate is a time frame in which much of the offsite nuclear plant protective measures can be assured to be accomplished.
- *Late (>24 hours) are times at which the offsite measures can be assumed to be fully effective.*

Radionuclide Release Magnitude Bins

The assessment of plant response under postulated severe accident scenarios is a complex integrated evaluation. The primary and secondary containment building responses are sensitive to pressures, temperatures, flows, and event timings. These parameters also affect the operator action timings, the radionuclide release timings, and the mitigating system performance assessments. Therefore, the proper plant specific characterization of the severe accident progression is important to the realistic representation of the plant and highly desirable for the Level 2 assessment. These deterministic calculations provide the following information:

- The pressures and temperatures for various accident scenarios in the RPV, the drywell, the wetwell, and the reactor building;
- *The times to reach these pressures and temperatures which is key to the assessment of recovery; (The time windows available for recovery actions must be estimated.)*
- The source term magnitude and timing.

Five severity classifications associated with volatile or particulate releases are defined as follows:

- High (H) - A radionuclide release of sufficient magnitude to have the potential to cause prompt fatalities.

- <u>Medium or Moderate</u> (M) - A radionuclide release of sufficient magnitude to cause near-term health effects.
- <u>Low</u> (L) - A radionuclide release with the potential for latent health effects.
- <u>Low-Low</u> (LL) - A radionuclide release with undetectable or minor health effects.
- <u>Negligible</u> (OK) - A radionuclide release that is less than or equal to the containment design base leakage.

A relationship was then developed with the five release severity categories. The results of this partitioning are shown in Table 3-1.

Table 3-1
Release Severity Categorization

Release Severity	Fraction of Released CsI Fission Products
High	greater than 10%
Medium/Moderate	1 to 10%
Low	0.1 to 1.0%
Low-Low	less than 0.1%
Negligible	much less than 0.1%

The resulting definitions of the radionuclide release end states are summarized in Table 3-2. The combinations of severity and timing classifications results in one OK release category and 12 other release categories of varying times and magnitudes. These 12 other release categories are shown in Table 3-3. These are the dominant release categories shown in column 2 of Table 4-5 of the Environmental Report.

Table 3-2
Release Severity And Timing Classification Scheme

Release Severity		Release Timing	
Classification Category	Cs Iodide % Release	Classification Category	Time of Initial Release[1] Relative to Time for General Emergency Declaration
High (H)	Greater than 10	Late (L)	Greater than 24 hours
Medium or Moderate (M)	1 to 10	Intermediate (I)	5 to 24 hours
Low (L)	0.1 to 1	Early (E)	Less than 5 hours
Low-low (LL)	Less than 0.1		
No iodine (OK)	0		

(1) The conditions dictating a General Emergency are used as the surrogate for the time when EALs are exceeded, which in turn is used as the relative time to measure when the release occurs.

Table 3-3
Dresden Release Categories

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	H/L	M/L	L/L	LL/L

Response 3(c):

"[Provide] each release (consequence) category used in the Level 3 analysis (as listed in Column 1 of Table 4-5), the specific source terms used to represent each release category, and a containment matrix describing the mapping of Level 1 results (plant damage state frequencies) into the various release categories."

Source Terms used to Represent each Release Category

As requested, Table 3-4 provides a list of the source terms associated with each of the release categories as listed in Column 1 of Table 4-5 of the ER.

Table 3-4
Source Terms Associated with Each Release Category

	Release Category[1,2]									
	L2-1	L2-2	L2-3	L2-4	L2-5	L2-6	L2-7	L2-8	L2-9	L2-10
MAAP Run	DR0024	DR0040	NA	DR0034	DR0031	NA	DR0028	DR0042	DR0039	DR0043
Time after Scram when General Emergency is declared	60 min	15 hr	NA	1.1 hr	15 hr	NA	45 min	15 hr	20 min	60 min
Fission Product Group:										
1) Noble										
Total Release % at 36 Hours	95	100	NA	100	100	NA	86	94	100	0.33
Start of Release (hr)	4.1	47.5	NA	1.1	37.8	NA	5.7	5.7	0.28	3
End of Release (hr)	4.1	55	NA	4	45	NA	6	6	2	36
2) CsI										
Total Release % at 36 Hours	23	35	NA	1.7	1.8	NA	0.35	0.22	96	6.30E-04
Start of Release (hr)	4.1	47.5	NA	1.9	37.8	NA	5.7	5.7	0.28	3
End of Release (hr)	4.1	60	NA	2	45	NA	5.7	11	2	6
3) TeO2										
Total Release % at 36 Hours	18	27	NA	1.6	0.9	NA	0.48	0.39	78	3.20E-05
Start of Release (hr)	4.1	55	NA	1.9	37.8	NA	5.7	5.7	0.28	3
End of Release (hr)	8	65	NA	4	45	NA	5.7	8	2	6
4) SrO										
Total Release % at 36 Hours	3.1	3.1	NA	5.8	0.7	NA	4.4	3.40E-03	4.6	3.20E-05
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	7	0.28	6
End of Release (hr)	7	60	NA	10	60	NA	8	10	8	8
5) MoO2										
Total Release % at 36 Hours	9.00E-04	5.20E-02	NA	0.027	3.00E-03	NA	4.50E-04	1.80E-03	1.9	2.30E-07
Start of Release (hr)	4.1	47.5	NA	1.9	37.8	NA	5.7	12	0.28	3
End of Release (hr)	4.1	47.5	NA	2	40	NA	16	16	2	6
6) CsOH										
Total Release % at 36 Hours	27	31	NA	2.8	0.8	NA	1.3	1.5	78	2.20E-04
Start of Release (hr)	4.1	55	NA	1.9	37.8	NA	5.7	5.7	0.28	3
End of Release (hr)	11	65	NA	2	45	NA	14	18	2	6

Table 3-4
Source Terms Associated with Each Release Category

	Release Category[1,2]									
	L2-1	L2-2	L2-3	L2-4	L2-5	L2-6	L2-7	L2-8	L2-9	L2-10
MAAP Run	DR0024	DR0040	NA	DR0034	DR0031	NA	DR0028	DR0042	DR0039	DR0043
Time after Scram when General Emergency is declared	60 min	15 hr	NA	1.1 hr	15 hr	NA	45 min	15 hr	20 min	60 min
Fission Product Group:										
7) BaO										
Total Release % at 36 Hours	1.4	1.4	NA	2.5	0.3	NA	1.9	6.80E-03	4.7	1.30E-05
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	8	0.28	6
End of Release (hr)	7	60	NA	10	60	NA	8	14	8	8
8) La2O3										
Total Release % at 36 Hours	0.4	0.32	NA	0.62	4.00E-02	NA	0.65	3.10E-03	0.6	6.70E-06
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	8	0.28	6
End of Release (hr)	7	60	NA	10	60	NA	8	12	8	8
9) CeO2										
Total Release % at 36 Hours	2.1	1.9	NA	2.8	0.3	NA	2.3	0.023	2.2	1.60E-05
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	8	5	6
End of Release (hr)	7	60	NA	10	60	NA	8	12	8	8
10) Sb										
Total Release % at 36 Hours	74	43	NA	26	21	NA	20	19	88	7.50E-04
Start of Release (hr)	4.1	55	NA	1.9	37.8	NA	5.7	8	0.28	3
End of Release (hr)	14	70	NA	12	70	NA	14	18	4	6
11) Te2										
Total Release % at 36 Hours	1.4	1.1	NA	0.52	1.30E-01	NA	0.31	0.38	0.3	1.00E-05
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	8	5	6
End of Release (hr)	14	60	NA	8	60	NA	8	12	20	8
12) UO2										
Total Release % at 36 Hours	1.00E-02	9.00E-03	NA	1.70E-02	1.00E-03	NA	2.00E-02	3.40E-03	1.50E-02	1.60E-07
Start of Release (hr)	4.1	55	NA	7	55	NA	5.7	8	5	6
End of Release (hr)	6	55	NA	10	60	NA	8	14	8	8

(1) Puff releases are denoted in the table by those entries with equivalent start and end times.
(2) All cases run for 36 hours except DR0040 and DR0031 run for 72 hours

Mapping of Level 1 Results into the Various Release Categories

One link between the Level 1 PSA accident sequences and the Containment Event Tree occurs in the definition of the Level 1 end states. The definition of the end states are developed to transfer the maximum amount of information regarding the accident sequence characteristics to the CET assessment. What follows summarizes the link between Level 1 end states and the entry condition to the CET such that a mapping of the Level 1 results into the various release categories can be provided.

A broad spectrum of accident sequences have been postulated that could lead to core damage and potentially challenge containment. The Dresden Level 1 PSA has calculated the frequency of those accident sequences that contribute to the core damage frequency for Dresden using system oriented (systemic) event trees. Each of these sequences may result in different challenges to containment. However, many of these challenges to containment have similarities in their functional failure characteristics. This has been confirmed in individual BWR PRAs including NUREG-1150. The result is that these studies have categorized these containment challenges into a finite, discrete group of accident sequence bins, which have similar functional failures.

As pointed out in past BWR PRAs, different portions of the spectrum of postulated core damage accidents represent substantially different challenges to the containment depending upon the system failures and phenomena that have contributed to the sequence. Therefore, the containment event tree response must be capable of reflecting the entire spectrum of challenges to ensure that the following are explicitly incorporated:

- System failures in the Level 1 evaluation (including support systems)
- Phenomenological interaction due to the type of core melt progression
- RPV conditions
  - Pressures
  - Decay heat level
- Containment conditions
- Timing of the sequence of events (i.e., core damage and containment failure (if applicable)).

Core Damage Functional Classes

An event sequence classification into five accident sequence functional classes can be performed using the functional events as a basis for selection of end states. The description of functional classes is presented here to introduce the terminology to be used in characterizing the basic types of challenges to containment. The reactor pressure vessel condition and containment condition for each of these classes at the time of initial core damage is noted in Table 3-5.

Table 3-5
Core Damage Functional Classes (from the Level 1 Analysis)

Core Damage Functional Class	RPV Condition	Containment Condition
I	Loss of effective coolant inventory (includes high and low pressure inventory losses)	Intact
II	Loss of effective containment pressure control, e.g., heat removal	Breached or Intact
III	LOCA with loss of effective coolant inventory makeup	Intact
IV	Failure of effective reactivity control	Breached or Intact
V	LOCA outside containment	Breached (bypassed)

In assessing the ability of the containment and other plant systems to prevent or mitigate radionuclide release, it is desirable to further subdivide these general functional categories. In the second level binning process, the similar accident sequences grouped within each accident functional class are further discriminated into subclasses such that the potential for system recovery can be modeled. The interdependencies that exist between plant system operation and the core melt and radionuclide release phenomena are represented in the release frequencies through the binning process involving these subclasses, as shown in past PRAs and PRA reviews. The binning process, which consolidates information from the systems' evaluation of accident sequences leading to core damage in preparation for transfer to the containment-source term evaluation, involves the identification of 18 classes and subclasses of accident sequence types. Table 3-6 provides a description of the possible subclasses used in the Dresden analysis.

The Accident Class designators and subclasses listed in Table 3-6 represent the core damage endstate categories from the Level 1 analysis that are grouped together as entry conditions for the Level 2 analysis. Each of the subclasses is then represented by a series of Containment Event Trees (CETs) to determine the Release Categorization for each of the accident scenarios. As such, the end states from the Level 2 analysis are assigned to one of the Release Categories noted in Table 3-3 as part of Response 3(b). The characterization of the Level 2 results (i.e., as H/E, M/I, etc., or Class V or OK) was then used to determine the frequency of the associated Consequence Category shown in Table 4-5 of the ER. Note that in this fashion, the Level 1 results are not directly linked to a release category, but rather the Level 2 endstate results based on the sum of all of the Release Category frequencies comprise the Consequence Category for each Phase II SAMA considered.

Table 3-6
Summary of the Core Damage
Accident Sequence Subclasses

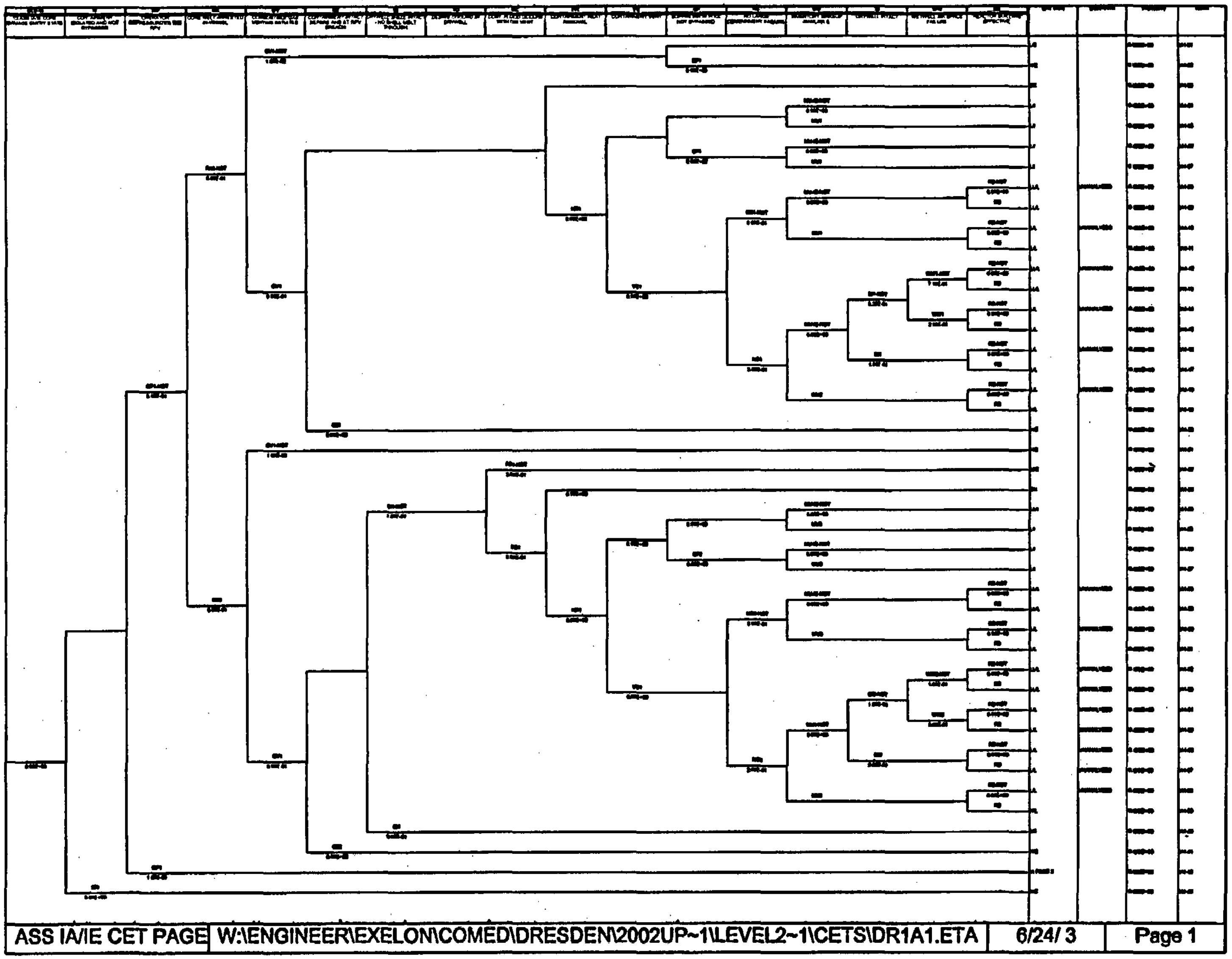
Accident Class Designator	Subclass	Definition	WASH-1400 Designator Example
Class I	A	Accident sequences involving loss of inventory makeup in which the reactor pressure remains high.	TQUX
	B	Accident sequences involving a station blackout and loss of coolant inventory makeup.	T_EQUV
	C	Accident sequences involving a loss of coolant inventory induced by an ATWS sequence with containment intact.	$T_T'C_MQU$
	D	Accident sequences involving a loss of coolant inventory makeup in which reactor pressure has been successfully reduced to 200 psi.; i.e., accident sequences initiated by common mode failures disabling multiple systems (ECCS) leading to loss of coolant inventory makeup.	TQUV
	E	Accident sequence involving loss of inventory makeup in which the reactor pressure remains high and DC power is unavailable.	
Class II	A	Accident sequences involving a loss of containment heat removal with the RPV initially intact; core damage induced post containment failure	TW
	L	Accident sequences involving a loss of containment heat removal with the RPV breached but no initial core damage; core damage after containment failure.	AW
	T	Accident sequences involving a loss of containment heat removal with the RPV initially intact; core damage induced post high containment pressure	N/A
	V	Class IIA or IL except that the vent operates as designed; loss of makeup occurs at some time following vent initiation. Suppression pool saturated but intact.	TW

Table 3-6
Summary of the Core Damage Accident Sequence Subclasses

Accident Class Designator	Subclass	Definition	WASH-1400 Designator Example
Class III (LOCA)	A	Accident sequences leading to core damage conditions initiated by vessel rupture where the containment integrity is not breached in the initial time phase of the accident.	R
	B	Accident sequences initiated or resulting in small or medium LOCAs for which the reactor cannot be depressurized prior to core damage occurring.	S_1QUX
	C	Accident sequences initiated or resulting in medium or large LOCAs for which the reactor is at low pressure and no effective injection is available.	AV
	D	Accident sequences which are initiated by a LOCA or RPV failure and for which the vapor suppression system is inadequate, challenging the containment integrity with subsequent failure of makeup systems.	AD
Class IV (ATWS)	A	Accident sequences involving failure of adequate shutdown reactivity with the RPV initially intact; core damage induced post containment failure.	$T_TC_MC_2$
	L	Accident sequences involving a failure of adequate shutdown reactivity with the RPV initially breached (e.g., LOCA or SORV); core damage induced post containment failure.	N/A
	T	Accident sequences involving a failure of adequate shutdown reactivity with the RPV initially intact; core damage induced post high containment pressure.	N/A
	V	Class IV A or L except that the vent operates as designed; loss of makeup occurs at some time following vent initiation. Suppression pool saturated but intact.	N/A
Class V	–	Unisolated LOCA outside containment	N/A

The CET calculation for each cutset uses Boolean logic and fault tree models to process the incoming Level 1 cutsets to ensure that the resulting Radionuclide release frequencies properly reflect the impact on release magnitude and timing of the containment and containment mitigation systems. A typical CET (for Accident Class 1A) is provided in Figure 3-1.

Figure 3-1
Typical Dresden Level 2 Containment Event Tree



In summary, the Level 1 end states do not translate directly into release categories. Each Level 1 accident sequence (all of the cutsets) is transferred into the appropriate CET. The CET is then used to determine the resulting frequency for each radionuclide release end state from each incoming cutset. This is typical of a full Level 2 for a binned fault tree model. This approach does not involve a matrix that relates Level 1 sequences directly to Radionuclide end states.

Although not created as part of the normal calculation process, the results of the analysis can be binned to show the contribution to each release category by Level 1 end state. Table 3-7 shows the requested results for the base case 2002 model.

Table 3-7

Matrix of Level 1 Results with Various Release Categories
Base Case (2002 Model)

Level 1 Accident Class	Level 2 Release Category / Level 3 Consequence Category										
	H/E (L2-1)	H/I (L2-2)	H/L [(1)] (L2-3)	M/E (L2-4)	M/I (L2-5)	M/L [(2)] (L2-6)	L/E or LL/E (L2-7)	L/I, LL/I, L/L, or LL/L (L2-8)	Class V (L2-9)	Intact (L2-10)	Total
1A/1E	1.04E-07	N/A	9.49E-09	1.61E-08	3.22E-08	N/A	2.72E-09	5.43E-08	N/A	8.41E-07	1.06E-06
1BE	9.82E-09	N/A	0.00E+00	0.00E+00	9.05E-08	0.00E+00	4.59E-10	1.23E-09	N/A	1.98E-07	3.01E-07
1BL	N/A	4.64E-09	0.00E+00	N/A	5.79E-08	0.00E+00	N/A	0.00E+00	N/A	4.55E-08	1.08E-07
1C	0.00E+00	N/A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	N/A	1.79E-08	1.79E-08
1D	0.00E+00	N/A	0.00E+00	0.00E+00	1.88E-08	N/A	0.00E+00	2.03E-09	N/A	4.77E-09	2.56E-08
2	0.00E+00	6.25E-10	N/A	1.15E-09	7.97E-08	N/A	N/A	N/A	N/A	0.00E+00	8.15E-08
3B	0.00E+00	0.00E+00	0.00E+00	N/A	0.00E+00	0.00E+00	1.09E-10	0.00E+00	N/A	1.52E-08	1.53E-08
3C	8.17E-08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.49E-10	8.20E-08
3D	1.18E-08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.00E+00	1.18E-08
4A	9.41E-08	N/A	N/A	9.15E-08	N/A	N/A	N/A	N/A	N/A	0.00E+00	1.86E-07
5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.74E-09	0.00E+00	1.74E-09
Total:	3.01E-07	5.26E-09	9.49E-09	1.09E-07	2.79E-07	0.00E+00	3.29E-09	5.76E-08	1.74E-09	1.12E-06	1.89E-06

(1) Included with the H/I Consequence Category (L2-2) for evaluation purposes.
(2) Included with the M/I Consequence Category (L2-5) for evaluation purposes.

RAI 4

Provide the following information concerning the MELCOR Accident Consequences Code System (MACCS) analyses:

a. *the MACCS analysis assumes all releases that occur at ground level and have a thermal content the same as ambient. These assumptions could be non-conservative when estimating offsite consequences. Provide an assessment of the sensitivity of offsite consequences (doses to the population within 50 miles) to these assumptions.*

b. *the discussion of meteorology indicates that there are data voids in the 2000 data set used. Interpolation was used between hours if only a brief period of data was missing, and hourly observations from the airport were used to fill larger data voids. Provide a characterization of the magnitude and extent of the data voids and the rationale for using the airport data rather than interpolation. Confirm that the 2000 data set is representative of the DNPS site and justify its use.*

c. *clarify the time periods used for am and pm for the atmospheric mixing heights (e.g., midnight to noon and noon to midnight, versus sunrise to sunset).*

Response 4(a):

"[T]he MACCS analysis assumes all releases that occur at ground level and have a thermal content the same as ambient. These assumptions could be non-conservative when estimating offsite consequences. Provide an assessment of the sensitivity of offsite consequences (doses to the population within 50 miles) to these assumptions."

MACCS2 was re-run for all 8 sequences assuming that all plumes originated from the top of the reactor building, at an elevation of 141 feet above grade, rather than ground level (top of reactor building at 658 feet, grade at 517 feet above sea level). Table 4-1 shows the increases that were obtained for each sequence. As can be seen, the calculated dose increase from the elevated release case compared to the ground level release case leads to an increase in the dose of between 4% and 8%. The cost associated with each consequence category went up by about 5-18% except for the containment intact case where a reduction in cost occurred. The overall impact using the same assumptions that were utilized in the ER is a $27,952 increase (+6.1%) in the calculated maximum averted cost risk. It is judged that this would not change the results of the SAMA analysis.

Table 4-1
Ratio of Dose Results
(Elevated to Ground-Level Releases)

Consequence Category	MAAP Run	Dose	Cost
L2-1	DR0024	1.04	1.08
L2-2	DR0040	1.06	1.05
L2-4	DR0034	1.06	1.10
L2-5	DR0031	1.07	1.18
L2-7	DR0028	1.06	1.10
L2-8	DR0042	1.05	1.18
L2-9	DR0039	1.05	1.06
L2-10	DR0043	1.08	0.73

Response 4(b):

"[T]he discussion of meteorology indicates that there are data voids in the 2000 data set used. Interpolation was used between hours if only a brief period of data was missing, and hourly observations from the airport were used to fill larger data voids. Provide a characterization of the magnitude and extent of the data voids and the rationale for using the airport data rather than interpolation. Confirm that the 2000 data set is representative of the DNPS site and justify its use."

The year 2000 meteorological data sets for QCNPS and DNPS were selected due to the fact that they had the least number of data voids (compared to 1998, 1999 and 2001).

The year 2000 DNPS meteorological data set had a total of 14 hours of missing data. Of these 14 hours, no more than two consecutive hours were missing. All gaps in the year 2000 meteorological data set for DNPS were filled by using interpolation methods.

Due to the rather small extent of the data voids, it is believed that the data set is representative of the DNPS site.

Response 4(c):

"[C]larify the time periods used for am and pm for the atmospheric mixing heights (e.g., midnight to noon and noon to midnight, versus sunrise to sunset).

The original source (George C. Holworth, "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution throughout the Contiguous United States," USEPA Office of Air Programs, January 1972) did not use the words "am" or "pm", but actually referred to "morning" and "afternoon" mixing heights. This source defined morning as being the four-hour period from 0200 to 0600 Local Standard Time and afternoon as being the four-hour period from 1200 to 1600 Local Standard Time.

The Code Manual for MACCS2: Volume 1 (from Appendix B, page B-2) states the following:

> "The first of these two values corresponds to the morning mixing height and the second to the afternoon height. In the current implementation, the larger of these two values and the value of the boundary weather mixing height is used by the code."
>
> "In its present form, that atmospheric model implemented in MACCS2 does not allow a change in the mixing layer to occur during transport of the plume. Mixing layer height is assumed to be constant and therefore only a single value is used by the code."

Since the Dresden MACCS2 analyses considered plumes that have durations in excess of 12 hours (some as long as 24 hours), these conditions mean that, for all intents and purposes, only the afternoon mixing height is used since it is always larger than the morning mixing height. Note that the boundary weather mixing height, wind speed and stability category are only used when there is no met data file. These fixed values are ignored by the code when an hourly met data file is supplied by the user, as was the case in the MACCS2 runs for Dresden.

RAI 5

According to Table F-1 of the Environmental Report (ER), Exelon evaluated 265 SAMA candidates. Of these 265 candidates, 21 were obtained from DNPS-specific documents. It is not clear that the set of SAMAs evaluated in the ER addresses the major risk contributors for DNPS. In this regard, provide the following:

a. *a description of how the dominant risk contributors at DNPS, including dominant sequences and cut sets from the current Probabilistic Risk Assessment (PRA) and equipment failures and operator actions identified through importance analyses (e.g., Fussell-Vesely, Risk Reduction Worth, etc.) were used to identify potential plant-specific SAMAs for DNPS.*

b. *the number of sequences and cut sets reviewed/evaluated and what percentage of the total CDF they represent.*

c. *a listing of equipment failures and human actions that have the greatest potential for reducing risk at DNPS based on importance analysis and cut set screening.*

d. *for each dominant contributor identified in the current PRA (2002 Update), a cross-reference to the SAMAs evaluated in the ER which addresses that contributor. If a SAMA was not evaluated for a dominant risk contributor, then justify why SAMAs to further reduce these contributors would not be cost beneficial.*

e. *the reasons for the difference in the number of SAMAs evaluated for Quad Cities Nuclear Power Station (QCNPS) and DNPS (280 v. 265).*

f. *a general description of the group of 130 insights mentioned in the original IPE and a discussion of how and whether the insights that were not implemented were factored into the SAMA evaluation.*

Response 5(a):

"[Provide] a description of how the dominant risk contributors at DNPS, including dominant sequences and cut sets from the current Probabilistic Risk Assessment (PRA) and equipment failures and operator actions identified through importance analyses (e.g., Fussell-Vesely, Risk Reduction Worth, etc.) were used to identify potential plant-specific SAMAs for DNPS."

A review of the CDF-based Risk Reduction Worth (RRW) rankings for the current model was performed. The rankings of these equipment failures, operator actions, and initiating events were checked to determine if any items could be beneficial that were not addressed by the existing SAMA list. The examination of the dominant RRW basic events encompassed the dominant sequences and cut sets from the current PRA model. RAI response 5(d) provides a more detailed discussion of this importance ranking review.

Response 5(b):

"[Provide] the number of sequences and cut sets reviewed/evaluated and what percentage of the total CDF they represent."

The CDF-based RRW listing was reviewed down to and including the 1.01 level, which indicates the events below this point would influence the CDF by less than 1.0%. This corresponds to about a $4000 averted cost-risk based on CDF reduction assuming 100% reliability of the associated event. An evaluation of the top LERF-based contributors to RRW was also performed. It was determined that a similar averted cost of about $4000 would be obtained by examining the LERF-based RRW factors down to a value of 1.03. RAI response 5(d) provides a more detailed discussion of the importance ranking review and the results.

Response 5(c):

"[Provide] a listing of equipment failures and human actions that have the greatest potential for reducing risk at DNPS based on importance analysis and cut set screening."

RAI response 5(d) provides a listing of equipment failures, human actions, and initiating events that have the greatest potential for reducing risk at DNPS based on importance analysis and cut set screening.

Response 5(d):

"[Provide] for each dominant contributor identified in the current PRA (2002 Update), a cross-reference to the SAMAs evaluated in the ER which addresses that contributor. If a SAMA was not evaluated for a dominant risk contributor, then justify why SAMAs to further reduce these contributors would not be cost beneficial."

Table 5-1 (for CDF) and Table 5-2 (for LERF) provide a correlation between the events identified in the DNPS PSA model (2002 Update) that are considered to have the greatest potential for reducing risk and their relationship to the SAMAs evaluated in the Environmental Report.

The events included in Table 5-1 are based on the core damage frequency RRW factors down to and including RRW values of 1.01. The events included in Table 5-2 are based on the large early release frequency RRW factors down to an RRW value of 1.03. Both of these RRW factors correspond to potential averted cost risk of about $4000. The events below this point are judged to be highly unlikely contributors to the identification of cost-beneficial enhancements.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
F-ICALONE	1.00E+00	1.87	FLAG: IC FAILURE NOT CAUSED BY FAILURE OF REACTOR VESSEL MAKE-UP	This event represents a sequence marker flag identifying those scenarios with isolation condenser failures. The isolation condenser can provide level control and decay heat removal. Many SAMAs were considered that explored alternate injection and decay heat removal capabilities. No additional SAMAs were suggested.
O-AD-MU1	1.10E-04	1.47	2ADOP-ACT-ADSH-- 2ICOP-IC-MU1-H--	This event represents the unlikely scenario of combined operator action failures for separate actions that otherwise are evaluated independently. This event is included for completeness as part of the human reliability dependency analysis. Phase I SAMAs 250 and 255 examine potential improvements in operator performance. No additional SAMAs were suggested for this topic.
%LOOP	3.09E-02	1.35	INIT: LOSS OF OFFSITE POWER	This event is a single unit loss of offsite power event. Improvements related to enhanced AC or DC reliability or availability were considered in Phase I SAMAs 90 through 129. Many other SAMAs were also considered that would provide mitigation benefits in loss of offsite power scenarios including Phase II SAMAs 1, 2, 6, and 10. No additional SAMAs were suggested for this broad topic.
%TF	4.47E-02	1.28	INIT: TRANSIENT WITH FW UNAVAILABLE AND MC AVAILABLE	This event represents the loss of feedwater initiating event frequency. Industry efforts over the last fifteen years have led to a significant reduction in the number of plant scrams from all causes. Many of the SAMAs explored potential benefits for mitigation from these events. No additional SAMAs were suggested for this broad topic.
2HI-SYSTEMUA-M--	2.13E-02	1.19	HPCI SYSTEM MUA	This event represents the probability of the HPCI system in maintenance. Potential improvements to enhance high pressure injection capabilities were considered in Phase I SAMAs 19, 178, 179, 185, 189, 193, 196, 198, 201, 203, and 204. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
%DLOOP	9.41E-03	1.18	INIT: DUAL LOSS OF OFFSITE POWER	This event represents the dual unit loss of offsite power initiating event frequency. See disposition above for %LOOP (Single Unit Loss of Offsite Power).
BDCBY125—-FCC	4.93E-06	1.14	COMMON CAUSE FAILURE OF UNIT 2 AND UNIT 3 125VDC BATTERIES (B=9.86E-03)	This event represents the common cause failure of the 125V DC batteries. Many SAMAs were included that address potential enhancements for DC reliability and/or alternate means of providing DC power. Phase I SAMAs 92, 93, 96, 97, 98, 99, 113, 124, 125, 126, 127, and 128 are all related to improved DC performance. No additional SAMAs were suggested for this broad topic.
2RPCDRPS-MECHFCC	2.10E-06	1.12	RPS MECHANICAL FAILURE	This event represents the Mechanical Scram failure probability based on the NUREG/CR-5500 INEEL evaluation of a representative BWR RPS system. Potential improvements to minimize the risks associated with ATWS scenarios were explored in Phase I SAMAs 213-227, 259, and 260. Phase I SAMAs 259 and 260 were retained as Phase II SAMAs 7 and 8, respectively. No additional SAMAs were suggested for this broad topic.
%TT	1.81E+00	1.12	INIT: TRANSIENT WITH FW AND MC AVAILABLE	This event represents the turbine trip initiating event frequency. Industry efforts over the last fifteen years have led to a significant reduction in the number of reactor scrams and turbine trips. Many of the SAMAs explored potential benefits for mitigation from these events. No additional SAMAs were suggested for this broad topic.
2PLSV-F-RECL-K--	1.50E-01	1.11	FAILURE OF SRVs TO RECLOSE ON REDUCED PRESSURE	This event represents the likelihood that the SRVs will not reclose after initially sticking open in response to a pressure transient. The failure value of 0.15 is based on limited industry evidence. See disposition for 2PLSVSORV-NTTK-- (Probability of SORV for non-turbine trip initiators) below.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2PLSVSORV-NTTK--	5.40E-02	1.10	PROBABILITY OF SORV FOR NON TT INITIATORS	This event represents the likelihood that an SRV will stick open in response to a pressure transient. For Dresden, this renders the isolation condenser ineffective. Consequently, early injection from HPCI or depressurization for low pressure injection is required for success. Many SAMAs considered potential benefits from improved injection capabilities or improved depressurization capabilities. No additional SAMAs were suggested.
%TDC	1.50E-06	1.09	INIT: LOSS OF MULTIPLE DC BUSES	This event represents the unlikely initiating event of a complete loss of both 125V DC buses. Many SAMAs were included that address potential enhancements for DC reliability and/or alternate means of providing DC power. Phase I SAMAs 92, 93, 96, 97, 98, 99, 113, 124, 125, 126, 127, and 128 are all related to improved DC performance. No additional SAMAs were suggested for this broad topic.
2DCRX-BUS2RECF--	7.10E-01	1.09	DC BUS 2 FAIL TO RECOVER (GIVEN LOSS OF MULTIPLE DC BUSES INITIATOR %TDC)	This event involves failure to recover one of the 125V DC buses given loss of both. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
3DCRX-BUS3RECF--	7.10E-01	1.09	DC BUS 3 FAIL TO RECOVER (GIVEN LOSS OF MULTIPLE DC BUSES INITIATOR %TDC)	This event involves failure to recover one of the 125V DC buses given loss of both. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
F-BUS241	1.00E+00	1.08	FLAG: LOSS OF POWER AT BUS 24-1	This event is a sequence marker flag for Bus 24-1 failures. Improvements related to enhanced AC or DC reliability or availability were considered in Phase I SAMAs 90 through 129. Many other SAMAs were also considered that would provide mitigation benefits in loss of offsite power scenarios including Phase II SAMAs 1, 2, 6, and 10. No additional SAMAs were suggested for this broad topic.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
F-BUS231	1.00E+00	1.08	FLAG: LOSS OF POWER AT BUS 23-1	This event is a sequence marker flag for Bus 23-1 failures. See disposition above for F-BUS241 (Sequence marker flag for loss of Bus 24-1).
2ADOP-DEPMADSH--	3.50E-03	1.08	OP ACT: DEPRESS RPV (MLOCA/SORV)	This event represents the human error probability for failing to depressurize for low pressure injection given a medium LOCA or SORV event and initial failure of HPCI to inject (thereby requiring depressurization for low pressure injection). Potential improvements to depressurization capabilities were considered in Phase I SAMAs 190, 191, 229, 230, 240, 241, and 247. No additional SAMAs were suggested for this broad topic.
2HITB2301TURBX--	9.60E-03	1.08	HPCI TURBINE FAILS TO RUN	This event represents the HPCI turbine failing during its mission time. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
O-AD-HI-MU1	1.10E-04	1.02	2ADOP-ACT-ADSH-- 2HIOP-OVRFILLH-- 2ICOP-IC-MU1-H--	This event represents the unlikely scenario of combined operator action failures for separate actions that otherwise are evaluated independently. This event is included for completeness as part of the human reliability dependency analysis. Phase I SAMAs 250 and 255 examine potential improvements in operator performance. No additional SAMAs were suggested for this topic.
BDGDG-3E-2S--XCC	1.88e-04	1.06	2SBO AND 3EDG FAILURE TO RUN CCF	This event represents the unlikely scenario of a common cause failure of the 2SBO and 3EDG. Improvements related to enhanced AC or DC reliability or availability were considered in Phase I SAMAs 90 through 129. Many other SAMAs were also considered that would provide mitigation benefits in loss of offsite power scenarios including Phase II SAMAs 1, 2, 6, and 10. No additional SAMAs were suggested for this broad topic.
RDLOOP4	2.20E-01	1.06	FAILURE TO RECOVER DLOOP WITHIN 4 HOURS	This event represents the probability of not recovering off-site power within 4 hours following a dual unit loss of off-site power. See disposition above for %DLOOP (Dual Unit Loss of Offsite Power).

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2ACBS-UAT-RATF--	1.00E-01	1.04	PROB AC BUS WILL NOT TRANSFER TO THE RESERVE AUX TRANSFORMER (RAT) GIVEN LOSS OF DC BUS 2	This event represents a pseudo-recovery action in loss of DC bus or loss of multiple DC bus initiated events. The importance of this event would be minimized by reducing the frequency of loss of DC events. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
2RXSE-LEAK—L--	1.00E-01	1.03	PROB REACTOR COOLANT LEAKAGE IS SUFFICIENT TO REQUIRE RPV MAKEUP SOURCES	This event represents the likelihood that the recirculation pump seals leak sufficiently to require RPV makeup given a loss of cooling (e.g., in SBO scenarios). Improvements to the reliability of the recirculation pump seals were examined in Phase I SAMA 3 that was retained as Phase II SAMA 1. No additional SAMAs were suggested.
%S1	2.40E-03	1.03	INIT: MEDIUM LOCA	This event represents the Medium LOCA initiating event frequency. Mitigation from such an event would be improved by the existence of more reliable or diverse low pressure injection systems and water sources. Such potential improvements were examined in Phase I SAMAs 177, 184, 187, 194, 197, 202, 205, and 208. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
%A	1.90E-04	1.03	INIT: LARGE LOCA	This event represents the Large LOCA initiating event frequency. Mitigation from such an event would be improved by the existence of more reliable or diverse low pressure injection systems and water sources. Such potential improvements were examined in Phase I SAMAs 177, 184, 187, 194, 197, 202, 205, and 208. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
2CAHU25-ABCDLHCC	8.00E-05	1.03	PREINIT: MISCALIBRATE LEVEL SWITCHES 263-25 A-B-C & D DUE TO CC – LOW	This event represents the unlikely scenario of a common cause miscalibration of level switches leading to unavailability of the isolation condenser. No additional SAMAs are suggested for this topic.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
RDLOOP30	6.40E-01	1.03	FAILURE TO RECOVER DLOOP WITHIN 30 MINUTES	This event represents the probability of not recovering off-site power within 30 minutes following a dual unit loss of off-site power. See disposition above for %DLOOP (Dual Unit Loss of Offsite Power).
2HITB-MULT—A–	4.20E-03	1.03	HPCI TURBINE FAILS TO START MULTIPLE TIMES (1.5 TIMES SINGLE START FAILURE)	This event represents the HPCI turbine failing when required to start more than once. See disposition above for 2HI-SYSTEMUA-M– (HPCI system in maintenance).
%MS	2.68E+00	1.03	INIT: MANUAL SHUTDOWN	This event represents the manual shutdown initiating event frequency. Industry efforts over the last fifteen years have led to a significant reduction in the number of manual shutdowns and scrams from all causes. Many of the SAMAs explored potential benefits for mitigation from these events. No additional SAMAs were suggested for this broad topic.
%TSW	1.98E-03	1.02	INIT: LOSS OF SERVICE WATER	This event is the loss of service water initiating event. Potential improvements and enhancements to the service water system were examined in Phase I SAMAs 10, 20, 21, and 23. No additional SAMAs were suggested, and no related SAMAs were retained for Phase II. It is noted that in Phase I SAMA 23, the cost of installing an additional service water pump had been estimated at approximately $5.9 million which is greater than the maximum averted cost risk (even if large uncertainties and external events are considered).
O-AD-CC2-MU1	1.00E-06	1.02	2ADOP-ACT-ADSH– 2CCOP-CNTC2–H– 2ICOP-IC-MU1-H–	This event represents the unlikely scenario of combined operator action failures for separate actions that otherwise are evaluated independently. This event is included for completeness as part of the human reliability dependency analysis. Phase I SAMAs 250 and 255 examine potential improvements in operator performance. No additional SAMAs were suggested for this topic.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2MSOPMSIVINLKH--	9.30E-01	1.02	OP ACT: BYPASS LOW LEVEL MSIV INTERLOCK (ATWS)	This event represents the human error probability of bypassing the MSIV isolation as directed in the EOPs. This issue was specifically examined in Phase I SAMA 223 that was dispositioned with reference to existing capabilities. However, this action requires the use of jumpers with a limited time available, and as such carries a relatively high HEP value. The potential benefit of implementing a dedicated low level interlock switch is explored as part of this RAI response (see Response 7(c)).
2IC-SYS——M--	7.74E-03	1.02	ISO CNDNSR SYSTEM MUA	This event represents the probability that the isolation condenser is in maintenance. The isolation condenser can provide level control and decay heat removal. Many SAMAs were considered that explored alternate injection and decay heat removal capabilities. No additional SAMAs were suggested.
2FW--LDCHIGH-F--	5.00E-02	1.02	CONDITIONAL PROB. OF FW PUMP TRIP ON HIGH LEVEL	This event represents the conditional probability of a feedwater pump trip on high level given a loss of multiple DC bus initiator. As such, the importance of this event would be reduced by minimizing the loss of DC failures. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
2FW--LDC-LOW-F--	5.00E-02	1.02	CONDITIONAL PROB. OF FW PUMP TRIP ON LOW LEVEL	This event represents the conditional probability of a feedwater pump trip on low level given a loss of multiple DC bus initiator. As such, the importance of this event would be reduced by minimizing the loss of DC failures. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
2HITB2301TURBA--	2.80E-03	1.02	HPCI TURBINE FAILS TO START	This event represents the HPCI turbine failing to start. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2LI--TOP-PEAKF--	2.50E-01	1.02	RX PWR IS TOP PEAKED SUCH THAT 2/3 RX LVL IS INSUFF TO COOL CORE (CS REQD)	This event was added to the model in response to a GE concern about LPCI steam cooling capabilities leading to elevated temperatures in upper portions of the core. Subsequent clarification on this issue will result in a re-examination of this assumption as part of the next update (i.e., LPCI injection with level maintained at 2/3 core height is a success state). No SAMAs were suggested for this issue.
2PVPPWATERBRKR--	8.00E-02	1.02	WATER LINE BREAK MEDIUM LOCA	This event represents the conditional probability of medium LOCA initiating events that are water line breaks as opposed to steam line breaks. See disposition above for %S1 (Medium LOCA Initiator).
2SLEV2-1106ABDCC	7.15E-03	1.02	EXPLOSIVE VALVES 2-1106A&B FAILURE TO OPEN DUE TO CCF	This event represents the common cause failure of the SLC system explosive valves. Diversification of the SLC explosive valves was considered in Phase I SAMA 259 which was retained as Phase II SAMA 8. No additional SAMAs were suggested.
BDGDG-3E-2S--ACC	6.32E-05	1.02	2 SBO AND 3EDG FAILURE TO START CCF	This event represents the unlikely scenario of a common cause failure of the 2SBO and 3EDG. See disposition above for BDGDG-3E-2S--XCC (2SBO and 3EDG failure to run CCF).
2ICOP-IC-MU1-H--	8.80E-03	1.02	OP ACT: INITIATE IC SHELL SIDE MAKEUP	This event represents the probability that IC shell side makeup will not be initiated. The isolation condenser can provide level control and decay heat removal. Many SAMAs were considered that explored alternate injection and decay heat removal capabilities. No additional SAMAs were suggested.
2ICOP-LODC---H--	1.40E-01	1.02	OP ACT: PREVENT LOSS OF IC FOLLOWING BATTERY DEPLETION	This event represents the probability that the isolation condenser will be maintained following battery depletion. The isolation condenser can provide level control and decay heat removal. Many SAMAs were considered that explored alternate injection and decay heat removal capabilities. No additional SAMAs were suggested.

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2FWAV3201ABC-DCC	9.65E-04	1.02	RFP RECIRC. (MIN-FLOW) VALVES FAIL TO OPEN DUE TO COMMON CAUSE	This event represents the unlikely scenario of a common cause failure of the RFP min-flow valves rendering Feedwater injection unavailable. Potential improvements to enhance high pressure injection capabilities were considered in Phase I SAMAs 19, 178, 179, 185, 189, 193, 196, 198, 201, 203, and 204. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
2CNPVDWRUPT--R--	6.00E-02	1.02	LARGE DW CONTAINMENT FAILURE CAUSES LOSS OF INJECTION	This event represents the scenario where un-mitigated containment pressurization results in a large drywell region containment failure leading to a loss of all injection systems. This scenario can be avoided by providing improved decay heat removal methods. Potential improvements for decay heat removal were examined in numerous Phase I SAMAs as well as Phase II SAMAs 2, 3, and 4. No additional SAMAs were suggested for this broad topic.
2HIHU2391-003H--	2.00E-03	1.02	PREINIT: HPCI STM FLOW MTU 2391-03 MISCALIBRATED	This event represents a pre-initiator human error that renders the HPCI system unavailable. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2HIHU2391-005H--	2.00E-03	1.02	PREINIT: HPCI STM FLOW MTU 2391-05 MISCALIBRATED	This event represents a pre-initiator human error that renders the HPCI system unavailable. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2HIKV2301-074D--	2.00E-03	1.02	STOP CHECK VALVE 2-2301-74 FAILS TO OPEN	This event represents a valve failure that prevents HPCI system injection. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2HIPM2301-AOPA--	2.00E-03	1.02	AUXILIARY OIL PUMP FAILS TO START	This event represents an auxiliary failure of the HPCI system. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2HIPM2301GSCPA--	2.00E-03	1.02	GSLO CONDENSATE PUMP FAILS TO START	This event represents an auxiliary failure of the HPCI system. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
XCSLISUCSTR--FCC	1.00E-04	1.01	COMMON CAUSE PLUGGING OF ECCS SUCTION STR DURING LOCAS	This event represents the unlikely occurrence of a common cause failure of the ECCS suction strainers. The Dresden strainers have recently been upgraded and re-sized such that the potential for common cause plugging has been reduced. No additional SAMAs were suggested.
SW-CCSW-FACTOR	2.70E-03	1.01	LOSW IE PERCENT FAILING CCSW DUE TO COMMON EFFECTS	This event represents the fraction of loss of SW initiating events that will also lead to a loss of CCSW due to common causes. See disposition above for %TSW (Loss of Service Water Initiating Event).
2CAHU-52-A-B2HCC	8.00E-05	1.01	PREINIT: MISCALIBRATE CAS PRESSURE SWITCHES 52A AND 52B DUE TO CC	This event represents the unlikely scenario of a common cause miscalibration of pressure switches leading to unavailability of ECCS injection (i.e., failure of RPV low pressure permissive interlock). This is included for completeness in the model since it has the potential of leading to core damage following a medium or large LOCA initiating event. No additional SAMAs are suggested for this topic.
2ECOP-OCST---H--	1.00E-01	1.01	OP ACT: ALIGN LO PRESS ECCS PUMP SUCTION(S) TO CST	This event represents the human error probability associated with failure to align ECCS pump suction to the CST. Cutset review indicates that this action is important in loss of service water initiated events. This idea was considered in Phase 1 SAMA 188. The potential benefit from improving the HEP value associated with this existing action is explored as part of this RAI response (see Response 7(c)).
2HIHU026325AHH--	2.00E-03	1.01	PREINIT: RX HI LEVEL LIS 263-25A3 MISCALIBRATED - HIGH	This event represents a pre-initiator human error that renders the HPCI system unavailable. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2HIHU026325BHH--	2.00E-03	1.01	PREINIT: RX HI LEVEL LIS 263-25B3 MISCALIBRATED - HIGH	This event represents a pre-initiator human error that renders the HPCI system unavailable. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).

Table 5-1
Correlation of CDF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
%FLSWRB545	6.10E-05	1.01	INIT: SW FLOOD IN RB ABOVE 545'	This event represents the initiating event frequency for a SW flood in the reactor building above the 545' elevation. Potential improvements to reduce internal flooding frequency were considered in Phase I SAMAs 153-158. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
%FLSWTB	1.43E-03	1.01	INIT: SW RUPTURE IN TB	This event represents the initiating event frequency for a SW rupture in the turbine building. Potential improvements to reduce internal flooding frequency were considered in Phase I SAMAs 153-158. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
2SWPP-RB-UN--R--	9.00E-01	1.01	BREAK IN USILOABLE SW PIPE IN RB	This event represents the conditional probability that the SW rupture is not isolatable. See disposition above for %FLSWTB (SW Rupture in turbine building initiating event).
%S2	2.90E-03	1.01	INIT: SMALL BREAK LOCA	This event represents the small break LOCA initiating event frequency. Many SAMAs investigated improvements to improved injection or containment heat removal capabilities that would reduce the importance of this event. No additional SAMAs were suggested.
BDCBS2M&3M—FCC	1.13E-07	1.01	MAIN DC BATTERY BUSES 2 AND 3 CCF	This event represents the unlikely scenario of a common cause failure of both main DC battery buses. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2RXSY-RXFAIL-F--	1.00E+00	17.68	FAILURE OF RX (CLASSES ID, IE (OP=F), II, IIIA, IIIC, IIID, IV)	This event is a Level 2 sequence marker flag identifying those sequences where the RX node has failed (i.e., where core damage was not terminated prior to the time of vessel failure). The capability to enhance or provide additional injection systems was examined in Phase I SAMAs 19, 177, 178, 179, 184, 185, 187, 189, 193, 194, 196, 197, 198, 201-205, and 208. No additional SAMAs were suggested.
2GVPH-INERT--X--	9.90E-01	10.45	CONTAINMENT INERTED; VENTING NOT REQUIRED	This event is effectively a Level 2 sequence marker flag that represents the normal operating condition with the containment inerted. No additional SAMAs were suggested.
2SIPHCONTFAILF--	1.00E+00	2.28	DW SHELL MELT-THROUGH FAILURE DUE TO CONT. FAILURE	This event represents the evaluated likelihood from the Level 2 analysis that a dry containment floor will lead to containment failure after vessel failure for accident classes II, IIID, and IV. The importance of this phenomena would be reduced by the presence of more reliable or diverse injection systems, more reliable or diverse drywell spray systems, and other alternate means to avoid this situation. SAMAs related to improved injection system performance are discussed in the disposition for 2RXSY-RXFAIL-F-- above. Items related to improved drywell spray performance were considered in Phase I SAMAs 35, 36, 52, 54, and 82. Phase I SAMA 35 was retained as Phase II SAMA 3. Alternate strategies for reducing the potential for drywell shell melt-through were also examined in Phase I SAMAs 43, 44, 47, 48, 50, 56, 57, and 86. None of these, however, were retained for Phase II, and no additional SAMAs were suggested.
2OPPH-NOLOCA-F--	3.08E-01	1.57	LOCA NOT INDUCED VIA HIGH TEMP, HIGH PRESSURE, OR SORV	This event represents a Level 2 phenomena event that would lead to a depressurized state. See disposition below for 2OPOP-DEPRESSH-- (Operator fails to depressurize in Level 2 given failed in Level 1).

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2OPOP-DEPRESSH--	5.20E-01	1.49	OP FAILS TO DEPRESS GIVEN OP FAILED IN LVL1 OR LOSS OF DC	This event represents the conditional failure probability used in the Level 2 analysis for operators to depressurize prior to vessel failure given that depressurization was unsuccessful to avert core damage. Potential improvements to the current depressurization capabilities and methods were examined in Phase I SAMAs 190, 191, 229, 230, 240, 241, and 247. None of these, however, were retained for Phase II, and no additional SAMAs were suggested.
2DIDW-ATWSSEQFSU	9.90E-01	1.43	DW INTACT FOR ATWS EVENTS (CLASS IV)	This event is effectively a Level 2 sequence marker flag that represents the drywell status at the time of core damage given an ATWS scenario. Note that the evaluated likely failure location for ATWS scenarios is in the wetwell. No additional SAMAs were suggested.
2RPCDRPS-MECHFCC	2.10E-06	1.43	RPS MECHANICAL FAILURE	This event also appears in the CDF importance listing in Table 5-1. It represents the Mechanical Scram failure probability based on the NUREG/CR-5500 INEEL evaluation of a representative BWR RPS system. Potential improvements to minimize the risks associated with ATWS scenarios were explored in Phase I SAMAs 213-227, 259, and 260. Phase I SAMAs 259 and 260 were retained as Phase II SAMAs 7 and 8, respectively. No additional SAMAs were suggested for this broad topic.
2CNWW-ATWSSEQF--	5.00E-01	1.42	WW WATER SPACE FAIL. FOR ATWS EVENTS (CLASS IV)	This event represents the evaluated likelihood that an ATWS scenario with containment failure in the wetwell is located below the normal torus water level. Its' importance would be minimized by reducing the potential for ATWS scenarios. See disposition above for 2RPCDRPS-MECHFCC (RPS mechanical failure).
2OPPH-OP8-NOTFSU	9.69E-01	1.41	SUCCESSFUL RPV DEPRESSURIZATION (CLASS IV)	This event represents the evaluated likelihood that successful RPV depressurization occurs in an ATWS. Its' importance would be minimized by reducing the potential for ATWS scenarios. See disposition above for 2RPCDRPS-MECHFCC (RPS mechanical failure).

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
%TT	1.81E+00	1.34	INIT: TRANSIENT WITH FW AND MC AVAILABLE	This event also appears in the CDF importance listing in Table 5-1. It represents the turbine trip initiating event frequency. Industry efforts over the last fifteen years have led to a significant reduction in the number of reactor scrams and turbine trips. Many of the SAMAs explored potential benefits for mitigation from these events. No additional SAMAs were suggested for this broad topic.
F-ICALONE	1.00E+00	1.31	FLAG: IC FAILURE NOT CAUSED BY FAILURE OF REACTOR VESSEL MAKE-UP	This event also appears in the CDF importance listing in Table 5-1. This event represents a sequence marker flag identifying those scenarios with isolation condenser failures. The isolation condenser can provide level control and decay heat removal. Many SAMAs were considered that explored alternate injection and decay heat removal capabilities. No additional SAMAs were suggested.
O-AD-MU1	1.10E-04	1.25	2ADOP-ACT-ADSH– 2ICOP-IC-MU1-H–	This event also appears in the CDF importance listing in Table 5-1. This event represents the unlikely scenario of combined operator action failures for separate actions that otherwise are evaluated independently. This event is included for completeness as part of the human reliability dependency analysis. Phase I SAMAs 250 and 255 examine potential improvements in operator performance. No additional SAMAs were suggested for this topic.
2SIPH-DWHEAD-F--	5.00E-01	1.24	DRYWELL HEAD CLOSURE FAILS DUE TO OVERPRESSURE	This event is a Level 2 phenomena event that represents the probability that a high pressure vessel failure scenario will lead to an early containment failure given that the reactor cavity is wet at the time of vessel failure. The importance of this event would be minimized by reducing the number of high pressure vessel failure scenarios. See disposition above for 2OPOP-DEPRESSH– (*Operator fails to depressurize given failed in Level 1 or loss of DC*). No additional SAMAs were suggested.

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
%A	1.90E-04	1.19	INIT: LARGE LOCA	This event also appears in the CDF importance listing in Table 5-1. It represents the Large LOCA initiating event frequency. Mitigation from such an event would be improved by the existence of more reliable or diverse low pressure injection systems and water sources. Such potential improvements were examined in Phase I SAMAs 177, 184, 187, 194, 197, 202, 205, and 208. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
%S1	2.40E-03	1.17	INIT: MEDIUM LOCA	This event also appears in the CDF importance listing in Table 5-1. It represents the Medium LOCA initiating event frequency. Mitigation from such an event would be improved by the existence of more reliable or diverse low pressure injection systems and water sources. Such potential improvements were examined in Phase I SAMAs 177, 184, 187, 194, 197, 202, 205, and 208. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
%TF	4.47E-02	1.16	INIT: TRANSIENT WITH FW UNAVAILABLE AND MC AVAILABLE	This event also appears in the CDF importance listing in Table 5-1. It represents the loss of feedwater initiating event frequency. Industry efforts over the last fifteen years have led to a significant reduction in the number of plant scrams from all causes. Many of the SAMAs explored potential benefits for mitigation from these events. No additional SAMAs were suggested for this broad topic.
%LOOP	3.09E-02	1.13	INIT: LOSS OF OFFSITE POWER	This event also appears in the CDF importance listing in Table 5-1. It represents a single unit loss of offsite power event. Improvements related to enhanced AC or DC reliability or availability were considered in Phase I SAMAs 90 through 129. Many other SAMAs were also considered that would provide mitigation benefits in loss of offsite power scenarios including Phase II SAMAs 1, 2, 6, and 10. No additional SAMAs were suggested for this broad topic.

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2HI-SYSTEMUA-M--	2.13E-02	1.13	HPCI SYSTEM MUA	This event also appears in the CDF importance listing in Table 5-1. It represents the probability of the HPCI system in maintenance. Potential improvements to enhance high pressure injection capabilities were considered in Phase I SAMAs 19, 178, 179, 185, 189, 193, 196, 198, 201, 203, and 204. None of these SAMAs were maintained for Phase II, and no additional SAMAs were suggested.
2SIPH-SI2-NOTFSU	5.00E-01	1.10	DRYWELL SHELL INTACT (OP=F)	This event represents the complement to the Level 2 phenomena event 2SIPH-DWHEAD-F-- discussed above. As such, no additional SAMAs were suggested.
2LI--TOP-PEAKF--	2.50E-01	1.10	RX PWR IS TOP PEAKED SUCH THAT 2/3 RX LVL IS INSUFF TO COOL CORE (CS R	This event also appears in the CDF importance listing in Table 5-1. It was added to the model in response to a GE concern about LPCI steam cooling capabilities leading to elevated temperatures in upper portions of the core. Subsequent clarification on this issue will result in a re-examination of this assumption as part of the next update (i.e., LPCI injection with level maintained at 2/3 core height is a success state). No SAMAs were suggested for this issue.
2PVPPWATERBRKR--	8.00E-02	1.10	WATER LINE BREAK MEDIUM LOCA	This event also appears in the CDF importance listing in Table 5-1. It represents the conditional probability of medium LOCA initiating events that are water line breaks as opposed to steam line breaks. See disposition above for %S1 (Medium LOCA Initiator).
XCSLISUCSTR--FCC	1.00E-04	1.09	COMMON CAUSE PLUGGING OF ECCS SUCTION STR DURING LOCAS	This event also appears in the CDF importance listing in Table 5-1. This event represents the unlikely occurrence of a common cause failure of the ECCS suction strainers. The Dresden strainers have recently been upgraded and re-sized such that the potential for common cause plugging has been reduced. No additional SAMAs were suggested.

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2FCPH-FC1-NOTFSU	3.80E-01	1.09	CONT. FLOODING INITIATED (CLASS IA/IC)	This event represents the evaluated likelihood that containment flooding is initiated in accident class 1A or 1C scenarios. Potential improvements to existing containment flooding capabilities were considered in Phase I SAMAs 45, 47, 48, 57, 61, 62, 81, and 86. No additional SAMAs were suggested.
BDCBY125——FCC	4.93E-06	1.08	COMMON CAUSE FAILURE OF UNIT 2 AND UNIT 3 125VDC BATTERIES (BETA = 9.86E-03)	This event also appears in the CDF importance listing in Table 5-1. This event represents the common cause failure of the 125V DC batteries. Many SAMAs were included that address potential enhancements for DC reliability and/or alternate means of providing DC power. Phase I SAMAs 92, 93, 96, 97, 98, 99, 113, 124, 125, 126, 127, and 128 are all related to improved DC performance. No additional SAMAs were suggested for this broad topic.
%TDC	1.50E-06	1.08	INIT: LOSS OF MULTIPLE DC BUSES	This event also appears in the CDF importance listing in Table 5-1. It represents the unlikely initiating event of a complete loss of both 125V DC buses. Many SAMAs were included that address potential enhancements for DC reliability and/or alternate means of providing DC power. Phase I SAMAs 92, 93, 96, 97, 98, 99, 113, 124, 125, 126, 127, and 128 are all related to improved DC performance. No additional SAMAs were suggested for this broad topic.
2DCRX-BUS2RECF–	7.10E-01	1.08	DC BUS 2 FAIL TO RECOVER (GIVEN LOSS OF MULTIPLE DC BUSES INITIATOR %	This event also appears in the CDF importance listing in Table 5-1. It involves failure to recover one of the 125V DC buses given loss of both. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
3DCRX-BUS3RECF--	7.10E-01	1.08	DC BUS 3 FAIL TO RECOVER (GIVEN LOSS OF MULTIPLE DC BUSES INITIATOR %	This event also appears in the CDF importance listing in Table 5-1. It involves failure to recover one of the 125V DC buses given loss of both. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2CAHU-52-A-B2HCC	8.00E-05	1.07	PREINIT: MISCALIBRATE CAS PRESSURE SWTICHES 52A AND 52B DUE TO CC	This event also appears in the CDF importance listing in Table 5-1. It represents the unlikely scenario of miscalibration of pressure switches leading to unavailability of ECCS injection (i.e., failure of RPV low pressure permissive interlock). This is included for completeness in the model since it has the potential of leading to core damage following a medium or large LOCA initiating event. No additional SAMAs are suggested for this topic.
2MSOPMSIVINLKH--	9.30E-01	1.07	OP ACT: BYPASS LOW LEVEL MSIV INTERLOCK (ATWS)	This event also appears in the CDF importance listing in Table 5-1. It represents the human error probability of bypassing the MSIV isolation as directed in the EOPs. This issue was specifically examined in Phase I SAMA 223 that was dispositioned with reference to existing capabilities. However, this action requires the use of jumpers with a limited time available, and as such carries a relatively high HEP value. The potential benefit of implementing a dedicated low level interlock switch is explored as part of this RAI response (see Response 7(c)).
2ACBS-UAT-RATF--	1.00E-01	1.07	PROB AC BUS WILL NOT XFER TO RAT GIVEN LOSS OF DC BUS 2	This event also appears in the CDF importance listing in Table 5-1. It represents a pseudo-recovery action in loss of DC bus or loss of multiple DC bus initiated events. Its' importance would be minimized by reducing the frequency of loss of DC events. See disposition above for %TDC (Loss of Multiple 125V DC Buses Initiating Event).
2SLEV2-1106ABDCC	7.15E-03	1.06	EXPLOSIVE VALVES 2-1106A&B FAILURE TO OPEN DUE TO CCF	This event also appears in the CDF importance listing in Table 5-1. It represents the common cause failure of the SLC system explosive valves. Diversification of the SLC explosive valves was considered in Phase I SAMA 259 which was retained as Phase II SAMA 8. No additional SAMAs were suggested.

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2CZPH-HPBDVS3F--	1.00E+00	1.05	HIGH PRESSURE BLOWDOWN OVERWHELMS VAPOR SUPPRESSION	This event represents the evaluated likelihood that given the unlikely scenario of a vessel rupture or a vapor suppression failure, that the RPV blowdown will indeed fail vapor suppression. Its' importance would be reduced by reducing the probability of vapor suppression failures. Improvements to the vacuum breakers at Dresden would reduce the probability of vapor suppression failures. Potential vacuum breaker improvements were explored in Phase 1 SAMA 68. No additional SAMAs were suggested.
2PVPPSTEAMBRKR--	9.20E-01	1.05	STEAM LINE BREAK MEDIUM LOCA	This event represents the conditional probability of medium LOCA initiating events that are steam line breaks as opposed to water line breaks. See disposition above for %S1 (Medium LOCA Initiator).
2HITB2301TURBX--	9.60E-03	1.05	HPCI TURBINE FAILS TO RUN	This event also appears in the CDF importance listing in Table 5-1. It represents the HPCI turbine failing during its mission time. See disposition above for 2HI-SYSTEMUA-M-- (HPCI system in maintenance).
2SIHU-RCVR---H--	9.00E-01	1.04	FAILURE TO RECOVER A WATER SYSTEM	This event represents the evaluated likelihood that an injection system will not be recovered prior to drywell shell melt through. See disposition above for 2SIPHCONTFAILF-- (Drywell Shell Melt-Through Fails Containment).
2SIPH-BARRIS-F--	1.00E+00	1.04	DW BARRIERS FAIL TO PREVENT DEBRIS FROM CONTACTING SHELL	This event represents the evaluated likelihood that drywell barriers would prevent debris from contacting the shell, thereby preventing drywell shell melt-through. See disposition above for 2SIPHCONTFAILF-- (Drywell shell melt-through fails containment).
2SIPH-SUMPOV-F--	1.00E+00	1.04	MELT OVERFLOWS SUMP	This event represents the evaluated likelihood that core debris will overflow the sump and contact the drywell wall liner. See disposition above for 2SIPHCONTFAILF-- (Drywell Shell Melt-Through Fails Containment).

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2DIDW-LOSSVSSF--	1.00E+00	1.04	DW NOT INTACT FOR LOSS OF VAPOR SUPP. (CLASS IIID)	This event represents the evaluated likelihood that vapor suppression failures in LOCA scenarios would lead to containment failure. Its' importance would be reduced by reducing the probability of vapor suppression failures. Improvements to the vacuum breakers at Dresden would reduce the probability of vapor suppression failures. Potential vacuum breaker improvements were explored in Phase 1 SAMA 68. No additional SAMAs were suggested.
2GVPHSTMINERTX--	1.00E+00	1.04	COMBUSTIBILE GAS VENTING NOT REQUIRED (STEAM INERTED - CLASS IIID)	This is a Level 2 phenomena event representing the evaluated likelihood that a vapor suppression failure scenario would result in a steam inerted environment in containment thereby precluding the need for combustible gas venting. See disposition above for 2DIDW-LOSSVSSF-- (Vapor suppression failures lead to containment failure).
2PLSV-F-RECL-K--	1.50E-01	1.04	FAILURE OF SRVs TO RECLOSE ON REDUCED PRESSURE	This event also appears in the CDF importance listing in Table 5-1. It represents the likelihood that the SRVs will not reclose after initially sticking open in response to a pressure transient. The failure value of 0.15 is based on limited industry evidence. See disposition for 2PLSVSORV-NTTK-- (Probability of SORV for non-turbine trip initiators) below.
2PLSVSORV-NTTK--	5.40E-02	1.04	PROBABILITY OF SORV FOR NON TT INITIATORS	This event also appears in the CDF importance listing in Table 5-1. It represents the likelihood that an SRV will stick open in response to a pressure transient. For Dresden, this renders the isolation condenser ineffective. Consequently, early injection from HPCI or depressurization for low pressure injection is required for success. Many SAMAs considered potential benefits from improved injection capabilities or improved depressurization capabilities. No additional SAMAs were suggested.

Table 5-2
Correlation of LERF Importance Listing to Evaluated SAMAs

Event Name	Probability	RRW	Basic Event Description	Disposition
2ADOP-DEPMADSH--	3.50E-03	1.04	OP ACT: DEPRESS RPV (MLOCA/SORV)	This event also appears in the CDF importance listing in Table 5-1. It represents the human error probability for failing to depressurize for low pressure injection given a medium LOCA or SORV event and initial failure of HPCI to inject (thereby requiring depressurization for low pressure injection). Potential improvements to depressurization capabilities were considered in Phase I SAMAs 190, 191, 229, 230, 240, 241, and 247. No additional SAMAs were suggested for this broad topic.
O-AD-HI-MU1	1.10E-04	1.03	2ADOP-ACT-ADSH-- 2HIOP-OVRFILLH-- 2ICOP-IC-MU1-H--	This event represents the unlikely scenario of combined operator action failures for separate actions that otherwise are evaluated independently. This event is included for completeness as part of the human reliability dependency analysis. Phase I SAMAs 250 and 255 examine potential improvements in operator performance. No additional SAMAs were suggested for this topic.
%DLOOP	9.41E-03	1.03	INIT: DUAL LOSS OF OFFSITE POWER	This event also appears in the CDF importance listing in Table 5-1. It represents the dual unit loss of offsite power initiating event frequency. See disposition above for %LOOP (Single Unit Loss of Offsite Power).

Response 5(e):

"[Provide] the reasons for the difference in the number of SAMAs evaluated for Quad Cities Nuclear Power Station (QCNPS) and DNPS (280 v. 265)."

Quad Cities included 30 plant-specific insights in addition to 250 generic insights as part of the SAMA list development. 19 of these plant-specific insights were not applicable to Dresden (e.g., they related to the SSMP or were specific to the IPEEE for Quad Cities), and as such were not included for Dresden. Two additional SAMAs that were PWR specific were included on the list for Quad, but not for Dresden. This means that 259 of the 265 Dresden SAMAs were also on the Quad list. The remaining 6 SAMAs were unique to Dresden. Phase 1 SAMAs 257, 258 related to the isolation condenser, and therefore were not applicable to Quad Cities, and SAMAs 261, 262, 263, and 265 were obtained from Dresden PRA Insights, and were not included in the Quad Cities SAMA list.

Response 5(f):

"[Provide] a general description of the group of 130 insights mentioned in the original IPE and a discussion of how and whether the insights that were not implemented were factored into the SAMA evaluation."

One of the important means of identifying plant specific improvements for the Dresden SAMA analysis was a review of the plant's IPE. As part of the IPE, an analysis of the cutsets and importance rankings was performed in order to identify plant weaknesses and to suggest changes that would address the weaknesses identified. The original Dresden IPE submittal report stated that over 130 IPE insights and over 60 Accident Management (AM) insights had been identified. Subsequent to that report, several additional insights were identified.

In summary, the original IPE included a commitment to implement two IPE insights. Procedure revisions were completed in 1993 and 1994 that implemented those two insights. This included provisions to allow continued IC operation during extended station blackout event, and detailed guidance to allow realignment of LPCI and CS pumps to the Condensate Storage Tank if NPSH problems are imminent if suction is maintained to the suppression pool.

In 1994, the ComEd PRA group identified 11 other IPE insights as warranting investigation for potential benefit. Further evaluation indicated that action was not warranted on most, but action was taken on two of those insights. This included a modification that would eliminate trip of any of a unit's Feedwater pumps on loss of the main 125V DC bus, and replacement of the Diesel Generator Air Start System Regulators. The remaining nine insights that were identified as having a major benefit were examined and were dispositioned as follows:

- Three of the insights related to removal or modification of DC dependencies related to operation of the isolation condenser. These insights were judged to have minimal benefit following the completion of procedural direction to allow prolonged IC operation without DC power that was implemented as indicated above.

- Three other insights were related to enhancing CRD flow. These were found to lead to a minimal reduction in CDF from the modified IPE model, and changes were not pursued further.

- The remaining three insights were deemed no longer applicable following completion of the insight modifications that were implemented, and no further action was taken.

The evaluation of those 11 IPE insights also noted that 12 other IPE insights had been fully or partially implemented via procedure revisions, operator aids, or changes in control room staffing.

The Accident Management insights from several sites were carefully considered by the BWROG in developing the EOPs and SAMGs that have been subsequently implemented at Dresden. No additional action was required.

Although the IPE insights were not directly used as input into the SAMA analysis, more recent insights from the updated PRA models were factored directly into the SAMA list. Seventeen of the Phase 1 SAMAs include the "Dresden Risk Management Insights" as the reference source (i.e., indicated in Table F-1 of the ER as Reference 64) and four others were based on IPEEE insights. These twenty-one items were specifically developed following the completion of the 1999 PRA model update and 2000 Fire Risk Model. The completion of the 2002 model update did not lead to any additional insights as the results did not dramatically change. In any event, a correlation between importance parameters for both CDF and LERF from the 2002 model and their relationship to the SAMA analysis is provided in Response 5(d). In summary, it was judged that these more recent insights were sufficient and appropriate for supplementing the generic SAMA lists with plant-specific insights.

RAI 6

The SAMA analysis did not include an assessment of SAMAs for external events. The DNPS IPE for External Events (IPEEE) has shown that the CDF due to internal fire initiated events is 1.7x10-5 per reactor year for Unit 2 and 3.1x10-5 per reactor year for Unit 3. The risk analyses at other commercial nuclear power plants also indicate that external events could be large contributors to CDF and the overall risk to the public. In this regard, provide the following:

a. *NUREG-1742 ("Perspectives Gained From the IPEEE Program," Final Report, 4/02), lists the significant fire area CDFs for DNPS (pages 3-15 and 3-16 of Volume 2). While these fire-related CDF estimates may be conservative, they are still large relative to the DNPS internal events CDF. For each fire area or dominant fire sequence, explain what measures were taken to further reduce risk, and explain why these CDFs can not be further reduced in a cost effective manner.*

b. the IPEEE Safety Evaluation Report (SER), Extended Power Uprate (EPU) SER, and NUREG-1742 (Tables 2.7 and 2.12) identify seismic outliers and improvements for DNPS. Confirm that all of the plant improvements that address the outliers have been implemented. If not, then discuss the rationale within the context of this SAMA study. For those improvements still pending (e.g., seismically-verified makeup path to the isolation condenser, and modifications to improve the reliability of the containment cooling service water cooling function), provide a brief description of each improvement and its status.

c. *Exelon states that Phase 2 SAMA 5 remains under investigation for resolution as part of the DNPS closeout of the IPEEE commitments. Describe the improvements under investigation, their status, and expected implementation schedule. As part of this response, identify the systems, structures, and components (SSCs) that limit the plant high confidence in low probability of failure (HCLPF). Justify why modifications to increase seismic capacity would not be cost-beneficial when evaluated consistent with the regulatory analysis guidelines for those structures, systems and components [SSCS] below 0.3g yet not expected to be modified.*

Response 6(a):

"NUREG-1742 ("Perspectives Gained From the IPEEE Program," Final Report, 4/02), lists the significant fire area CDFs for DNPS (pages 3-15 and 3-16 of Volume 2). While these fire-related CDF estimates may be conservative, they are still large relative to the DNPS internal events CDF. For each fire area or dominant fire sequence, explain what measures were taken to further reduce risk, and explain why these CDFs can not be further reduced in a cost effective manner."

As an IPEEE, the Dresden fire study was performed primarily to develop risk insights. It was done in the traditional style of Fire PRAs, and as such, employs conservatism and involves some level of uncertainty (also see Attachment A that provides more details on the types of conservatisms and uncertainties associated with the use of quantitative results from Fire PRAs). Therefore, it cannot be used directly to provide a realistic cost-benefit analysis as part of the SAMA evaluations.

In any event, Table 6-1 provides a list of the nine insights that were developed from the Fire IPEEE results, and provides a disposition of these insights with respect to the SAMA analysis. As can be seen, no unique SAMAs were identified based on a review of these insights.

Table 6-1
Fire IPEEE Insights and Relationship to SAMA Analysis

Insight Description	Disposition Comments / Relationship to SAMA Analysis
1. CDF contribution of fires is consistent with other BWRs.	Original fire risk study credited the Safe Shutdown Procedures and selected EOP equipment. With the exception of the severe Control Room fire scenario, the new fire risk study did not credit the Safe Shutdown Procedures. The new study did include more EOP equipment than the original study, however. Despite little credit being given to the Safe Shutdown Procedures, the new fire risk study gave a significantly lower fire CDF than did the original fire risk study. No additional SAMAs were suggested.
2. Fire scenarios involving loss of 125 VDC are some of the main contributors to fire CDF for Unit 2. Important operator actions are alignment of spare battery charger or spare (alternate) Unit 2 battery.	125 VDC control power is also important in the internal events PRA model. Procedures already exist to align the Alternate 125V DC batteries or chargers. • DOA 6900-02, Failure of Unit 2 125V DC Power Supply • DOA 6900-03, Failure of Unit 3 125V DC Power Supply Many SAMAs were included that address potential enhancements for DC reliability and/or alternate means of providing DC power. Phase I SAMAs 92, 93, 96, 97, 98, 99, 113, 124, 125, 126, 127, and 128 are all related to improved DC performance. No additional SAMAs were suggested.
3. This insight observes that local manual operation of the Isolation Condenser valves when DC power is lost would reduce CDF by approximately a third.	This insight should NOT be interpreted as indicating that a one-third reduction in fire risk could be achieved via a change to the EOPs. Instead, this insight is referring to conservatism in the revised fire risk study in not crediting the SSPs for such scenarios. The SSPs (implemented in approximately 1987) have always included steps for local manual operation of the subject valves for fires that fail DC power. Operators are trained on those procedure steps as well as the SSP guidance for accessing the valves during possible fire scenarios. The details of how to access and operate specific valves for specific fire scenarios is required for the SSPs but would be inappropriate for the symptom-based EOPs. No additional SAMAs were suggested.

Table 6-1
Fire IPEEE Insights and Relationship to SAMA Analysis

4. Excluding the control room severe fire, the dominant core damage sequence is loss of decay heat removal. Recovery of decay heat removal has significant risk reduction potential.	Loss of decay heat removal sequences are also important in the internal events PRA model. Current treatment in the internal events PRA model also conservatively does not include recovery. Potential improvements for decay heat removal were examined in numerous Phase I SAMAs as well as Phase II SAMAs 2, 3, and 4. No additional SAMAs were suggested.
5. Postulated fires in the Main Control Room represents the largest risk contributor. The bounding Main Control Room fire event which forces abandonment is the single largest risk contributor.	This insight does not make any recommendations for improvements but provides comments concerning the Control Room Evacuation scenario being the largest single risk contributor. One comment is that this scenario's risk importance is consistent with other fire IPEEE studies. Note that the CDF for Control Room Evacuation is effectively based on an assumed CCDP of 0.5 while CCDPs for all of the other fire scenarios are calculated using the fire risk model. Therefore, the fractional CDF contribution of control room fires given by the revised fire risk study has a large uncertainty and is of limited use in evaluating potential changes to reduce risk. No additional SAMAs were suggested.
6. Fire induced failure of certain ADS circuits could cause spurious opening of ADS valve(s) that would not be prevented by use of the ADS inhibit switch. The cables are not exposed to a significant fire threat and are not a dominant risk contributor.	Various Safe Shutdown Procedures (SSPs) already include recovery steps. One example is opening breakers or pulling fuses to remove power from the ADS valves and thus prevent fire-induced spurious opening. With the exception of the Control Room Evacuation procedures, SSP recovery actions were not credited in the new fire risk study. Therefore, the new fire risk study is overly conservative with respect to recovery of spurious operation. The conservatism of the new fire risk model is acceptable. Not crediting SSP actions (other than those for Control Room Evacuation) was a decision by senior management for the purpose of illustrating that the Dresden fire CDF is acceptable even with little credit given to the SSPs. No additional SAMAs were suggested.
7. Other than the control room severe fire scenario (requiring control room evacuation), the most significant control room fire scenario involves a loss of offsite power accompanied by a loss of onsite Division II AC power.	Loss of offsite power events with loss of one or both onsite AC power divisions are also significant in the internal events PRA model. Improvements related to enhanced AC or DC reliability or availability were considered in Phase I SAMAs 90 through 129. Many other SAMAs were also considered that would provide mitigation benefits in loss of offsite power scenarios including Phase II SAMAs 1, 2, 6, and 10. No additional SAMAs were suggested.

Table 6-1

Fire IPEEE Insights and Relationship to SAMA Analysis

8. The lower damage threshold for non-IEEE 383 qualified cables limited the effectiveness of installed automatic fire suppression systems. The significance of the Reactor Feed Pump oil fire scenario would be reduced if IEEE 383 qualified cables had been installed.	Cable replacement or installation of fire barriers such as cable wrap would be prohibitively expensive. Additionally, the insight was applicable to the fire modeling methods used in the IPEEE, but more recent research and discussions with the NRC Staff have indicated that existing suppression systems are considered more (not less) effective for non-IEEE 383 qualified cables. Specifically, NRC fire protection inspectors have issued violations for installation of IEEE 383 qualified cables without necessary augmentation of suppression systems that were originally installed for non-qualified cables. The basis for issuing violations is recent research that shows that fires in qualified cables take longer to suppress than do fires in non-qualified cables. This issue was brought to the attention of Dresden Engineering during the 2002 triennial fire protection inspection. (Note that the suppression systems of NRC concern in those inspections were Halon and Cardox, not water.) In summary, the comments made in Insight #8 may no longer be valid based on recent NRC fire inspection findings at Dresden and other plants. No additional SAMAs were suggested.
9. This insight describes three fire risk asymmetries between Unit 2 and Unit 3. Differences in cable routings between the units contributed to Unit 3 having a higher fire CDF using the revised fire risk model.	Note that because the SSPs are not credited, fire risk results from the revised fire risk study should be regarded as bounding rather than best estimate CDF values. Therefore, although this insight indicates that a potential reduction in Unit 3 fire CDF could be achieved by major relocation of cables and cable trays, this is qualitatively not warranted given the known conservatisms in the analysis and the expenses that would be involved in performing the re-routings. No additional SAMAs were suggested.

Additionally, a review of the Dresden Fire PRA model cutsets was performed to determine the dominant sequence types. Excluding the control room severe fire, it was determined that although there are many different scenarios and initiating events, there are just three dominant sequence types: loss of decay heat removal (TW), loss of injection at high pressure (TQUX), and loss of injection at low pressure (TQUV). These three scenarios are also significant contributors to the internal events calculated core damage frequency.

Potential improvements to respond to the three dominant Fire PRA sequence types were examined in many portions of the SAMA analysis. This included potential improvements to high pressure injection capabilities, RPV depressurization capabilities, low pressure injection capabilities, and decay heat removal capabilities. Potential improvements to enhance high pressure injection capabilities were considered in Phase I SAMAs 19, 178, 179, 185, 189, 193, 196, 198, 201, 203, and 204. Potential improvements to RPV depressurization capabilities were considered in Phase I SAMAs 190, 191, 229, 230, 240, 241, and 247. Potential improvements to low pressure injection systems and water sources were examined in Phase I SAMAs 177, 184, 187, 194, 197, 202, 205, and 208. Potential improvements for decay heat removal were examined in numerous Phase I SAMAs as well as Phase II SAMAs 2, 3, and 4. As such, it is judged that any improvements that could be justified using the internal events CDF as a measure (with extra margin considered to account for potential benefits from external events as described in Response 7(c)), is the best use of available capabilities to determine the estimated averted costs and benefits.

Response 6(b):

"[T]he IPEEE Safety Evaluation Report (SER), Extended Power Uprate (EPU) SER, and NUREG-1742 (Tables 2.7 and 2.12) identify seismic outliers and improvements for DNPS. Confirm that all of the plant improvements that address the outliers have been implemented. If not, then discuss the rationale within the context of this SAMA study. For those improvements still pending (e.g., seismically-verified makeup path to the isolation condenser, and modifications to improve the reliability of the containment cooling service water cooling function), provide a brief description of each improvement and its status."

IPEEE Safety Evaluation Report and NUREG-1742 Seismic Outliers and Improvement Status

As indicated in NUREG-1742, an extensive number of plant improvements or other actions were planned to resolve the USI A-46 outliers. These improvements pertained primarily to enhancing anchorage/support capacity and reducing or eliminating the potential for adverse interactions. Dresden recently informed the NRC that all of the outliers have either been resolved or will be completed no later than the end of the Unit 2 refueling outage scheduled for October 2003 except for those listed in Table 6-2 which will be completed by the end of the Unit 3 refueling outage scheduled for fall 2004. Reference letter from R. J. Hovey, Dresden Nuclear Power Station, *Delay in Completion of Unresolved Safety Issue (USI) A-46 Commitment*, RHLTR 03-0046, dated July 17, 2003. Remaining unresolved issues and scheduled completion dates are shown in Table 6-2.

Table 6-2
Unresolved Safety Issue Status

Description	Completion Schedule
Unit 3 Modifications to five cubicles of a 250 volt direct current (VDC) Motor Control Center (MCC)	D3R18 Scheduled for fall 2004

EPU SER Seismic Outlier and Improvement Status

"The NRC SER on the DNPS IPEEE indicates that the licensee had implemented a number of improvements during the resolution of unresolved safety issue (USI) A-46, *Verification of Seismic Adequacy of Equipment in Operating Plants*, and that a number of additional improvements were still under consideration. In particular, the SER states that the licensee was developing a concept for providing a seismically-qualified/verified make-up path to each unit's isolation condenser and that this design change would be implemented in conjunction with the approved schedule for resolution of the USI A-46 outliers. The DNPS IPEEE SMA took credit for this modification for the scenario in which the dam fails during a seismic event, but the modification has not been implemented at this time."

Additional background:

Dresden responded to an NRC EPU RAI regarding seismic capability in a letter from K. A. Ainger, RS-01-208, dated September 26, 2001, *Additional Information Supporting the License Amendment Request to Permit Uprated Power Operation at Dresden Nuclear Power Station.*

> "The sources of makeup water to the IC shell side are not seismically qualified, but given the redundancy and diversity of these sources, there is a high confidence that at least one source will be available following a seismic event. The current sources include initial makeup from on-site tanks and the Unit 1 fire pump, and makeup from the ultimate heat sink (UHS). The DNPS response to the Individual Plant Examination of External Events (IPEEE) (Reference 1) included a commitment to provide a seismic makeup path to the IC by November 2003."

This commitment to provide a seismic makeup path to the IC is on schedule to be completed by November 2003.

In the same document, the following is stated:

> "Question 2: Provide additional discussion regarding the results of the study to confirm the adequacy of the isolation condenser to provide suppression pool cooling following a small break LOCA with a dam failure, and the acceptability of proceeding with the power uprate based on the results of this study.
>
> Response
>
> The study for the small break loss of coolant accident (SBLOCA) coincident with a dam failure has been completed for EPU conditions. The study assumed a one inch small break, consistent with the guidance in EPRI NP-6041-SL, "A Methodology for Assessment of Nuclear Power Plant Seismic Margin (Revision 1)." EPU decay heat was used in the analysis. The analysis demonstrates that the IC and available emergency core cooling systems (ECCS) (i.e., high pressure coolant injection (HPCI) and low pressure coolant injection (LPCI)) are sufficient to mitigate a seismically induced SBLOCA for a 24-hour period. The study shows that additional equipment, specifically a cooling water supply to the CCSW heat exchangers, will be required 24 hours after the onset of the event to supply suppression pool cooling.
>
> DNPS has developed a conceptual design using large portable pumps that would be used to restore the required CCSW cooling flow via suction from the intake canal. These pumps would be stored in an area that could withstand the postulated seismic event, and would be staged with hose connections to the CCSW piping. The necessary fittings will be installed on the existing CCSW piping. Power for the portable pumps will be supplied either by portable diesel engines or by temporary power connections to the available existing electrical buses. Procedures will be developed to ensure that the necessary actions will be taken within the 24 hour period to establish suppression pool cooling flow. These actions will provide the capability to mitigate the seismically induced SBLOCA for the 72 hour time frame given in EPRI NP-6041-SL. These actions will be

completed on the same schedule as the modification to provide a seismically qualified makeup path to the IC as described in Reference I."

The CCSW fitting modification and development of Procedures to ensure that the necessary actions will be taken within the 24 hour period to establish suppression pool cooling flow are scheduled to be completed on the same schedule as the IC make-up seismic upgrade modification.

Response 6(c):

"Exelon states that Phase 2 SAMA 5 remains under investigation for resolution as part of the DNPS closeout of the IPEEE commitments. Describe the improvements under investigation, their status, and expected implementation schedule. As part of this response, identify the systems, structures, and components (SSCs) that limit the plant high confidence in low probability of failure (HCLPF). Justify why modifications to increase seismic capacity would not be cost-beneficial when evaluated consistent with the regulatory analysis guidelines for those structures, systems and components (S[S]Cs) below 0.3g yet not expected to be modified."

See Response 6(b) for the improvements that have been or will be made, their status, and expected implementation schedule.

Table 6-3 shows the new HCLPF capacity of items listed on page 1-3 and 1-4 of the original IPEEE submittal. The new HCLPF capacities are based on additional evaluations and improvements that have been made or are scheduled to be made as identified in Response 6(b).

Table 6-3
HCLPF Capacities of Previously Identified Outliers

Original Capacity (pga)	New Capacity (pga)	Description	Basis for New Capacity
0.15g	>0.3g	Cable Trays-Turbine, Reactor & Service Bldgs., El. 517' (GIP LAR 007)	More rigorous evaluation.
0.17g	>0.3g	Buses - D03-8303B-----M05, D02-8302B----M05, D03-8303A---M05, Dist. Panel D03-83125----P06	Anchorage Modification.
0.17g	>0.3g	Distribution Panel - D02-83125----P06 and Bus D02-8302A---M05	Anchorage Modification.
0.17g	>0.3g	Cabinet - D02-2252-0010	Anchorage Modification.
0.20g	No change	Condensate Storage Tanks - D00-3303-A----T05, D00-3303-B----T05	Original evaluation
0.22g	>0.3g	Control Panels D02-0902-0004, 0015, 0017, 0019 & 0036, D03-0903-0004, 0015, 0017, 0019 & 0036	Modification.

Table 6-3
HCLPF Capacities of Previously Identified Outliers

Original Capacity (pga)	New Capacity (pga)	Description	Basis for New Capacity
0.23g	>0.3g	Control Panels D02-0902-0028 & -0003, D03-0903-0028	Additional evaluation.
0.26g	No change	Diesel Fuel Oil Storage Day Tank D00-5202-T05	Original evaluation.
0.27g	No change	Battery Charger - D02-8300-2A---B05	Original evaluation.
0.27g	No change	Distribution Panels - D02-9802-A & B---P06	Original evaluation.
0.27g	No change	Switchgear - D02-7328---S35 & D02-7329----S35	Original evaluation.
0.27g	No change	Bus #2A-1 - D02-8302A1----P06	Original evaluation.
0.27g	No change	125V DC/TB Battery Bus #2 D02-83125-2-P06	Original evaluation.
0.27g	No change	125V DC/Battery Charger #2 D02-8300-2---B05	Original evaluation.
0.28g	No change	125V DC Battery Charger – D03-8300-3A---B05	Original evaluation.
0.28g	No change	Unit 2&3 Torus Suppression Chambers	Original evaluation.
0.28g	>0.3g	Cabinet - D02-2252-0021	Anchorage modification.
0.29g	No change	Motor Control Centers D02-83250----M05 & D02-7826-4---M05	Original evaluation.
0.29g	No change	Bus #2B-1 - D02-8302B-1---P06	Original evaluation.
0.29g	No change	125V DC/TB Res Bus #2 D02-83125-1---P06	Original evaluation.

As can be seen in Table 6-3, there are a limited number of components with HCLPF capacities that fall into the range of 0.2g to 0.3g. In fact, the majority of SSCs at Dresden already have HCLPF values of at least 0.3g. Additionally, only the Condensate Storage Tanks (CSTs) have a capacity less than 0.26g. Modifications to increase the CST seismic capacities would be expected to cost more than several hundred thousand dollars, and minimal benefit is expected from increasing the remaining outliers from their current near 0.3g values to >0.3g. As such, it is judged that further modifications to increase seismic capacity are not warranted.

RAI 7

The SAMA analysis did not include an assessment of the impact that PRA uncertainties and external event risk considerations would have on the conclusions of the study. Some license renewal applicants have opted to double the estimated benefits (for internal events) to accommodate any contributions for other initiators when sound reasons exist to support such a numerical adjustment, and to incorporate additional margin in the SAMA screening criteria to address uncertainties in other parts of the analysis (e.g., an additional factor of two in comparing costs and benefits of each SAMA). At DNPS, external events (both fire and seismic) are dominant contributors to the total CDF, and are over a factor of 10 greater than internal event contributions. On that basis, provide the following information to address these concerns:

a. an estimate of the uncertainties associated with the calculated core damage frequency (e.g., the mean and median internal events CDF estimates and the 5th and 95th percentile values of the uncertainty distribution).

b. an assessment of the impact on the Phase 1 screening if risk reduction estimates are increased to account for uncertainties in the risk assessment and the additional benefits associated with external events (as applicable).

c. an assessment of the impact on the Phase 2 evaluation if risk reduction estimates are increased to account for uncertainties in the risk assessment and the additional benefits associated with external events (as applicable). Consider the uncertainties due to both the averted cost-risk and the cost of implementation to determine changes in the net value for these SAMAs.

Response 7(a):

"[Provide] an estimate of the uncertainties associated with the calculated core damage frequency (e.g., the mean and median internal events CDF estimates and the 5th and 95th percentile values of the uncertainty distribution)."

The 2002 update of the Dresden PRA model was utilized as the basis for the SAMA analysis performed in support of the environmental report. This version of the model was not populated with uncertainty distributions for the data input parameters. Consequently, development of the median internal events CDF estimates and the 5^{th} and 95^{th} percentile values of the uncertainty distribution are not readily available. (Note that population of the uncertainty distribution parameters is anticipated for a future model revision update.) Table 7-1 provides estimates of internal events Level 1 CDF uncertainty distributions that were obtained for other plants from various sources.

Table 7-1
Representative Core Damage Frequency Uncertainty Distributions

Plant / Model	Point Estimate Mean Value	Para-metric Mean Value	5th Percentile Value	Median Value	95th Percentile Value	95th / P.E. Mean Ratio	Error Factor	Reference
Peach Bottom	3.6E-6 (1)	4.5E-6	3.5E-7	1.9E-6	1.3E-5	3.6	6.1	NUREG/CR-4551, Volume 4, Rev. 1, Part 1 (Table S-1a)
Grand Gulf	2.0E-6 (2)	4.1E-6	1.8E-7	1.1E-6	1.4E-5	7.0	8.8	NUREG/CR-4551, Volume 6, Rev. 1, Part 1 (Table S-2)
LaSalle / RMIEP	3.1E-5	4.4E-5	2.1E-6	1.6E-5	1.4E-4	4.5	8.2	NUREG/CR-4832, Volume 2 (RMIEP), (Table 3.1)
LaSalle / Current	6.64E-6	6.88E-6	2.82E-6	5.20E-6	1.39E-5	2.1	2.2	LS-PSA-014, LaSalle Quantification Notebook, Revision 2, June 2003 (Appendix G)
H.B. Robinson	4.3E-5	4.5E-5	1.5E-5	3.3E-5	1.1E-4	2.6	2.7	Docket No. 50/261 (Response to Request for Additional Information Regarding SAMA Analysis)
V.C. Summer	5.6E-5	5.6E-5	1.9E-5	4.4E-5	1.3E-4	2.3	2.6	Docket No. 50/395 (Response to SAMA Request for Additional Information)

(1) From NUREG/CR-4550, Vol. 4, Rev. 1, Part 1, Page 5-1.
(2) From NUREG/CR-4550, Vol. 6, Rev. 1, Part 1, Page 5-1.

The collective information shown in Table 7-1 indicates that the point estimate to mean ratio could be as little as 2 or as large as 7. The LaSalle/RMIEP distribution parameters are chosen as representative since they represent the second-most broadest distribution. Therefore, a factor of 4.5 increase from the calculated point estimate mean internal events CDF with an error factor of 8 is used as a reasonably conservative estimate to approximate the uncertainty distribution. This correlates to an estimated 95th percentile value of about 8.6E-6/yr for the Dresden internal events core damage frequency. Additionally, the assumed error factor of 8 can be used to approximate the median and 5th percentile values as well as is shown below.

Dresden Approximated Uncertainty Distribution:

95th Percentile:	4.5 * (Point Estimate Mean)	= 8.5E-6/yr
Median:	95th / EF = 8.5E-6/yr / 8	= 1.1E-6/yr
5th Percentile:	Median / EF = 1.1E-6/yr / 8	= 1.3E-7/yr

Response 7(b):

"[Provide] an assessment of the impact on the Phase 1 screening if risk reduction estimates are increased to account for uncertainties in the risk assessment and the additional benefits associated with external events (as applicable)."

As indicated in Response 7(a), it is estimated that the 95th percentile value would be approximately a factor of 4.5 higher than the reported mean CDF value of 1.9E-6. This can be assumed to correspond to an internal events upper bound value of about 8.5E-6.

The Dresden Internal Fire risk model was updated in 1999 as part of the revised IPEEE submittal report. The CDF contribution to internal fires was estimated at 1.7E-5/yr for Unit 2 and 3.0E-5/yr for Unit 3. However, the methodology invoked to determine the fire CDF is judged to be highly conservative, and therefore it is judged that it is not appropriate at this time to directly compare internal events CDF values with the reported Fire CDF. [1]

The seismic portion of the IPEEE program was completed in conjunction with the SQUG program. Dresden performed a seismic margins assessment (SMA) following the guidance of NUREG-1407 and EPRI NP-6041. The SMA is a deterministic evaluation that does not calculate risk on a probabilistic basis. No core damage frequency sequences were quantified as part of the seismic risk evaluation. However, an extensive number of plant improvements were identified and these have are being resolved as is noted in Response 6(b).

Consequently, to account for both uncertainties in the risk assessment and the potential additional benefits associated with external events, the Phase I screening was re-performed assuming a factor of almost five increase to the base cost risk for DNPS to $2.0M (compared to the base internal events cost-risk of $457,000 used in the ER).

[1] Attachment A provides an assessment of the use of quantitative risk estimates from Fire PRAs, and why it is judged that the calculated CDF values should not be directly compared at this time.

The screening criteria utilized in Table F-1 of the Dresden ER includes the following categories:

#1 – Not applicable to the Dresden design
#2 – Similar item is addressed under other proposed SAMAs
#3 – Already implemented at Dresden
#4 – No significant safety benefit associated with this SAMA for Dresden
#5 – Cost of implementation clearly greater than the maximum averted cost risk
#6 – Retained for Phase II analysis
#7 – Requested additional information from Dresden (Not Used)
#8 – ABWR design issue, not practical

For the revised Phase I screening, SAMA items that previously screened by Criteria #1 or #8 were not re-examined. SAMA items that previously screened by Criteria #2 or #3 were also re-examined to see if an alternative approach to addressing the SAMA could be potentially beneficial, and to look at the potential impact of additional benefits that might be afforded by including external events in the analysis. SAMA items that previously screened by Criteria #4 or #5 were also all re-examined, and the previously retained items (i.e., Criteria #6) were still retained and were subject to re-analysis as described in Response 7(c). The results of the revised Phase I screening for all previous criteria #4, #5, and #6 entries are included in Table 7-2. Criteria #2 or #3 entries are only included in Table 7-2 if the disposition is changed. As can be seen, two additional SAMAs are now retained for Phase II (See Phase I SAMA 188 and Phase I SAMA 223) where the revised disposition column is noted as being the key for noting changes compared to the ER.

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
1	*Cap downstream piping of normally closed component cooling water drain and vent valves.*	SAMA would reduce the frequency of a loss of component cooling event, a large portion of which was derived from catastrophic failure of one of the many single isolation valves.	#4 - No significant safety benefit.	The RBCCW system and the SW system vent and drain valves are not observed to be failure modes at Dresden. Their failures are not included in the Dresden PSA. The risk impact of vent and drain valve failures is estimated to be negligible at Dresden.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.	#6 – Retain		Still retained.	1

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

<table>
<tr><th>Phase I SAMA ID number</th><th>SAMA title</th><th>Result of potential enhancement</th><th>Original / Revised Screening Criteria</th><th>Original Disposition</th><th>Revised Disposition Including Uncertainty and External Events</th><th>Phase II SAMA ID number</th></tr>
<tr><td>7</td><td>Proceduralize shedding component cooling water loads to extend component cooling heatup on loss of essential raw cooling water.</td><td>SAMA would increase time before the loss of component cooling (and reactor coolant pump seal failure) in the loss of essential raw cooling water sequences.</td><td>#4 - No significant safety benefit.</td><td rowspan="3">PWR RCP seal leakage issue. The competing risks associated with shedding other RBCCW loads is not considered justified. Therefore, this SAMA is not pursued.

Dresden has the following features that reduce the impact of loss of Recirculation Pump seal cooling:
- Minimal Seal leakage might occur if both the cooling from RBCCW <u>and</u> the purge flow from CRD become unavailable. This is postulated for SBO events or loss of SW events.
- a new improved Recirculation pump seal with significantly reduced potential for leakage (12.5 gpm/pump versus some PWR estimates of 480gpm/pump)
- multiple high pressure injection systems that provide RPV makeup capability to assure adequate RPV inventory. These include:
  - HPCI (turbine driven system)
  - CRD (Unit 2 and Unit 3)
  - SBLC from test tank or SBLC tank
  - Feedwater
- HPCI and SBLC are independent of SW and RBCCW failure
- FW and CRD are independent of RBCCW failure

Because of the availability of multiple high pressure injection systems, the small Recirculation Pump seal leakage is not a significant contributor to the risk profile.</td><td>Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.</td><td>N/A</td></tr>
<tr><td>11</td><td>Create an independent RCP seal injection system, with a dedicated diesel.</td><td>SAMA would add redundancy to RCP seal cooling alternatives, reducing CDF from loss of component cooling or service water or from a station blackout event.</td><td>#5 - Cost would be more than risk benefit</td><td>Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.</td><td>N/A</td></tr>
<tr><td>12</td><td>Use existing hydro-test pump for RCP seal injection.</td><td>SAMA would provide an independent seal injection source, without the cost of a new system.</td><td>#5 - Cost would be more than risk benefit</td><td>Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.</td><td>N/A</td></tr>
</table>

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
19	Use fire protection system pumps as a backup seal injection and high-pressure makeup.	SAMA would reduce the frequency of the RCP seal LOCA and the SBO CDF.	#5 - Cost would be more than risk benefit	Fire protection is a low head system at Dresden and cannot currently be used as a HP injection source. The ability to provide high pressure injection during an SBO may be beneficial, but the cost of the required modifications would be high. Installation of new high pressure piping, a high head, high flow pump (as it would also have to support the fire system) and a supporting diesel generator or pump motor is similar in scope to SAMA 185. The cost is also considered to be similar ($5 million to $10 million) and is greater than the maximum averted cost-risk for Dresden ($457,000). See also SAMA 178.	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
22	Improved ability to cool the residual heat removal heat exchangers.	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water cross-tie. A portable diesel-driven pump is under consideration to provide cooling water to a LPCI heat exchanger. This was discussed in the EPU correspondence as the tentative plan for dealing with the seismic outlier of Dresden Island Lock & Dam, i.e., loss of UHS, by Fall 2003.	#6 - Retain	Dresden has redundant methods of decay heat removal including: - LPCI in torus cooling - SDC (separate system) - Venting - Main Condenser LPCI in torus cooling is cooled by the CCSW from the intake. Dresden's Shutdown Cooling system has heat exchangers that are cooled by RBCCW and SW from the intake. Plant capability and procedures are available to allow cross-tie to the opposite unit's RBCCW system. The portable diesel-driven pump is considered to deal with large reduction in intake level.	Still retained.	2
23	8.a. Additional Service Water Pump	SAMA would conceivably reduce common cause dependencies from SW system and thus reduce plant risk through system reliability improvement.	#5 - Cost would be more than risk benefit	The cost of implementing this SAMA has been estimated at approximately $5.9 million and is greater than the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
24	Create an independent RCP seal injection system, without dedicated diesel	This SAMA would add redundancy to RCP seal cooling alternatives, reducing the CDF from loss of CC or SW, but not SBO.	#4 - No significant safety benefit.	The recirculation pump seal leakage at Dresden could compromise the long term success of the Isolation Condenser. An independent safety related seal cooling system could reduce this impact; however, the risk impact of the recirculation seal leak is already very low.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
25	Provide reliable power to control building fans.	SAMA would increase availability of control room ventilation on a loss of power.	#4 - No significant safety benefit.	Control Room HVAC is powered by Non-ESS buses that can be powered by EDGs given a LOOP. Control Room HVAC is not required for successful accident mitigation.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
26	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.	#5 - Cost would be more than risk benefit	The cost of installing a redundant, diverse train of HVAC for a Switchgear Room has been estimated at $10 million (Reference 19). This estimate far exceeds the maximum averted cost-risk for Dresden ($457,000). Assuming the cost to install a redundant train of HVAC in other areas is approximately equivalent to this estimate, providing a redundant train of HVAC would not be cost beneficial for any system and is screened from further analysis.	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
29	Create ability to switch fan power supply to DC in an SBO event.	SAMA would allow continued operation in an SBO event. This SAMA was created for reactor core isolation cooling system room at Fitzpatrick Nuclear Power Plant.	#4 - No significant safety benefit.	The systems that require room cooling and have the capability of operating during an SBO include only HPCI (no IC room cooling dependency). During a postulated SBO, HPCI can operate for the duration of the event which is limited by DC battery life. Use of a DC powered fan would increase the drain on the batteries with no impact on the reliability of the HPCI systems as long as there is no gland seal failure. For the low probability event of gland seal failure the crew is directed to bypass high temperature room trips. This would avoid the trip of HPCI. Component failures of these systems could also occur, but this is judged to represent a negligible risk impact. As such there is no measurable safety benefit associated with this SAMA.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
34	Install an independent method of suppression pool cooling.	SAMA would decrease the probability of loss of containment heat removal. For PWRs, a potential similar enhancement would be to install an independent cooling system for sump water.	#5 - Cost would be more than risk benefit	Installation of a new, independent, suppression pool cooling system is similar in scope to installing a new containment spray system, which has been estimated to cost approximately $5.8 million. This exceeds the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	#6 - Retain	A potential enhancement would be to proceduralize the crosstie between the containment spray path of one unit to the LPCI system of the opposite unit. Another alternative is the addition of a connection between containment spray and the plant's fire protection system. (See DEOP 0500-03).	Still retained. Consider benefit that could be obtained by the addition of a connection between the containment spray and the plant's fire protection system. Also consider lower cost alternative of proceduralizing existing capabilities from other unit LPCI cross-tie.	3

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
36	Provide dedicated existing drywell spray system.	SAMA would provide a source of water to the containment to control containment pressure, when used in conjunction with containment heat removal. This would use an existing spray loop instead of developing a new spray system.	#5 - Cost would be more than risk benefit	Installation of a new, independent, containment spray system, has been estimated to cost approximately $5.8 million. This exceeds the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
38	Install a filtered containment vent to remove decay heat.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products being scrubbed. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	#5 - Cost would be more than risk benefit	Potential to improve both the Level 1 and Level 2 results. Cost expected to exceed the maximum averted cost-risk for Dresden ($457,000)	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
39	Install a containment vent large enough to remove ATWS decay heat.	Assuming that injection is available, this SAMA would provide alternate decay heat removal in an ATWS event.	#5 - Cost would be more than risk benefit	Dresden does not have a hard pipe vent of sufficient capacity to mitigate ATWS pressurization unless other mitigation steps are successful. Cost expected to exceed the maximum averted cost-risk for Dresden ($457,000)	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
40	Create/enhance hydrogen recombiners with independent power supply.	SAMA would reduce hydrogen detonation at lower cost. Use either 1) a new independent power supply 2) a non-safety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.	#4 - No significant safety benefit.	The Dresden primary containment is inert. The Nitrogen Make-up system maintains an inerted atmosphere within containment during normal operation. In accident conditions, it provides a feed and bleed function which purges the containment atmosphere of accumulated combustible gases (including oxygen and hydrogen, etc.) and replaces them with nitrogen. Nitrogen Containment Atmospheric Dilution (NCAD) this modification has been installed on both units. This system provides a reliable source of Nitrogen for combustible gas control following an accident. It would be used should the normal make-up flow path not be available during post-accident conditions. The design flow rate is 29 scfm through each line at 31 psig.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
41	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.	#4 - No significant safety benefit.	The NCAD system is designed to control the O2 and H2 concentrations by venting and purging with nitrogen. In addition, hydrogen recombiners are precluded from operating in conditions with high hydrogen, i.e., severe accidents. In addition, because of their small processing capacity are ineffective in treating the dominant contributors to severe accident risk. Hydrogen recombiners are precluded from operating in conditions with high hydrogen, i.e., severe accidents. Negligible impact on risk results from adding hydrogen recombiners.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
43	Create a large concrete crucible with heat removal potential under the basemat to contain molten core debris.	SAMA would ensure that molten core debris escaping from the vessel would be contained within the crucible. The water cooling mechanism would cool the molten core, preventing a melt-through of the basemat.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events". Other evaluations have shown the worth value for a core retention device to be on the order of $7000 (averted cost-risk) compared to an estimated implementation cost of over $1 million (per unit).	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
44	Create a water-cooled rubble bed on the pedestal.	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events". Other evaluations have shown the worth value for a core retention device to be on the order of $7000 (averted cost-risk) compared to an estimated implementation cost of over $1 million (per unit).	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
45	Provide modification for flooding the drywell head.	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.	#4 - No significant safety benefit.	BWR Mark I risk is typically dominated by events that result in early failure of the drywell shell due to direct contact with core debris and events that bypass the containment. This is also true at Dresden. The head flooding system would, therefore, not be expected to have any significant impact on the overall risk. The potential for competing risks due to Reactor Building flooding is considered to eliminate any positive safety benefit.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID *number*
46	Enhance fire protection system and/or standby gas treatment system hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.	#4 - No significant safety benefit.	Current Standby Gas Treatment Systems do not have sufficient capacity to handle the loads from severe accidents that result in a bypass or breach of the containment. Loads produced as a result of RPV or containment blowdown would require large filtering capacities. These filtered vented systems have been previously investigated and found not to provide sufficient cost benefit. Dresden has limited fire protection sprinkler systems in the Reactor Building. Use of these for fission product scrubbing in the R.B. could create competing risks associated with spray failures and flooding of equipment with very limited potential benefit.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
50	Create a core melt source reduction system.	SAMA would provide cooling and containment of molten core debris. Refractory material would be placed underneath the reactor vessel such that a molten core falling on the material would melt and combine with the material. Subsequent spreading and heat removal form the vitrified compound would be facilitated, and concrete attack would not occur	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events". Other evaluations have shown the worth value for a core retention device to be on the order of $7000 compared to an estimated implementation cost of over $1 million.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
53	Install a secondary containment filter vent.	SAMA would filter fission products released from primary containment.	#5 - Cost would be more than risk benefit	Secondary containment at Dresden makes extensive use of blow out panels to protect the structural integrity of the building in the event of internal pressure challenges such as steamline breaks in the reactor building or external pressure challenges such as tornadoes. Major structural redesign of the reactor building would be required to make the reactor building capable of retaining and processing a primary containment failure.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
54	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.	#5 - Cost would be more than risk benefit	A passive system is another alternative enhancement for the Containment Spray function. See SAMA 35. Cost expected to exceed the maximum averted cost-risk for Dresden ($457,000)	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
55	Strengthen primary/secondary containment.	SAMA would reduce the probability of containment overpressurization to failure.	#5 - Cost would be more than risk benefit	BWR Mark I risk is typically dominated by events that result in early failure of the drywell shell due to direct contact with core debris and events that bypass the containment. Strengthening the primary /secondary containment would have a small impact on the overall risk of these accidents. Reference 17 discusses the cost of increasing the containment pressure and temperature capacity, which is effectively strengthening the containment. This cost is estimated assuming the change is made during the design phase whereas for Dresden, the changes would have to be made as a retrofit. The cost estimated for the ABWR was $12 million and it is judged that retrofitting an existing containment would cost more. The cost of implementation for this SAMA exceeds the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
56	Increase the depth of the concrete basemat or use an alternative concrete material to ensure melt-through does not occur.	SAMA would prevent basemat melt-through.	#5 - Cost would be more than risk benefit	Core retention devices have been investigated in previous studies. IDCOR concluded that "core retention devices are not effective risk reduction devices for degraded core events". Other evaluations have shown the worth value for a core retention device to be on the order of $7000 compared to an estimated implementation cost of over $1 million/site.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
57	Provide a reactor vessel exterior cooling system.	SAMA would provide the potential to cool a molten core before it causes vessel failure, if the lower head could be submerged in water.	#5 - Cost would be more than risk benefit	This has been estimated to cost $2.5 million and exceeds the maximum averted cost-risk for Dresden ($457,000). ORNL [35] has performed thermal hydraulic calculations on BWR external cooling methods and determined that the current BWR RPV support skirt design makes it impractical to cool the RPV by external cooling to prevent RPV breach. Therefore, the modification would require RPV support skirt modification and reanalysis to allow the external cooling to be effective.	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
58	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum.	SAMA would provide a method to depressurize containment and reduce fission product release.	#5 - Cost would be more than risk benefit	Based on engineering judgement, the cost of this enhancement is expected to greatly exceed the maximum averted cost risk ($0.4 million).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
64	1.h. Simulator Training for Severe Accident	SAMA would lead to improved arrest of core melt progress and prevention of containment failure	#4 - No significant safety benefit.	Simulators could be upgraded and used to provide operator training for severe accidents; however, these scenarios are rare and the instruction time would compete with time required to train operators on more likely scenarios that are severe accident precursors. The benefit of simulator training is difficult to quantify as the results would be based on the improved reliability of human actions in the mitigation of severe accidents. Training can positively influence the values of HEPs, but the impact is small. In addition, the TSC would be manned in a severe accident evolution and could provide additional support by personnel familiar with the SAMGs. Previously assessed by the NRC as not required to support Accident management because of marginal cost benefit.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
66	3.a. Larger Volume Containment	SAMA increases time before containment failure and increases time for recovery	#5 - Cost would be more than risk benefit	Enlargement of the containment would be similar in scope to the ABWR design change SAMA to implement a larger volume containment, but would likely exceed the $8 million estimate for that change as a retrofit would be required. This is greater than the maximum averted cost-risk ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
68	3.c. Improved Vacuum Breakers (redundant valves in each line)	SAMA reduces the probability of a stuck open vacuum breaker. See Table 6 and Section A.4.3.3 of ABWR SAMDAs.	#5 - Cost would be more than risk benefit	The Dresden plant has six (6) individual vacuum breaker lines with two vacuum breakers in parallel in each line. Providing redundant vacuum breakers in each line would decrease the potential for vapor suppression failure and suppression pool bypass. This plant modification requires new valves, the structural changes to implement the modification, and the outage time to install. Based on the PRA results that vapor suppression failure and pool bypass are negligible risk contributors and the apparent extremely high cost, this proposed SAMA is not considered cost effective.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
92	Provide additional DC battery capacity.	SAMA would ensure longer battery capability during an SBO, reducing the frequency of long-term SBO sequences.	#3 - Already installed. #4 - No significant safety benefit.	Dresden already has included spare batteries. These can be used to extend IC operability and allow more credit for AC power recovery. This would decrease the frequency of core damage and offsite releases. The addition of 250V DC batteries could be evaluated to provide all the HPCI DC power requirements. However, room cooling and torus cooling would be more limiting.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
93	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.	#5 - Cost would be more than risk benefit	Further extension of battery life with fuel cells is estimated to have a small impact on the Dresden residual risk profile. In addition, the cost of hardware (fuel cells), engineering, and hazard analysis is expected to exceed the maximum cost averted of $457,000.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
107	Create a backup source for diesel cooling. (Not from existing system)	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.	#5 - Cost would be more than risk benefit	A new system for diesel cooling would require extensive engineering, safety analysis, hardware and labor for installation. This would exceed the $457,000 maximum averted cost.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
110	Bury offsite power lines.	SAMA could improve offsite power reliability, particularly during severe weather.	#5 - Cost would be more than risk benefit	While the actual cost of this SAMA will vary depending on site characteristics, the cost of burying offsite power lines has been estimated at a cost significantly greater than $25 million for another commercial US nuclear plant. Implementing this SAMA at Dresden is considered to be within the same order of magnitude and exceeds the maximum averted cost-risk for the plant ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
113	Provide DC power to the 120/240-V vital AC system from the Class 1E station service battery system instead of its own battery.	SAMA would increase the reliability of the 120-VAC Bus.	#4 - No significant safety benefit	1) Loss of 120V AC is not an Initiating Event 2) 120 VAC is not a risk significant support system [from a risk reduction worth perspective that is key for the SAMA analysis]	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
120	9.f. Improved Uninterruptable Power Supplies	SAMA would provide increased reliability of power supplies supporting front-line equipment, thus reducing core damage and release frequencies.	#4 - No significant safety benefit	1) Loss of 120V AC is not an Initiating Event 2) 120 VAC is not a risk significant support system [from a risk reduction worth perspective that is key for the SAMA analysis]	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
124	10.a. Dedicated DC Power Supply	This SAMA addresses the use of a diverse DC power system such as an additional battery or fuel cell for the purpose of providing motive power to certain components (e.g., HPCI).	#5 - Cost would be more than risk benefit	Dresden has the capability to operate the Isolation Condenser (once initiated) without DC power. This is included in the Dresden PRA as a success path. The cost of implementation for this mod is *estimated at $3 million, which is greater* than the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening *criteria category.*	N/A
129	Add an automatic bus transfer feature to allow the automatic transfer of the 120V vital AC bus from the on-line unit to the standby unit	Plants are typically sensitive to the loss of one or more 120V vital AC buses. Manual transfers to alternate power supplies could be enhanced to transfer automatically.	#4 - No significant safety benefit	1) Loss of 120V AC is not an Initiating Event 2) 120 VAC is not a risk significant support system [from a risk reduction worth perspective that is key for the SAMA analysis]	Considering uncertainty and potential impacts from *external events does not* introduce any significant changes. No change to the screening criteria category.	N/A
138	Locate residual heat removal (RHR) inside of containment.	SAMA would prevent intersystem LOCA (ISLOCA) out the RHR pathway.	#5 - Cost would be more than risk benefit	Competing risks associated with such a design are manifold and would require extensive analysis to demonstrate capability. For an existing plant, the cost of moving an entire system is judged to greatly exceed the maximum averted cost-risk for Dresden ($457,000). Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
139	Install additional instrumentation for ISLOCAs.	SAMA would decrease ISLOCA frequency by installing pressure of leak monitoring instruments in between the first two pressure isolation valves on low-pressure inject lines, RHR suction lines, and HPSI lines.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
140	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
141	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures. In addition, the Dresden EOPs provide secondary containment monitoring parameters which include room specific temperature, room specific radiation, vent radiation, and room specific water level. The instrumentation and procedural guidance help locate and isolate breaks which have bypassed primary containment.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
143	Provide leak testing of valves in ISLOCA paths.	SAMA would help reduce ISLOCA frequency. At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
145	Ensure all ISLOCA releases are scrubbed.	SAMA would scrub all ISLOCA releases. One example is to plug drains in the break area so that the break point would cover with water.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures. The cost of performing the analysis to identify all ISLOCA pathways and to ensure that any physical modifications implemented to mitigate ISLOCAs are not detrimental to the plant (e.g., cause flooding hazards) combined with the cost of installing the required equipment is judged to greatly exceed any benefit. Additionally, the suggested enhancement of plugging drain lines would not guarantee a release would be scrubbed as the release may occur above the break location. Room flooding equipment and waterproofing of mitigative components would be required to make this SAMA potentially effective. Such changes would be extremely costly and potential competing risk appears to significantly outweigh any possible safety benefit.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
146	Add redundant and diverse limit switches to each containment isolation valve.	SAMA could reduce the frequency of containment isolation failure and ISLOCAs through enhanced isolation valve position indication.	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
147	Early detection and mitigation of ISLOCA	SAMA would limit the effects of ISLOCA accidents by early detection and isolation	#4 - No significant safety benefit	Related to mitigation of an ISLOCA. Per IN-92-36, and its additional supplement, ISLOCA contributes little risk for BWRs, because of the lower primary system pressures.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition *Including Uncertainty and* External Events	Phase II SAMA ID number
148	8.e. Improved MSIV Design	This SAMA would decrease the likelihood of containment bypass scenarios.	#4 - No significant safety benefit	Redundant MSIVs are designed to isolate on severe accidents that could lead to radionuclide release and bypass containment. These include breaks outside containment. The MSIVs are leak tested to ensure their adequacy. The maintenance Rule program monitors the performances of the MSIVs providing early feedback on any degradation. The PRA has determined that the risk contribution from MSIV failures to isolate is very small.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
153	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	SAMA would prevent flood propagation, for a plant where internal flooding from turbine building to safeguards areas is a concern.	#4 - No significant safety benefit	Dresden plant configuration is not susceptible to flood propagation from the Turbine Building to adjacent buildings with safety equipment. Flooding from Turbine Hall into adjacent buildings considered to have negligible impact.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
155	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.	#4 - No significant safety benefit	The total contribution to CDF from internal flooding is 1.8E-7/yr or less than 10% of the total internal events CDF. Internal flood is not considered to be a dominant contributor to the CDF at Dresden and adequate precautions and training are believed to be in place to prevent and respond to postulated flood.	Table 1-2 in Response 1(b) indicates that the current contribution from internal flooding is about 3%. Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
157	Shield electrical equipment from potential water spray	SAMA would decrease risk associated with seismically induced internal flooding	#5 - Cost would be more than risk benefit	Protecting equipment from spray may be a cost beneficial means of reducing risk at Dresden. However, there are very few, if any, locations that can be effectively protected from water spray adverse effects that are not already protected. This fact coupled with the knowledge that the total CDF from all internal floods is so low, means that any plant modification is nearly impossible to justify. The 4-kV emergency buses in Reactor Building have water hoods. Some MCCs have small hoods. Additional spray protection could be provided to switchgear in Turbine Building. Main risk reduction would be from providing water spray protection to Unit 3 125 VDC battery bus and switchgear in cage outside of Unit 3 Battery Charger room.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
164	Install a new condensate storage tank (CST)	Either replace the existing tank with a larger one, or install a back-up tank.	#4 - No significant safety benefit	For SBO conditions, the CST contains enough water to allow make-up injection from HPCI for a period longer than its estimated operability (based on battery life). The 1A, 2/3A and 2/3B CSTs have a combined nominal water volume (typical) of 410,000 gallons. For LOCA initiators, the CST does not contain enough water to provide injection for the 24 hour mission time. The CST makeup systems do not currently have the capacity to match the inventory loss for a LOCA. Feedwater has connections to unlimited water supplies (SBCS) not dependent on the CST. CST connections to Core Spray and LPCI already exist. The ability to refill the CST from external water sources is considered both desirable and not difficult. The Technical Support Guidelines (TSGs) Appendix J provides the makeup sources available to Dresden to allow CST refill. The Isolation Condenser (IC) which is a separate mitigation system also has significant makeup capabilities independent of the CST. The TSG Appendix K cites the systems that can make-up to the shell side of the IC. This represents a significant benefit over other plants without an IC.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
165	Provide cooling of the steam-driven AFW pump in an SBO event	This SAMA would improve success probability in an SBO by: (1) using the FP system to cool the pump, or (2) making the pump self cooled, or (3) providing a fan cooling capability.	#5 - Cost would be more than risk benefit	AFW is a PWR system for steam generator make-up injection. The HPCI pump at Dresden is equivalent in many respects to the PWR AFW pump. The HPCI turbine requires room cooling over a 24 hour mission time or the SBO mission time of 4 hours. Installation of an additional room cooling system for HPCI that would be independent of AC and DC power would be the only type of "system" that would change the risk profile. This additional system is expected to cost more than the maximum cost averted of $457,000 and therefore to not be cost beneficial.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
166	Proceduralize local manual operation of AFW when control power is lost.	This SAMA would lengthen AFW availability in an SBO. Also provides a success path should AFW control power be lost in non-SBO sequences.	#4 - No significant safety benefit	AFW is a PWR system for steam generator make-up injection. HPCI is the turbine driven injection system for Dresden. The available injection time for these systems is limited by factors such as battery life, depressurization on HCTL, and injection source volume. HCTL is reached in the suppression pool at approximately 7 hours after the initiating event of an SBO without IC operation. Providing local, manual control capability for the HPCI system (removing the DC dependence) could extend injection an additional three hours beyond the 4 hour battery life. However, hardware changes would be necessary in addition to procedure updates for Dresden. For SBOs with the IC operating, HPCI could extend the time of adequate core cooling (by providing RPV makeup for seal LOCA events). This operation of HPCI will allow adequate core cooling to be extended as long as the battery supply of DC can be preserved or the battery (DC) requirement bypassed by manual action. HPCI room cooling is the limiting condition under this scenario. DC power is not the limiting support system for HPCI operation. The room cooling requirement for AC power for the HPCI fan is most limiting. This SAMA for local generation of HPCI without DC does not result in any noticeable change in CDF because of the small failure profitability of DC and the presence of more limiting failure modes (i.e., room cooling). Therefore, the potential benefit for this modification is very small.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
167	Provide portable generators to be hooked into the turbine driven AFW, after battery depletion.	This SAMA would extend AFW availability in an SBO (assuming the turbine driven AFW requires DC power)	#4 - No significant safety benefit		Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
172	Install an independent diesel generator for the CST make-up pumps	This SAMA would allow continued inventory make-up to the CST during an SBO.	#4 - No significant safety benefit	HPCI is the turbine driven injection system for Dresden. The 1A, 2/3A and 2/3B CSTs have a combined nominal water volume (typical) of 410,000 gallons. Given a battery life of 4 hours (required for HPCI operation), no additional water source would be required for injection during the 4 hour SBO mission time. Minimal benefit would be gained from this SAMA. Even if CST water is exhausted, the switchover of suction from the CST to the torus would continue to allow HPCI injection. The limiting time and action for HPCI effectiveness in an SBO (other than batteries) or other accident sequences without DHR is the torus water temperature greater than HCTL. This leads to RPV depressurization and the unavailability of HPCI as an effective RPV make up method regardless of CST volume. Therefore, there is negligible risk benefit associated with increasing CST make up capability under SBO conditions. The Technical Support Guidelines (TSGs) Appendix J provides the makeup sources available to Dresden to allow CST refill. The Isolation Condenser (IC) which is a separate mitigation system also has significant makeup capabilities independent of the CST. The TSG Appendix K cites the systems that can make-up to the shell side of the IC. This represents a significant benefit at Dresden over other plants without an IC.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
178	Provide an additional HPSI pump with an independent diesel	This SAMA would reduce the frequency of core melt from small LOCA and SBO sequences	#5 - Cost would be more than risk benefit	This is primarily a PWR insight where RPV depressurization is not as easily available. The availability of an additional high pressure water injection source is not a significant risk reduction measure for Dresden because of the existing design. Dresden has substantial high pressure RPV inventory control methods. These include: - HPCI - Feedwater (motor driven) - Isolation Condenser - CRD pumps These methods represent substantial high pressure inventory control methods including active HPSI from the turbine driven HPCI system which is independent of AC power initially. Dresden has a turbine driven high pressure injection with the capability to provide a supplement or an alternative to the Isolation Condenser (IC) system for safe shutdown. FW depends on offsite AC power to provide high-pressure injection. Onsite AC power is available from either unit EDG the swing EDG, or either SBO DG (5 sources) to support CRD operation. Because of the cost associated with this SAMA and the existing Dresden capability, a negligible change in risk is calculated. Even the maximum cost averted ($457,000) could not justify the engineering and hardware of an additional pump.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
184	Upgrade Chemical and Volume Control System to mitigate small LOCAs.	For a plant like the AP600 where the Chemical and Volume Control System cannot mitigate a Small LOCA, an upgrade would decrease the Small LOCA CDF contribution.	#5 - Cost would be more than risk benefit	A potential functional equivalent for Dresden would be the enhancement of the RWCU system such that injection flow rates on the order of 1000 gpm were possible. This change is considered to be similar in function, scope, and cost to SAMA 185 ($5-$10 million) with the exception of the independent power source. However, new power circuits and wiring would likely be needed for the larger pumps. The low end of the cost of implementation estimate ($5 million) is judged to be applicable for this SAMA, which is greater than the maximum averted cost risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
187	Replace 2 of the 4 safety injection (SI) pumps with diesel-powered pumps.	This SAMA would reduce the SI system common cause failure probability. This SAMA was intended for the System 80+, which has four trains of SI.	#4 - No significant safety benefit	Dresden has a diverse set of injection systems and more than one method of containment heat removal. Common cause failure of the 4 train LPCI system is a low contributor to risk and removing the 4/4 system failures would have minimal impact on the results. The CCF of all four LPCI pumps to fail to start or run (2LIPM-2ABCD14ACC, 2LIPM-2ABCD14XCC) does not appear in any CDF cutsets above the truncation limit for the plant model and would not impact the results if it were improved.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
188	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.	#3 - Already implemented at Dresden Revise to: #6 - Retain	This is already directed at Dresden.	However, a cutset review indicates that this action is important in loss of service water initiated events. The potential benefit from improving the HEP value associated with this existing action is explored as part of this RAI response.	11

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
189	Raise high pressure core injection/reactor core isolation cooling backpressure trip setpoints	This SAMA would ensure high pressure core injection/reactor core isolation cooling availability when high suppression pool temperatures exist.	#4 - No significant safety benefit	The HPCI high backpressure trip is already set at a pressure above the containment ultimate pressure; thus, raising the trip limits would have no impact.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
190	Improve the reliability of the automatic depressurization system.	This SAMA would reduce the frequency of high pressure core damage sequences.	#5 - Cost would be more than risk benefit	High pressure melt scenarios are significant contributors to the Dresden CDF. The SAMA is interpreted to mean improved reliability of the ERVs and Target Rock SRVs and their support systems. A plant modification to eliminate dependence on DC power to increase the success probability of these valves would reduce the high pressure injection accident classes of IA and IE. No such design is currently available. This would require a research and development project and would exceed the maximum cost averted of $457,000.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
193	Proceduralize intermittent operation of HPCI.	SAMA would allow for extended duration of HPCI availability.	#4 - No significant safety benefit	Limitations on HPCI operation in an SBO are based on battery depletion. Multiple starts and stops of the system are a larger drain on the battery than continuous operation with excess flow directed to the torus. In addition, multiple starts of the system introduce additional start demands which may increase the system failure probability for a given period of operation. The principal sequence dependent limitation for operation of HPCI is battery life in SBO and HCTL in other sequences where LPCI suppression pool cooling is not available. Negligible benefit has been identified for this SAMA at Dresden. HPCI pump operation must be controlled for SBO to preclude the minimum flow valve operation from dumping excessive amounts of CST water to the torus. HPCI in the CST pressure control mode is recommended and currently preferred operating mode of HPCI.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
194	Increase available net positive suction head (NPSH) for injection pumps.	SAMA increases the probability that these pumps will be available to inject coolant into the vessel by increasing the available NPSH for the injection pumps.	#5 - Cost would be more than risk benefit	Requires major plant changes such as new LPCI/CS pumps, moving the LPCI pumps, a new suppression pool design, a larger CST (only applicable for injection phase), or an additional containment cooling system. The cost of these changes would exceed the maximum averted cost-risk for Dresden.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
195	Modify Reactor Water Cleanup (RWCU) for use as a decay heat removal system and proceduralize use.	SAMA would provide an additional source of decay heat removal.	#5 - Cost would be more than risk benefit	RWCU heat removal capacity is too low for decay heat removal. In order to make RWCU a viable heat removal system, the piping, pumps, heat exchangers, and power sources would have to be upgraded. This SAMA is considered to be similar in scope to SAMA 191. The cost of implementation for such a change (approximately $5 million) is greater than the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
199	Re-open MSIVs	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.	#6 - Retain	There are two important aspects of the MSIV closure response: - For non-ATWS conditions, the ability to rapidly respond to MSIV closure and restore the main condenser as a heat sink is not explicitly directed. - For ATWS conditions, Dresden EOPs direct MSIV low level closure bypass in order to retain the main condenser as a heat sink; however, this assumes the MSIVs have not yet closed. For both cases, explicit procedural direction to re open the MSIVs could be included.	Still retained.	4

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
201	2.a. Passive High Pressure System	SAMA will improve prevention of core melt sequences by providing additional high pressure capability to remove decay heat through an isolation condenser type system	#3 - Already installed. #5 - Cost would be more than risk benefit	Dresden has an IC which provides the capability for passive inventory control for a short time following scram. Active systems are used for IC shell makeup and RPV makeup due to Recirculation pump seal leakage. The addition of tanks for IC makeup and another Active system for RPV makeup make the "passive" feature not cost beneficial. The cost of this enhancement has been estimated to be $1.7 million in Reference 17. This is greater than the maximum averted cost-risk for Dresden ($457,000).	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
202	2.c. Suppression Pool Jockey Pump	SAMA will improve prevention of core melt sequences by providing a small makeup pump to provide low pressure decay heat removal from the RPV using the suppression pool as a source of water.	#5 - Cost would be more than risk benefit	From a review of the contributors to the Dresden risk profile, it is found that the availability of low pressure pumps for RPV make up is not a dominant contributor. The low pressure pump availability for RPV injection is a negligible contributor to the risk profile. The expense of adding another low pressure injection system without introducing severe competing risks is expected to be high. It can be concluded that the cost will not be able to be justified.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
207	4.c. High Flow Suppression Pool Cooling for ATWS response	SAMA would improve suppression pool cooling.	#5 - Cost would be more than risk benefit	The Suppression Pool Cooling system is already sized to accommodate flow to remove all decay heat and operate under ATWS conditions with SBLC injection success. Increasing the capabilities of suppression pool would require new pumps, heat exchangers, piping, and other equipment. The implementation cost of this change is considered to be approximately equivalent to SAMA 35 ($5.8 million) and is screened from further review as it is significantly greater than the maximum averted cost-risk for Dresden ($457,000).	The cost is considered to be greater than the upper bound maximum averted cost risk of $2.0M. No change to the screening criteria category.	N/A
211	Install nitrogen bottles as a back-up gas supply for safety relief valves.	This SAMA would extend operation of safety relief valves during an SBO and loss of air events (BWRs).	#4 - No significant safety benefit	Dresden depressurization capability is primarily supported by DC power. The EMRVs are powered by 125V DC and are available during an SBO. The single Target Rock SRV uses nitrogen pneumatic supply as the motive power to open the valve against spring pressure, but 125V DC is still required for valve control. An accumulator is available to allow a limited number of SRV openings after loss of Drywell Air. Because of the SRV redundancy with the EMRVs, only a negligible change in risk would be achieved.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
215	Create cross-connect ability for standby liquid control trains	This SAMA would improve reliability for boron injection during an ATWS event.	#5 - Cost would be more than risk benefit	Each unit's SLC system has two trains which have common suction and discharge headers. Redundant suction and discharge paths exist beyond these headers, which can be isolated, if required. No further cross connection is beneficial between the trains of a given unit. An inter unit cross-tie is a potential enhancement. However, because the SLC system response is dominated by common cause failures of the explosive valves and the operator action to initiate SLC, the ability for use of a cross tie will have limited benefit in the risk profile. This small change in the small ATWS contribution results in little potential safety improvement, but a substantial cost.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
223	Bypass MSIV isolation in Turbine Trip ATWS scenarios	SAMA will afford operators more time to perform actions. The discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities	#3 - Already installed. Revise to: #6 - Retain	BWROG EPC Issue 98-07 addresses this issue. The bypass of the MSIV isolation was moved upward in the flowchart, rendering it more important. Bypass of MSIV isolation is procedurally directed in the DEOPs under failure to scram conditions.	However, this action requires the use of jumpers with a limited time available, and as such carries a relatively high HEP value. The potential benefit of implementing a dedicated low level interlock switch is explored as part of this RAI response.	12

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
229	Create/enhance RCS depressurization ability	With either a new depressurization system, or with existing PORVs, head vents, and secondary side valve, RCS depressurization would allow earlier low pressure ECCS injection. Even if core damage occurs, low RCS pressure would alleviate some concerns about high pressure melt ejection.	#5 - Cost would be more than risk benefit	PWR issue related to the limited depressurization capability of the PWR. In addition, reference 19 estimates the cost of this SAMA to range between $500,000 and $4.6 million. For Dresden, more effective depressurization capabilities would require significant hardware changes and/or additions on top of the analysis that would be required to implement the change. The cost estimate for the modification is considered to be on the high end of the range provided in Reference 19. The cost of implementation for this SAMA is judged to greatly exceed the maximum averted cost-risk for Dresden ($457,000)	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
233	Install secondary side guard pipes up to the MSIVs	This SAMA would prevent secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. This SAMA would also guard against or prevent consequential multiple SGTR following a Main Steam Line Break event.	#5 - Cost would be more than risk benefit	This is primarily a PWR issue. The steam lines for a BWR inside the inside MSIV are completely within the containment requiring no guard pipe. Between the two MSIVs is a very short length of pipe that contributes a negligible amount to the CDF and LERF. The addition of a guard pipe to the steam tunnel for the short pipe length is judged to be very expensive and substantially in excess of any potential benefit associated with risk reduction.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
239	Increase seismic ruggedness of plant components. Increase the seismic capacity of components on the safe shutdown paths with capacities less than 0.3g to 0.3g.	SAMA would increase the availability of necessary plant equipment during and after seismic events. Extends the safe shutdown path seismic capacity to at least 0.3g.	#6 - Retain	Components were identified in the IPEEE whose seismic ruggedness could be improved.	Still retained.	5

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
244	1.e. Improved Accident Management Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.	#5 - Cost would be more than risk benefit	The risk as measured by CDF, LERF, and population dose is low. The instrumentation available to the operating crew at Dresden is comparable to that available at other BWRs. Based on a review of the accident sequences that contribute to the Dresden risk profile, the estimated risk reduction associated with additional accident mitigation instrumentation is judged to be negligible.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
248	2.h. Safety Related Condensate Storage Tank	SAMA will improve availability of CST following a Seismic event	#5 - Cost would be more than risk benefit	The HPCI system has a safety related water source from the torus. The cost of engineering, installation, and safety analysis of an additional large water source is significantly greater than the maximum cost averted $457,000.	The anticipated implementation cost is judged to exceed the benefit even if the benefit is increased by almost a factor of five to account for uncertainty and potential impacts from external events. No change to the screening criteria category.	N/A
249	4.d. Passive Overpressure Relief	This SAMA will prevent catastrophic failure of the containment. Controlled relief through a selected vent path has a greater potential for reducing the release of radioactive material than through a random break.	#6 - Retain	Dresden has installed a hard piped containment vent system that provides a controlled means of containment overpressure relief. The passive feature of adding a rupture disk to this system introduces competing risks that limit the usefulness of the vent over the spectrum of severe accidents.	Still retained.	6
255	Train operations crew for response to inadvertent actuation signals	This SAMA would improve chances of a successful response to the loss of two 120V AC buses, which may cause inadvertent signal generation.	#4 - No significant safety benefit.	The 120V AC system is not risk significant at Dresden [from a risk reduction worth perspective that is key for the SAMA analysis]. While other plants have identified specific 120V AC failure scenarios that would lead the generation of inadvertent signals, no comparable vulnerabilities have been identified at Dresden.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
256	Install tornado protection on gas turbine generators	This SAMA would improve onsite AC power reliability.	#4 - No significant safety benefit.	No gas turbines on-site. Additional measures could be taken to improve the protection of other on-site AC power sources; however, the IPEEE investigated risk from high wind events and found it to be negligible.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A
259	Diversify the explosive valve operation	An alternate means of opening a pathway to the RPV for SBLC injection would improve the success probability for reactor shutdown.	#6 - Retain	SBLC injection failure is a dominant contributor to ATWS mitigation failure. Evaluate SBLC system improvements.	Still retained.	7
260	Enrich Boron	The increased boron concentration will reduce the time required to achieve the shutdown concentration. This will provide increased margin in the accident timeline for successful operator activation of SBLC.	#6 - Retain	Increasing the boron concentration for SBLC may be a cost effective means of reducing ATWS risk.	Still retained.	8
261	Bypass Low Pressure Permissive	LPCI and CS injection valves require a permissive signal from the same 2 pressure sensors in order to open. The instruments are currently specified as diverse. However, because this is a "pinch point" for all CS and LPCI injection, it is judged prudent to consider a plant modification to allow a bypass switch (1/division) to insert the permissive if the sensors fail to perform their function. A few other BWRs currently have this capability (e.g., Perry).	#6 - Retain	A reduction in this CCF will result in a small decrease in CDF.	Still retained.	9

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
262	Modify R.B. Blowout Panels	The Reactor Building blowout panels are designed to blow free from their normal positions. Hinging the Reactor Building blowout panels so they reclose once the reactor building to environment pressure differential subsides has several advantages: - Prevents frigid external air if present from entering the reactor building - Limits reactor building accelerated circulation that could reduce radionuclide residence time in the Reactor Building - May contribute to improved SGTS operation in the long term where late revolatilization of CsI could be effectively mitigated.	#4 - No significant safety benefit.	No change in CDF is calculated and no impact on LERF. Other risk measures would be affected in a negligible way.	Considering uncertainty and potential impacts from external events does not introduce any significant changes. No change to the screening criteria category.	N/A

Table 7-2
Revised Phase I SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase I SAMA ID number	SAMA title	Result of potential enhancement	*Original / Revised Screening Criteria*	Original Disposition	Revised Disposition Including Uncertainty and External Events	Phase II SAMA ID number
263	Supplemental Air Supply for the Containment Vent	The containment vent function is among the last resort methods currently specified in BWRs to remove heat from containment and control containment pressure under extremely adverse circumstances. The Dresden air compressors are required to support the containment vent function. The air compressors in turn require cooling, normally from TBCCW/SW. An alternative method to supply air to the vent valves for opening would be desirable if SW were to become inadequate.	#6 - Retain	Possible Alternatives: - Air or N2 bottles located near the AOVs that can be remotely valved into the AOVs to allow AOV operation. or - Air supply line connections into the Reactor Building from external to the reactor building to allow Air Bottles or pneumatic supply trucks to supply the required air pressure for AOV operation.	Still retained.	10

Response 7(c):

"[Provide] an assessment of the impact on the Phase 2 evaluation if risk reduction estimates are increased to account for uncertainties in the risk assessment and the additional benefits associated with external events (as applicable). Consider the uncertainties due to both the averted cost-risk and the cost of implementation to determine changes in the net value for these SAMAs."

To perform this assessment, a two-step approach was taken. The first step was to reexamine the Phase II evaluation utilizing an upper bound maximum averted cost estimate of $2.0M consistent with the revised Phase I screening. This revised screening would then result in a set of potential plant changes that could be cost beneficial when compared to the upper bound estimate of the averted cost. For these potential enhancements, a comparison was then made to a more realistic estimated averted cost to determine if the proposed change would be cost beneficial.

To provide an upper bound estimate on the risk reduction estimates to account for potential uncertainties on the risk assessment and the additional benefits associated with external events, each of the previously retained Phase II SAMAs plus the additional retained SAMAs from the revised Phase I screening in Response 7(b) have been reassessed. The reassessment assumes that the maximum averted cost risk is about $2.0M compared to the original maximum averted cost of $457K used in the ER. Table 7-3 shows the results of this reassessment with each of the previously calculated averted costs multiplied by a factor of 5.

Additional Phase II SAMA Analyses

The revised Phase I screening described in Response 7(b) resulted in two additional SAMAs being carried forward to Phase 2. Additional Phase II SAMA analyses were performed to support the revised screening provided in Table 7-3. Each of these is described below.

PHASE II SAMA NUMBER 11

Description: Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.

Model Changes: Reduce HEP for aligning ECCS pump suction from base PRA model value of 0.1 to 1E-2.

Results: The results from this case indicate a reduction from the base CDF of 2.1E-8/yr that applies primarily to loss of DHR scenarios (Class II) because the operator action is credited to support long term injection for loss of DHR events. There was no reduction in LERF (base LERF = 3.03E-7/yr). This would lead to an averted cost-risk of $3,652 utilizing the same methodology and assumptions that were utilized in the ER.

PHASE II SAMA NUMBER 12

Description: Enhance bypass of MSIV isolation interlock (ATWS)

Model Changes: Reduce HEP for operator failure to bypass MSIV low RPV level interlock (ATWS) from 0.93 to 1E-2. In addition, increase complementary HEP for operator successful bypass of MSIV low RPV level interlock (ATWS) from 7E-2 to 0.99.

Results: The results from this case indicate a reduction from the base CDF of 2.0E-8/yr that applies only to ATWS scenarios (Class IVA and IC). Maintaining the availability of the main condenser for decay heat removal enhances the ability for successful mitigation of ATWS events. The LERF decreased from the base LERF of 3.03E-7/yr to 2.99E-7/yr. This would lead to an averted cost-risk of $6,067 utilizing the same methodology and assumptions that were utilized in the ER.

The results of the reassessment including the two new Phase II SAMA analyses are provided in Table 7-3. The potential costs are consistent with those provided in Response 11.

Table 7-3
Revised Phase II SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Upper Bound Averted Cost Estimate	Potential Cost	Revised Disposition
1	3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.	5 * $8,318 = $41,590 * 2 Units = $83,180	$50-100K for procedural enhancements with engineering analysis required.	When the upper bound averted cost estimate is applied to two units at the site, this procedural change may be cost beneficial. Retain for more detailed cost benefit analysis (see Table 7-4).
2	22	Improved ability to cool the residual heat removal heat exchangers.	SAMA would reduce the probability of a loss of decay heat removal by implementing procedure and hardware modifications to allow manual alignment of the fire protection system or by installing a component cooling water cross-tie. A portable diesel-driven pump is under consideration to provide cooling water to a LPCI heat exchanger. This was discussed in the EPU correspondence as the tentative plan for dealing with the seismic outlier of Dresden Island Lock & Dam, i.e., loss of UHS, by Fall 2003.	5 * $7,713 = $38,565 * 2 Units = $77,130	$50-100K for procedural enhancements with engineering analysis required, plus $100K minimum for hardware changes.	Not cost beneficial. Implementation of this SAMA would involve procedural and hardware changes that would exceed the upper bound averted cost estimate.

Table 7-3
Revised Phase II SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Upper Bound Averted Cost Estimate	Potential Cost	Revised Disposition
3a	35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	5 * $68,950 = $344,750 * 2 Units = $689,500	>$265K as reported in ER for procedural enhancements with engineering analysis and hardware changes required.	The fire protection system (FPS) can already provide water to the RPV system at DNPS through the RFP drain valves, but hardware and procedures have not been developed to use it through the RHR system as an RPV injection source or a containment spray source. Assuring the viability of such a proposed change would also require extensive engineering analysis. However, development of such capabilities may be beneficial when compared to the upper bound averted cost estimate. Retain for more detailed cost benefit analysis (see Table 7-4).
3b	35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	5 * $68,950 = $344,750 * 2 Units = $689,500	$50-100K for procedural enhancements with engineering analysis required.	Dresden has capabilities to use LPCI cross-tie from other unit. This is currently procedurally directed for alternate injection to the RPV, but procedures have not been developed to use it as an alternate containment spray source. Retain for more detailed cost benefit analysis (see Table 7-4).
4	199	Re-open MSIVs	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.	5 * Negligible = Negligible	Not required.	Not cost beneficial. Minimal benefit is obtained and associated implementation costs would easily exceed the upper bound averted cost estimate.
5	239	Increase seismic ruggedness of plant components. Increase the seismic capacity of components on the safe shutdown paths with capacities less than 0.3g to 0.3g.	SAMA would increase the availability of necessary plant equipment during and after seismic events. Extends the safe shutdown path seismic capacity to at least 0.3g.	Not calculated	>$200K for CST (largest outlier at 0.2g). Remaining SSCs are all at 0.26g or higher.	Not cost beneficial. The majority of SSCs at Dresden already have HCLPF values of at least 0.3g. Only the Condensate Storage Tanks (CSTs) have a capacity less than 0.26g. Modifications to increase the CST seismic capacities would be expected to cost more than several hundred thousand dollars, and minimal benefit is expected from increasing the remaining outliers from their current near 0.3g values to >0.3g.

Table 7-3
Revised Phase II SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Upper Bound Averted Cost Estimate	Potential Cost	Revised Disposition
6	249	4.d. Passive Overpressure Relief	This SAMA will prevent catastrophic failure of the containment. Controlled relief through a selected vent path has a greater potential for reducing the release of radioactive material than through a random break.	5 * $6,369 = $31,845	>$100K / unit	Not cost beneficial. Implementation of this SAMA would involve extensive hardware changes that would exceed the upper bound averted cost estimate.
7	259	Diversify the explosive valve operation	An alternate means of opening a pathway to the RPV for SBLC injection would improve the success probability for reactor shutdown.	5 * $24,515 = $122,575	>$100K / unit	Not cost beneficial. Any hardware change would easily exceed the minimum hardware cost of $100K for this type of change, and therefore would exceed the upper bound averted cost estimate.
8	260	Enrich Boron	The increased boron concentration will reduce the time required to achieve the shutdown concentration. This will provide increased margin in the accident timeline for successful operator activation of SBLC.	5 * $1,439 = $7,195	Not Required	Not cost beneficial. Minimal benefit is obtained and associated implementation costs would easily exceed the upper bound averted cost estimate.
9	261	Bypass Low Pressure Permissive	LPCI and CS injection valves require a permissive signal from the same 2 pressure sensors in order to open. The instruments are currently specified as diverse. However, because this is a "pinch point" for all CS and LPCI injection, it is judged prudent to consider a plant modification to allow a bypass switch (1/division) to insert the permissive if the sensors fail to perform their function. A few other BWRs currently have this capability (e.g., Perry).	5 * $24,609 = $123,045	>$100K / unit	Not cost beneficial. Any hardware change would easily exceed the minimum hardware cost of $100K for this type of change, and therefore would exceed the upper bound averted cost estimate.

Table 7-3

Revised Phase II SAMA Disposition (Assuming Maximum Averted Cost Risk of $2.0M)

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Upper Bound Averted Cost Estimate	Potential Cost	Revised Disposition
10	263	Supplemental Air Supply for the Containment Vent	The containment vent function is among the last resort methods currently specified in BWRs to remove heat from containment and control containment pressure under extremely adverse circumstances. The Dresden air compressors are required to support the containment vent function. The air compressors in turn require cooling, normally from TBCCW/SW. An alternative method to supply air to the vent valves for opening would be desirable if SW were to become inadequate.	5 * $6,026 = $30,130 * 2 Units = $60,260	Lower cost alternative of providing backup bottles or portable air compressors estimated at $50-100K for procedural enhancements, training, and hardware modifications.	When the upper bound averted cost estimate is applied to two units at the site, this enhancement may be cost beneficial. Retain for more detailed cost benefit analysis (see Table 7-4).
11 (1)	188	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.	5 * $3,652(2) = $18,260 * 2 Units = $36,520	$25-50K for procedural enhancements.	When the upper bound averted cost estimate is applied to two units at the site, this procedural enhancement may be cost beneficial. Retain for more detailed estimate cost benefit analysis (see Table 7-4).
12 (1)	237	Bypass MSIV isolation in Turbine Trip ATWS scenarios	SAMA will afford operators more time to perform actions. The discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities	5 * $6,067 (2) = $30,335 * 2 Units = $60,670	$50-100K for procedural enhancements with engineering analysis required, plus $100K minimum for hardware changes to implement automatic MSIV isolation bypass capabilities.	Not cost beneficial. Implementation of this SAMA would involve procedural and hardware changes to implement a dedicated low level interlock switch that would exceed the upper bound averted cost estimate.

Notes to Table 7-3

(1) This is a new Phase II SAMA identifier that was not included in the ER.

(2) Detailed development of the PRA model changes made for this Phase II SAMA investigation are provided prior to the table.

Response 7(c) - continued:

"[Provide] an assessment of the impact on the Phase 2 evaluation if risk reduction estimates are increased to account for uncertainties in the risk assessment and the additional benefits associated with external events (as applicable). Consider the uncertainties due to both the averted cost-risk and the cost of implementation to determine changes in the net value for these SAMAs."

As can be seen in Table 7-3, five of the Phase II SAMAs could be categorized as cost beneficial when compared to the upper bound averted cost estimate. It should be noted, however, that there are many factors to consider when looking at the benefits of the SAMA candidates. Plant specific implementation of SAMA candidates may be complicated by space limitations, outage costs, regulatory requirements, and other considerations. These factors tend to result in underestimation of the costs. Additionally, the specific PSA analyses that were performed in addressing specific SAMA candidates were done optimistically. That is, the potential cost-benefit was derived from a case that maximized the CDF (and/or offsite release) reduction that would result from implementation of the SAMA. Both of these factors would, in effect, offset the uncertainties associated with the CDF estimates.

A factor of 5 is judged as a reasonable value to account for uncertainty and to account for potential contributions from external events that were not included in the averted cost estimates in the ER. Attachment A includes information about why a factor of three is more appropriate than a factor of more than 10 that would be obtained if the unmodified Fire PRA results were used directly.[2] The remaining portion (from a factor of 3 up to 5) is to account for uncertainty, and the potential contributions from other external events.

Additionally, each SAMA case was re-examined to ensure that the better estimated averted cost from the internal events model was appropriately representing the potential benefit rather than representing the maximum benefit as was typically done for screening purposes. This includes a re-examination of the assumptions utilized in the initial screening analysis as well as recognizing existing model limitations that could lead to over-estimation of the averted costs. In some cases, the implementation costs were also refined to better reflect the potential cost benefit. The results of this additional screening are illustrated in Table 7-4.

Re-analysis of Phase II SAMA 3a and 3b

For Phase II SAMA 3, the averted cost estimate was determined by making the drywell spray system perfectly reliable for all cases in the Level 2 analysis where it is currently considered (i.e., all accident classes except for Class II, IIID, IV, and V). In practice, though, the proposed modifications (either by establishing a means for using the fire system or by utilizing existing LPCI cross-tie capabilities from the other unit) would not alter the release categorization in two scenarios that accounted for much of the calculated averted cost. These two scenarios are as follows:

- Station blackout or loss of multiple DC bus scenarios where power would not be available to operate the drywell spray valves independent of the source of water.

[2] Attachment A provides an assessment of the use of quantitative risk estimates from Fire PRAs, and why it is judged that the calculated CDF values should not be directly compared at this time.

- Accident Class IIIC scenarios with LPCI pumps available that conservatively did not credit use of the existing LPCI pumps for the drywell spray function (e.g., low pressure permissive failures that would disable the injection function, but would not disable the drywell spray function for these pumps).

A more realistic averted cost estimate can be obtained for this SAMA by excluding these cases as benefiting from the proposed modification. In that case, consistent with the ER, there is still no reduction in the CDF, but the LERF decrease goes from the base case value of 3.03E-7/yr to 2.85E-7/yr (instead of down to 2.43E-7/yr), and other release category changes occur as well. With these changes, the averted cost estimate drops from the originally calculated value of $68,950 to $7,601 using the same methodology and assumptions that were utilized in the ER.

Table 7-4
Refined Phase II SAMA Disposition of Remaining Dresden SAMA Candidates

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Better Estimated Averted Cost	Better Estimated Potential Cost	Better Estimate Disposition
1	3	Enhance loss of component cooling procedure to present desirability of cooling down reactor coolant system (RCS) prior to seal LOCA.	SAMA would reduce the potential for RCP seal failure.	5 * $8,318 = $41,590 * 2 Units = $83,180	>$100K for procedural enhancements with very extensive engineering analysis and training required.	Not cost beneficial. Procedural changes to reduce RPV pressure to minimize seal leakage would be contrary to current BWROG EOP strategies. Validating a recommended approach (such as depressurizing the RPV to 200 psig) would involve extensive analysis to determine acceptable conditions to implement such an approach. Consequently, any changes would require very extensive engineering analysis and justification to provide the viability and acceptability of such an approach. Performing extensive engineering analysis, establishing a procedure, and providing training for the recommended approach would likely lead to potential costs that could easily exceed the upper bound of the estimated potential cost, or >$100K. This would lead to overall implementation costs that are higher than the estimated averted cost.
3a	35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	5 * $7,601 (1) = $38,005 * 2 Units = $76,010	>$265K as reported in ER for procedural enhancements with engineering analysis and hardware changes required.	Not cost beneficial. The fire protection system (FPS) can already provide water to the RPV system at DNPS through the RFP drain valves, but hardware and procedures have not been developed to use it through the RHR system as an RPV injection source or a containment spray source. Assuring the viability of such a proposed change would also require extensive engineering analysis. Overall implementation costs including hardware modifications would exceed the estimated averted cost.

Table 7-4
Refined Phase II SAMA Disposition of Remaining Dresden SAMA Candidates

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Better Estimated Averted Cost	Better Estimated Potential Cost	Better Estimate Disposition
3b	35	Develop an enhanced drywell spray system.	SAMA would provide a redundant source of water to the containment to control containment pressure, when used in conjunction with containment heat removal.	5 * $7,601 [(1)] / 2 with less conservative treatment of global failure of the suppression pool suction strainers = $19,003 * 2 Units = $38,006	$50-100K for procedural enhancements with engineering analysis required.	Not cost beneficial. Dresden has capabilities to use LPCI cross-tie from other unit. This is currently procedurally directed for alternate injection to the RPV, but procedures have not been developed to use it as an alternate containment spray source. A detailed review of the cutsets that contribute to the averted cost indicates that the currently calculated benefit is totally dependent on the assigned value for common cause failure of the suppression pool suction strainer failures which is currently assigned a 1.0E-4 value for LOCA scenarios based on engineering judgment. This is believed to be conservative since the strainers have been enhanced and replaced at Dresden similar to changes made at other BWRs, and since new requirements exist for control of fibrous materials inside containment and water cleanliness. Given these considerations, it is estimated that the averted cost estimate is high by at least a factor of two for these scenarios due to the conservatisms and uncertainty associated with the very unlikely global common cause failure value of all of the suppression pool suction strainers. The revised best estimate averted cost includes this reduction factor. Consequently, this would lead to potential costs that are higher than even the lower bound value of the estimated averted cost.

Table 7-4

Refined Phase II SAMA Disposition of Remaining Dresden SAMA Candidates

Phase II SAMA ID number	Phase I SAMA ID number	SAMA title	Result of potential enhancement	Better Estimated Averted Cost	Better Estimated Potential Cost	Better Estimate Disposition
10	263	Supplemental Air Supply for the Containment Vent	The containment vent function is among the last resort methods currently specified in BWRs to remove heat from containment and control containment pressure under extremely adverse circumstances. The Dresden air compressors are required to support the containment vent function. The air compressors in turn require cooling, normally from TBCCW/SW. An alternative method to supply air to the vent valves for opening would be desirable if SW were to become inadequate.	5 * $6,026 / 3 with less conservative credit for existing capabilities = $10,043 * 2 Units = $20,086	Lower cost alternative of providing backup bottles or portable air compressors estimated at $50-100K for procedural enhancements, training, and hardware modifications.	Not cost beneficial. Very minimal credit is currently taken for recovery of instrument air in the Dresden model. The SAMA analysis changed the current value of 0.9 to 0.0 to estimate the averted cost benefit. For comparison, the Quad Cities model currently uses a recovery value of 0.148 for recovery of instrument air in support of venting. Given these considerations, it is estimated that the averted cost estimate is high by at least a factor of three for these scenarios compared to the capabilities that already exist and could be more realistically credited. The revised best estimate averted cost includes this reduction factor. Consequently, this would lead to potential costs that are higher than even the lower bound value of the estimated averted cost.
11	188	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling.	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.	5 * $3,652 = $18,260 * 2 Units = $36,520	$50K for procedural enhancements.	Not cost beneficial. Current procedures exist to perform such actions at Dresden. The relatively high HEP value of 0.1 is largely based on uncertainty associated with environmental conditions that may exist when performing the actions in the reactor building. Improvements to existing procedures would not justify a significant reduction in the HEP value. Larger benefit could only by significant restructuring of the procedures and EOPs to make this action always viable before environmental conditions put its performance in doubt. This would require procedural enhancements at the upper end of the estimated potential cost, or $50K. This would lead to overall implementation costs that are higher than the estimated averted cost.

(1) Revised from original analysis to reflect a better estimated averted cost based on a re-analysis of the scenarios that could actually benefit from the proposed modifications.

RAI 8

For certain SAMAs considered in the ER, there may be lower cost alternatives that could achieve much of the risk reduction, such as adding a diesel-driven battery charger. Confirm that low cost alternatives to Phase 2 SAMAs were considered, and provide a brief discussion of these alternatives.

Response 8:

Lower cost alternatives were considered in both the initial Phase I screening all the way through to the final revised Phase II screening. Examples included a portable generator to provide prolonged battery capacity (see Table 7-2, Phase I SAMA 167), and backup bottles or portable compressors for supplementing instrument air capabilities (see Table 7-3, Phase II SAMA 10). Other lower cost alternatives were also explored in the form of potential procedural changes (see Table 7-3, Phase II SAMAs 1, 3b, 4, and 11). While many of these may only involve procedural changes in concept, a more thorough investigation leads to the finding that more costs would actually be incurred when considering that the procedure changes may also require engineering analysis, experimentation, and extensive training (see also Response 11). Additionally, a more refined evaluation of the initial averted cost estimates indicate, that in most of the cases, analysis simplifications or existing model limitations tend towards an overestimation of the averted cost. The identified modeling limitations are not considered significant when considering the typical uses of the PRA models, but come to the forefront when specific risk reduction values are calculated. As such, none of the remaining SAMAs (including lower cost alternatives) were determined to be cost beneficial.

RAI 9

During the review of the EPU application, the staff noted several areas where the PSA should be modified to reflect modifications to the plant or changes in success paths. These include: a plant modification to install a recirculating pump run back control circuit; a plant modification to trip the condensate/booster pump D in the event of a LOCA to prevent an overload condition from occurring; a change in success criteria for reactor pressure vessel (R.V.) depressurization in a transient without a stuck open relief valve (two valves under EPU conditions); a change in success criteria for R.V. over pressure protection in ATWS sequences (12 of 13 valves under EPU conditions). Confirm whether these model changes, as well as others, have been incorporated in the PSA used for the SAMA analysis. For those not incorporated, provide an assessment of the impact that the model change would have on the SAMA analysis.

Response 9:

The model was revised to include all appropriate EPU changes:

- The purpose of the recirc. pump runback control circuit is to prevent the reactor trip frequency from increasing due to EPU. The recirc. pump runback is needed because there no longer are "spare" condensate pumps or feedwater pumps. Due to this modification, the transient initiating event frequency is not expected to change. However, effects on the plant can only be incorporated in the PRA after some plant experience via the next periodic update of initiating event frequencies.

  The potential risk impact of the recirc. runback modification was addressed in a response to a NRC RAI to support the EPU application [Reference 9-1]. The response to the RAI addressed both 1) the failure of the recirc. runback to operate as designed, and 2) spurious recirc. runback. The response to the RAI judged that the incorporation of the recirc. runback modification would result in a negligible risk increase.

- The circuit to trip condensate/condensate booster pump "D" on a LOCA signal is expected to be very reliable. The risk impact of the condensate/condensate booster pump "D" trip logic was also addressed in Reference 9-1. The risk impact was calculated to be 1.7E-10/yr. Due to the minor contribution to CDF, this failure mode was not explicitly included in the PRA model.

- The success criterion for RPV depressurization is reflected in the revised transient without SORV model.

- The success criterion for ATWS overpressure protection is reflected in the revised ATWS model.

- The higher decay heat load due to power uprate reduces the time available for certain operator actions. This has been reflected in revised HEP's for those actions.

<u>REFERENCE</u>

[9-1] Letter from K.A. Ainger, Exelon Generation Company, to U.S. NRC, "Additional Risk Information Supporting the License Amendment Request to Permit Uprated Power Operation at Dresden Nuclear Power Station and Quad Cities Nuclear Power Station", RS-01-168, August 14, 2001.

RAI 10

During the review of the EPU application, the staff noted that a new means of inducing a LOOP initiating event potentially exists under EPU conditions. The end result could be an overbusy condition on the unit auxiliary or reserve auxiliary transformer. Given this new condition, provide an evaluation of the costs and benefits associated with the replacement of the affected transformer with a higher capacity transformer.

Response 10:

The risk impact of the induced LOOP initiating event was addressed in a response to a NRC RAI to support the EPU application [Reference 10-1]. Information from the response to the RAI is summarized below.

BACKGROUND

During normal operation the station loads are distributed between the Unit Auxiliary Transformer (UAT) and the Reserve Auxiliary Transformer (RAT). Normally, the loads for two non-essential 4kV buses are aligned to the UAT and the loads for the other two non-essential 4kV buses are aligned to the RAT. If either the UAT or RAT become unavailable during normal operation without a reactor scram, the increased loads for the EPU configuration may result in an overload condition for the remaining transformer's bus duct connection to the 4kV buses.

The scenario of concern is a loss of the UAT or RAT due to transformer failure, failure of protective relaying (e.g., false fast transfer signal), or spurious opening of multiple circuit breakers [see note (1)], causing a fast transfer of all running loads to the other transformer. Under these conditions, certain bus duct segments are overloaded, requiring operator action within one hour to reduce load to within the bus duct rating. This action will be procedurally directed. The one hour time frame for load reduction was determined based on an Exelon Generation Company (EGC), LLC evaluation of a General Electric Company study on short term overload conditions for the bus ducts. The simplifying assumption is made that failure to take this action would lead to a loss of offsite power (LOOP). In reality, overload of the bus duct results in heating above the allowable temperature limits if ambient temperature is at the design value. No deterministic evaluation has been conducted to determine if overheating will result in complete failure of the bus duct, thereby causing a LOOP.

RESULTS

The induced LOOP initiating event is calculated to result in a 6E-9/yr increase in the Dresden Level 1 CDF. The risk evaluation accounts for the estimated frequency of the transformer overduty condition and failure of the plant or operating staff to mitigate the event.

(1) Spurious opening of an individual circuit breaker to an individual 4kV bus would cause a fast transfer of the individual 4kV bus loads to the alternate transformer. However, based on the estimated EPU loads, the transfer of loads for a single 4kV bus (i.e., loads from three 4kV buses on a single transformer) would not place the transformer bus ducts in an overload condition.

CONCLUSIONS FOR SAMA

Based on the minor risk impact, the costs associated with the replacement of the affected transformer or associated electrical equipment (e.g., 4kV bus duct connections) is judged not to be warranted.

Additional details of the risk calculation can be found in Reference [10-1].

REFERENCE

[10-1] Letter from T. W. Simpkin (Exelon Generation Company) to U. S. NRC, "Additional Information Supporting the License Amendment Request to Permit Uprated Power Operation, Dresden Nuclear Power Station and Quad Cities Nuclear Power Station," RS-01-200, dated September 19, 2000.

RAI 11

In Section 4.20.5 of the ER, Exelon states that a preliminary cost estimate was prepared for each of the remaining candidates (remaining after the initial screening). However, implementation costs were provided for only one of the Phase 2 SAMAs. Provide the estimated implementation costs (preliminary cost estimates) for the Phase 2 SAMAs, so that the staff can readily determine whether any of these SAMAs are potentially cost-beneficial when considering the impact of external events and uncertainties. In addition, indicate the minimal cost assumptions used for procedure and hardware changes.

Response 11:

For all of the Phase 2 SAMAs evaluated in Section 4.20.5 of the ER, only one of them had a benefit that was close to the potential implementation cost. Therefore, only one estimated cost was supplied (i.e., >$265K for overall implementation of allowing FPS to act as an alternate drywell spray system). As a supplement to the original SAMA evaluation, Exelon has developed the following estimated implementation costs for use in Response 7(c). These costs have been estimated based on existing SAMA evaluations and have addressed the following cost elements:

- Procedural changes
- Engineering evaluations
- Hardware modifications
- Testing to support engineering evaluations and/or training to support procedural modifications

The following references have been used to assign an appropriate cost to these elements.

REFERENCES

[11-1] NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Oconee Nuclear Station", Supplement 2, U.S. Nuclear Regulatory Commission, Washington, D.C., December 1999.

[11-2] Peach Bottom SAMA Evaluation and RAI Responses

[11-3] HB Robinson SAMA Evaluation and RAI Response

[11-4] VC Summer SAMA Evaluation and RAI Response

[11-5] GE Nuclear Energy, "Technical Support Document for the ABWR," 25A5680, Rev. 1, November 1994.

PROCEDURAL CHANGES

Procedure development and modification requires preparation by a System Engineer, technical review and validation, oversight review, and a variety of additional plant reviews prior to release.

In addition, plant staff will need to be trained prior to implementation. A few examples of other procedure change estimates are provided below.

- ABWR [11-5] indicates that improvements to existing maintenance procedures would cost approximately $300K.

- PB [11-2] describes a procedural modification to allow for cross-tie of CCW at an estimated implementation cost of $50K.

For the Dresden SAMA analyses, a range for procedural changes is estimated to cost from $25K to $50K. The lower estimate is judged to be more appropriate for changes to existing procedures, and the upper estimate is judged to be more appropriate for the development of new procedures.

ENGINEERING EVALUATIONS

In support of procedural and hardware modifications, an engineering evaluation will be required. For a procedural modification, the engineering requirements could easily double the cost of the change. This would increase the procedural change cost to an estimated range of $50K to $100K.

HARDWARE MODIFICATIONS

The following provides examples from previous SAMA evaluations.

- PB [11-2] evaluated alternate methods to provide cooling to the RHR pumps at an estimated implementation cost of $250K.

- PB [11-2] also estimated a cost of $1600K to replace all 8 station batteries.

- Numerous hardware changes were evaluated for the ABWR [11-5] at a cost range from $1000K to $6000K.

- Hardware modifications were evaluated for Oconee [11-1] including automatic refill systems for the refueling water storage tank, automatic switchover of HPI to the spent fuel pool, and others ranging from $1000K to $5000K.

For the Dresden SAMA analysis, several hardware modifications have been evaluated and range in cost from $100K to over $1000K. A minimum of $100K is used to account for engineering analysis, purchase, and maintenance of any proposed hardware modification.

TESTING/TRAINING

Similar to engineering costs to support a procedural change, testing of a plant system to establish operating limits or extensive training requirements to implement the procedure modification is estimated to double the cost of the procedural change. An example of this would be for a proposed SAMA to justify the operation of RCIC at low RPV pressures (such as was explored for Quad Cities), or to implement a containment venting strategy within prescribed limits. Procedural changes in addition to potential testing/training costs could increase the overall implementation cost to a range of $100K to $200K.

SUMMARY OF IMPLEMENTATION COST

Based on a review of previous SAMA evaluations and an evaluation of expected implementation costs at Dresden, Table 11-1 provides the estimated costs for each potential element of the proposed SAMA implementation. Depending on the individual elements involved with each proposed SAMA, these estimates are then used to determine the total implementation cost with the remaining Phase II SAMAs as described in Response 7(c).

Table 11-1
Estimated Implementation Costs

Type of Change	Estimated Cost Range
Procedural only	$25K-$50K
Procedural change with engineering required	$50K-$100K
Procedural change with engineering and testing/training required	$100K-$200K
Hardware modification	$100K to > $1000K

RAI 12

For Phase 2 SAMAs 3, 6, 7, and 10, hardware modifications, as well as procedural changes, are necessary. However, the hardware modifications are not fully described. Briefly describe the proposed hardware modifications.

Response 12:

The following briefly describes the hardware modifications required to implement Phase 2 SAMAs 3, 6, 7, and 10.

Phase 2 SAMA #3: This SAMA addresses the use of the Fire Protection System as a source of water for Drywell Sprays. This modification would require the addition of a spool piece and piping to allow for a connection between FPS and the RHR system. As described in Section 4.20.6.3 of the ER, this capability would also require procedural changes along with engineering analysis to show the capability of FPS to remove heat from the Drywell atmosphere in this new mode of operation.

Phase 2 SAMA #6: Implementation of this SAMA would require installation of a rupture disk in the existing containment vent path or the addition of a completely new vent pathway. If the existing vent piping was to be used, then the valves currently installed in that line would have to be locked open or removed to allow for proper functioning of the rupture disk. If the existing valves were to remain in the vent path, then logic would have to be added to allow for opening of these valves at the proper time to allow for the rupture disk to function.

Phase 2 SAMA #7: Implementation of this SAMA would require either replacement of the existing valves to allow for a more reliable method of opening the path for SBLC, or to install a new bypass pathway using explosive valves to provide SBLC injection to the RPV.

Phase 2 SAMA #10: This SAMA would require the use of portable air bottles with the installation of dedicated tie-in points for quick connection in the event of loss of normal instrument air. The capability could also be achieved using a portable compressor with the same dedicated tie-in points.

Phase 2 SAMA #12: This is a new Phase 2 SAMA identified in the response to RAI 7c and would involve an enhancement to the capability for the operator to bypass the MSIV isolation interlock for an ATWS. One possible hardware modification to provide this benefit would be the installation of a dedicated low level interlock bypass switch.

ATTACHMENT A
FIRE PRA AND USE OF QUANTITATIVE RISK ESTIMATES

Overview

The following summarizes the fire PRA topics where quantification of the associated figure of merit, CDF, may introduce different levels of modeling uncertainty than the internal events PRA.

The uncertainties generally reflect the following:

- lack of adequate data for initiating events
- lack of realistic fire modeling capabilities including mitigation
- lack of ability to track all cables (e.g., BOP cables)
- uncertainty in crew response, especially for control room fires, and their modeling
- limited peer reviews that examine the need for realism instead of conservatism

In many cases, analysts choose to address these uncertainties by incorporating margin into the analysis (i.e., conservative assumptions).

Elements of Fire PRA

Fire PRAs are useful tools to identify design or procedural items that could be clear areas of focus for improving the safety of the plant. Fire PRAs use a structure and quantification technique similar to that used in the internal events PRA.

Since less attention historically has been paid to fire PRAs, conservative modeling is common in a number of areas of the fire analysis to provide a "bounding" methodology for fires. This concept is contrary to the base internal events PRA which has had more analytical development and is judged to be closer to a realistic assessment (i.e., not conservative) of the plant.

There are a number of fire PRA topics involving technical inputs, data, and modeling that prevent the effective comparison of the calculated core damage frequency figure of merit between the internal events PRA and the fire PRA. These areas are identified as follows:

Initiating Events: The frequency of fires and their severity are generally conservatively overestimated. A revised NRC fire events database indicates the trend toward lower frequency and less severe fires. This trend reflects the improved housekeeping, reduction in transient fire hazards, and other improved fire protection steps at utilities.

System Response: Fire protection measures such a sprinklers, CO_2, fire brigades may be given minimal (conservative) credit in their ability to limit the spread of a fire.

Cable routings are typically characterized conservatively because of the lack of data regarding the routing of cables or the lack of the analytic modeling to represent the different routings. This leads to limited credit for balance of plant systems that are extremely important in CDF mitigation.

Fire Modeling: Fire damage and fire spread are conservatively characterized. Fire modeling presents bounding approaches regarding the fire immediate effects (e.g., all cables in a tray are always failed for a cable tray fire) and fire propagation.

HRA: There is little industry experience with crew actions under conditions of the types of fires modeled in fire PRAs. This has led to conservative characterization of crew actions in fire PRAs. Because the CDF is strongly correlated with crew actions, this conservatism has a profound influence on the calculated fire PRA results.

Level of Detail: The fire PRAs may have reduced level of detail in the mitigation of the initiating event and consequential system damage.

Quality of Model: The peer review process for fire PRAs is less well developed than for internal events PRAs. For example, no generally accepted industry standard, such as NEI 00-02, exists for the structured peer review of a fire PRA. This may lead to less assurance of the realism of the model.

Summary and Conclusions

The fire PRA may be subject to more modeling uncertainty than the internal events PRA evaluations. While the fire PRA is generally self-consistent within its calculational framework, the fire PRA does not compare well with internal events PRAs because of the number of conservatisms that have been included in the fire PRA process. Therefore, the use of the fire PRA figure of merit as a reflection of CDF may be inappropriate. Any use of fire PRA results and insights should consider areas where the "state of the art" in fire PRAs is less evolved than other PRA topics.

Relative modeling uncertainty is expected to narrow substantially in the future as more experience is gained in the development and implementation of methods and techniques for modeling fire accident progression and the underlying data.

Until that time, however, the following assessment is made to provide a methodology for estimating the conservatisms included in the reported Fire PRA CDF numbers for Dresden when compared to the internal events CDF numbers.

Initiating Events

A review of a recent NRC report [Reference A-1] was made to obtain an estimate of potential reductions in the fire initiating event frequencies that may occur if more recent and less conservative data were utilized in the Dresden analysis. Note that the NRC report only presents the data in the form of fire frequency by major plant location (it does not provide a breakdown by component such as that which was utilized for the Dresden analysis). As such, a direct comparison is not possible, but if all of the areas listed for each plant location are added up for Dresden and placed into one of the categories provided in the NRC report, then an approximate comparison can be made. Table A-1 provides the comparison, and as can be seen, in all areas, the NRC reported frequency per area is lower than that which was utilized in the Dresden analysis.

Table A-1
Comparison of Recent NRC Report Fire Initiating Event Frequencies with Dresden IPEEE Values

Location	NRC [A-1]	Dresden	Ratio (Dresden / NRC)
Reactor Building	2.8E-2	1.0E-1 / (2 Units) = 5.0E-2	1.8
Turbine Building	4.1E-2	3.6E-1 / (2 Units) = 1.8E-1	4.4
Control Room	7.2E-3	2.4E-2	3.3
Cable Spreading Room	8.4E-4	2.7E-3	3.2
Switchgear Rooms	5.1E-3	7.2E-2 / (2 Units) = ~3.6E-2	7.1
EDG Building	1.4E-2	~ 3.0E-2 per room	2.1
SWS Pumphouse	7.2E-3	2.9E-2	4.0
Battery Room	8.4E-4	~ 3.5E-3 per room	4.2
Other	N/A	0.12	N/A

Therefore, based on the comparison provided in Table A-1, it is judged that a factor of two reduction on the Initiating Event / System Response portion of the Fire CDF can be made as a reasonable assumption to make to provide a more accurate comparison to the internal events CDF.

System Response / Fire Modeling

The Dresden Fire modeling typically utilized bounding approaches regarding the fire immediate effects (e.g., all cables in a tray are always failed for a cable tray fire, and all failed cables lead to failure states of the associated equipment). In the analysis, severity factors were utilized in some cases to distinguish between large versus small fires, and therefore the consequences associated with each. However, the complement of the severity factor was also maintained in the Dresden analysis such that the total frequency was always accounted. The NRC data would support lower initial fire frequencies and lower severity factors in an updated analysis that would lead to lower frequencies associated with many of the dominant fire scenarios. While no direct comparison can be made to approximate the effects this has on the Fire CDF, it is estimated that this modeling approach can also be characterized by at least a factor of two reduction in the Fire CDF to provide a more accurate comparison to the internal events CDF.

HRA / Level of Detail

An examination of the dominant fire scenarios for Dresden from the IPEEE indicates that approximately 26% (Unit 2) and 44% (Unit 3) of the reported CDF (excluding Control Room fires) is due to Loss of Containment Heat Removal scenarios. These scenarios are conservative in nature since they involve many hours to evolve (i.e., >24 hours) at which time many ad hoc procedures could be written or previously failed systems could be recovered. In the Dresden fire analysis, system recovery was not credited at all for these scenarios.

Other PRA models have also credited recovery of failed systems (e.g., RHR pumps or Instrument Air) in support of scenarios such as the dominant loss of containment heat removal scenarios. Such recoveries were also conservatively excluded from the reported Dresden Fire CDF since the fire damage could preclude such recovery actions. However, safe shutdown procedures do exist for some types of fire damage (e.g., damage to power supplies or cables for major pumps used to achieve cold shutdown), and materials needed for the proceduralized repairs (e.g., electrical cables and necessary cable lugs) are pre-staged on site. Additionally, recovery actions are not precluded per se from other (i.e., non fire-related) failures that exist in the cutsets in leading to core damage. Typical recovery values for these types of scenarios range from 0.1 to 0.4.

Other dominant scenarios in the Dresden fire model included operator action failures that are based solely on the direction provided in the EOPs and Off-normal procedures that are credited in the internal events model. Additionally, the Safe Shutdown Procedures that exist for potential fires in all fire areas were not credited at all in the Dresden fire analysis. Credit for these procedures also has the potential for reducing the HEP values utilized in the Fire analysis since they may provide more timely cues or actions to consider given a fire in a specific area compared to the cues that would arise from the symptom-based EOPs.

Considering all of these effects together, it is judged that the simplified HRA modeling and lack of sufficient level of detail in the model can easily lead to an additional factor of 1.5 reduction in the in the Fire CDF to provide a more accurate comparison to the internal events CDF. This can be supported by noting that a 0.2 recovery factor on the Loss of Containment Heat Removal cases alone would lead to about a factor of 1.5 reduction in the total Fire CDF for Dresden Unit 3.

Combined Impact for Comparison to the Internal Events CDF

The CDF contribution to internal fires was estimated at 1.7E-5/yr for Unit 2 and 3.1E-5/yr for Unit 3 in the Dresden IPEEE submittal. Using the Unit 3 value as a bounding case, and the reduction factors provided above, the following assessment is made.

Reported Fire CDF:
3.1E-5/ yr

Reduction from Conservatisms in the Initiating Event frequencies and System Response (2):
3.1E-5/yr / 2 = 1.55E-5/yr

Reduction from Conservatisms in Fire Modeling (2):
1.55E-5/yr / 2 = 7.75E-6/yr

Reduction from HRA Simplifications and Lack of Detail in the Scenario Modeling (1.5):
7.75E-6/yr / 1.5 = 5.17E-6/yr

Considering all of the conservatisms in the reported Fire CDF indicates that if the fire results were reported in a more realistic fashion for Dresden, then the actual result would be no more than a factor of 3 (i.e., 5.2E-6/yr / 1.9E-6/yr = 2.7, or approximately 3) higher than the internal events CDF. This conclusion is supported by the discussion above.

REFERENCES

[A-1] U.S. Nuclear Regulatory Commission (Division of Risk Analysis and Applications), "Fire Events - Update of U.S. Operating Experience, 1986-1999; Commercial Power Reactors", RES/OERAB/S02-01, January 2002.