From: <Richard_J_Gallagher@dom.com>
To: "Richard Emch" <RLE@nrc.gov>
Date: 9/16/04 1:03PM
Subject: Clarification of RAI responses

Rich,

On September 2, 2004, you provided Dominion with 14 questions via email. The purpose of those questions was to obtain clarification of responses Dominion had provided (on August 13, 2004) to the RAIs that were sent by you on June 22, 2004. During a September 13 teleconference, Dominion provided draft responses to the clarifying questions, to demonstrate its understanding of those questions. Attached below, please find Dominion's final responses.

Also, during the September 13 teleconference, one additional question was asked that needed a final response. We have included that response in the attached document as Response #15.

As always, if you have any further questions, please feel free to call.

(See attached file: 091604 15 Questions Response.doc)

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Responses to RAI Follow-up Questions That Were Received on 09/02/04

1. (U2 & U3) Different revisions of the PRA were used for the identification of SAMAs and the quantification of benefits. The response to RAI 6a lists the highest importance basic events from the PRA used for SAMA identification (Rev. 2 for U2; 10/99 for U3) and the importance of the same basic events from the PRA used for quantification (Rev. 3 for U2; 10/02 for U3). Confirm that the highest importance events from the later PRA are included in the list. If not, identify those basic events and the SAMAs that address those events.

   RESPONSE TO QUESTION 1.:

   The basic events not included in the Unit 2 and Unit 3 PRA importance lists were identified. Those with a RRW $\geq$ 1.005 from the more recent PRA model were specifically evaluated. They were then compared to the SAMA list to determine which events were already addressed by a SAMA. The result was that all of the additional basic events were mapped to previously identified SAMAs. Therefore, no new SAMAs were created.

2. (U2) The response to RAI 1b (p. 5) mentions results of a PRA model more recent than the version used for SAMA quantification. Confirm the existence of this update, identify the major changes (models/assumptions and results/risk profile), and discuss any potential impact on the SAMA analysis.

RESPONSE TO QUESTION #2.

Dominion believes that the reviewer meant to reference RAI 1c (p. 5). Dominion should not have included the referenced sentence in its response to RAI 1c. The SAMA analysis was based on the approved PRA model at the time the analysis was performed. In keeping with its continuous improvement philosophy, Dominion periodically updates its PRA model, but it does not expect to update its SAMA analysis in the future. However, Dominion did evaluate the overall changes made for the Revision 4 and 5 PRA models and has listed some of the most important changes below:

An intermediate version was created in June 2003, that was required for the Risk Informed Inservice Inspection (RI-ISI) project at Unit 2. The latest model version was completed in September 2003. The major changes for Revisions 4 and 5 are summarized below.

A. Revision 4 (6/2003) = Revision 3 plus Change Packages listed below

CDF = 3.48E-05/yr.	Truncation = 2.00E-09
LERF = 3.28E-07/yr.	Truncation = 2.00E-09

The summary of the change packages included:

1) Reflect installation of a switch in the Service Water (SW) swing pump closing circuit to prevent the respective swing pump from loading onto the EDG in the event that there is a SIAS or LNP while the respective operating pump is electrically aligned to the same facility as the swing pump.

2) Reflect installation of a switch in the RBCCW swing pump closing circuit to prevent the respective swing pump from loading onto the EDG in the event that there is a SIAS or LNP while the respective operating pump is electrically aligned to the same facility as the swing pump.

3) Credit operator action to mitigate anticipated transient without scram (ATWS) by manually tripping the reactor.

4) Credit steam generator makeup via condensate when the main feedwater pumps are unavailable for all events.

5) Change success criteria for loss of normal power (LNP), loss of CCW (LOCCW) and steamline break (SLB) events with respect to the number of the charging pumps required to mitigate the event.

B. Revision 5 (9/2003) = Revision 4 plus Change Packages listed below

CDF = 2.9E-05/yr.	Truncation = 2.00E-09
LERF = 3.2E-07/yr.	Truncation = 2.00E-09

1) Reduce the required number of charging pumps for successful once-through-cooling in main steam line breaks to two.
2) Eliminate the need for ECCS makeup in loss of component cooling water (LOCCW) events in which a catastrophic RCP seal leak does not occur.
3) Include LOCCW events with catastrophic RCP seal leaks (due to failure of the operators to trip the RCPs or a random failure of the seals).

The changes as noted above reflect physical hardware modifications, operator actions or other improvements made to the PRA model. A review of the above enhancements has concluded that they have insignificant impact on the SAMA analysis.

3. (U2) Relative to peer review F&O AS-5 (Item A.2 in Table 2), confirm that manual control of AFW after loss of air or loss of DC is credited in the PRA. (For example, is success in manual AFW control included in the top success branch in the event tree provided in response to RAI 2c?) If so, what is the failure probability and its importance? Is unavailability of indications due to dependency on power considered in determining this HEP? How was the evaluation of SAMA 113 performed in response to RAI 6g (i.e., what events were revised)?

RESPONSE TO QUESTION #3.

The AFW flow control valves at Unit 2 are designed to fail open on a loss of power or instrument air. Although the valves are equipped with a manual hand wheel for local manual operation and can also be isolated (with flow alternately controlled by a bypass valve around the FCV), this is not modeled. Instead, flow, based on local manual operation of the turbine driven AFW pump, is modeled.

The model shows that if a loss of the remote control, a loss of instrument air, or a loss of control power occurs, the operators will take local manual control of the turbine driven AFW pump. Because the probability of success for this operation is very high, based on indicators, training and time available, the Unit 2 PRA does not model the failure probability of the AFW manual flow control.

The unavailability of indications that would result from a prolonged Station Blackout (SBO), lasting greater than 8 hours, is also not modeled. Instead, the model credits the ability to feed the steam generator(s) and maintain decay heat removal. If a prolonged SBO were to occur, resulting in the loss of Steam Generator pressure and level indication, the Station Emergency Response Organization (SERO), with its Technical Support Center (TSC) would have the means to determine what auxiliary feedwater flowrate would be required to remove decay heat, while preventing the overfilling of the steam generator(s).

The single event that was revised to quantify MP2 SAMA #113 was OALTDAFW. For this event, the probability of the failure of local manual operation of the turbine-driven AFW pump, was set to zero (0). In other words, this operation was made 100% successful.

4. (U3) Relative to Level A peer review F&Os SY-4 and HR-1 (Items A.2 and A.3 in Table 2), please provide a more detailed discussion and support for the conclusion that the incorporation of model changes in response to this F&O will have a negligible impact on the SAMA analysis.

RESPONSE TO QUESTION #4.

Latent operator errors would impact the base PRA model and need to be included for completeness. Dominion anticipates revising this aspect of the Unit 3 model within the next update cycle. However, it is not expected that incorporation of the above cited peer review comments related to latent operator errors in the SAMA analysis, would result in the identification of any new SAMAs. Latent operator errors are a result of leaving a component in the wrong position following surveillance or maintenance. Component and system lineups are procedure directed at Millstone. A SAMA related to a latent error would most likely consist of additional instructions within a procedure. The Millstone procedures used for surveillance activities and system operability checks on significant safety systems already contain the steps for independent review and signoff and therefore contain the steps necessary to reduce errors. Therefore, it is not expected that a SAMA would be beneficial for latent operator errors.

5. (U3) Relative to peer review F&O TH-8 (Item B.19 in Table 2), the impact in Table 2 says that the DWST will provide only 9 hours of water for the AFW pumps. Considering the high importance of the AFW system (the AFW is involved in 3 of the top 4 CDF sequences and the turbine driven AFW pump has a FV importance of 0.235), and the potential for a dependency between operator action to initiate bleed and feed, justify further why the failure to provide alternate sources of water for the AFW after the DWST is emptied has a negligible impact on the SAMA analysis.

RESPONSE TO QUESTION #5.

The required supply in the DWST was based on a very conservative, bounding analysis of a small LOCA in the RCS, with the AFW available for decay heat removal. The analysis assumed that the AFW supplies the steam generators at full flow conditions throughout the transient, without regard to the steam generator level control (in reality, this condition would lead to overfilling of the steam generators and steam lines). At this rate, the analysis very conservatively assumes there would be a 9 hour water supply (although the Technical Specification analysis conservatively calculates that there would be 10 hours of water supply, plus enough water to allow for a 6 hour cooldown period to reduce reactor coolant temperature to the residual heat removal entry condition of 350°F). The same analysis, with the steam generator level control in effect (as would be the case in such circumstances), would show that there is enough inventory in the DWST to supply AFW for 24 hours. Larger breaks would put less demand on the AFW since a larger fraction of the decay heat would be removed through the break, thus extending the DWST drain down time even more.

An additional 200,000 gallons of water is normally available in the Condensate Storage Tank and can be used to supply the AFW pumps if the DWST is depleted. However, this additional volume is not credited in the model, even though the probability of success of aligning this additional source of water would be very high, due to simple valve manipulation involved, the operator familiarity with the lineup and the fact that the lineup is proceduralized.

Therefore, after closer inspection, it is apparent that this SAMA is already implemented at Millstone Unit 3. This would account for the low benefit of adding yet an additional source of AFW.

Responses to RAI Follow-up Questions That Were Received on 09/02/04

6. (U3) The date provided for Rev. 4 is 10/99. The ER states that the WOG peer review took place in 9/99. What version of the PRA was used in the peer review? The ER implies that it was the version used for the SAMA analysis (10/99). Table G.2-1 indicates a 8/99 version, but this is not included in the response to RAI 1d. Please clarify.

RESPONSE TO QUESTION #6.

The 8/99 release date in Table G.2-1 of the Environmental Report is not correct. The Unit 3 PRA model was updated for the WOG peer review on 9/99. The same model was released for official use on 10/99.

7. (U2 & U3) The truncation value used has a significant impact on the CDF. Please provide the truncation values used for obtaining the CDFs given for U2 PRA Revisions 0, 1, and 2, and U3 PRA Revisions 0 (12/95), 2, and 3.

RESPONSE TO QUESTION #7.

Dominion agrees that the truncation value used can have a significant impact on the CDF. Therefore, the actual truncation values for the model revisions that were used for the SAMA analysis, were provided in the response to RAI 1.d. When investigating the truncation values used in earlier revisions of the PRA model, Dominion is having difficulty developing a meaningful comparison. This is a result of how long ago the earlier PRA models were developed, the advancing PRA codes, the different quantification methods, and the PRA models having undergone considerable changes.

8. (U2 & U3) Of all of the PRA changes listed in response to RAI 1d, indicate which ones (1 or 2) were the major contributors to the changes in CDF from one revision to the next.

RESPONSE TO QUESTION #8.

Each model revision encompasses many changes. The final model quantification is done with all the changes in place, so it not possible to calculate the impact on the CDF from each individual modification. The list below provides qualitative ranking of the top two major contributors to changes in CDF for each revision:

Unit 2 PRA Model

Revision 1:
a) Credit for passive ventilation in the Intake Structure
b) Loss of Normal Power (LNP) event frequency modification

Revision 2:
a) The new cross-tie to Unit 3 AC power sources (the SBO diesel, RSST)
b) Modification of the Total Loss of Cooling event tree

Revision 3:
a) The modification to the AC Power Distribution logic
b) Modification of the DC logic

Unit 3 PRA Model

Revision 1: There was no Revision 1.

Revision 2: The changes were minor, resulting in a small decrease in the CDF from Revision 0.

Revision 3:
a) Modifications to the Station Blackout logic
b) Update to the Unit 3 plant-specific database

Revision 4:
a) Modification to the SBO event tree to incorporate the results of core uncovery time from the RCP seal LOCA leakage
b) Modified truncation limit for the CDF calculation

*Revision 5:
a) Incorporation of the accident sequence analysis for LOCAs, SBO, ATWS, and total loss of Service Water
b) Removal of initiating events associated with common cause failure to run of 3 and 4 Service Water pumps, based on industry guidance on identification of CCF groupings

*This was designated Revision 0 (10/02) in the previous response.

9. (U2) What is meant by the last sentence in the description of the Rev. 0 and Rev. 1 PRAs?

RESPONSE TO QUESTION #9.

The last sentence in the description should have said, "This revision was made to address NRC SER comment no. [x] in the table included with Response 1d." The modified responses are included below:

Revision 0 (01/2000); Model used in peer review

CDF = 9.26E-05/yr.
LERF = (Not developed)

Revision 0 included work performed in some important areas. One was the incorporation of more timely plant-specific data into the failure rate determination of specific components. Another was an improvement in the determination of human error probabilities (HEPs). Calibration and restoration HEPs were placed in the model. In addition, some initiating event frequencies were revised to be more in line with other IPEs. The event tree plant damage state (PDS) designations were reevaluated and a new naming scheme was implemented. This revision was made to address NRC SER comment no. 2 in the table included with Response 1d.

Revision 1 (06/2000)

CDF = 8.12E-05/yr.
LERF = (Not developed)

The revision included incorporating some comments from the Peer Review Report, updating the LNP event frequency, and correcting errors found in Revision 0. A reexamination of the Intake Structure loss of HVAC revealed that passive recirculation thru induced ventilation out the wall louvers was sufficient to prevent Service Water Trip. This revision was made to address the NRC SER comment no. 6 in the table included with Response 1d.

10. (U2) Describe the sequences identified as COOL in the response to RAI 1e.

RESPONSE TO QUESTION #10.

COOL (SW+Seal LOCA+RBCCW) represents the loss of cooling water to the primary side components, leading to an eventual degradation of the reactor coolant pump seal integrity. The Reactor Building Component Cooling Water system provides cooling to the thermal barrier in the RCP seal design. A typical sequence involves the following:

- An operating RBCCW pumps fails,
- Operators fail to align the spare RBCCW pump,
- Operators fail to trip the reactor coolant pumps after the loss of the thermal barrier cooling (which leads to a small LOCA from the RCP seals),
- The Service Water system fails to isolate non-essential loads after the safety injection actuation signal, thus diverting flow from the HPSI pump, and
- The HPSI pump fails because of insufficient SW cooling flow

11. (U3) Regarding the 10/02 revision of the PRA, the response to RAI 1e indicates a total CDF (excluding internal flooding) of 2.57E-5 with a truncation value of 1E-11. The response to RAI 1d gives a value of 2.04E-5 with a truncation value of 1E-9. The ER provides a value of 2.88E-5 and states that a truncation value of 1E-11 was used. Please explain.

RESPONSE TO QUESTION #11.

The previous response to RAI 1.e. reported a total CDF (excluding internal flooding) of 2.57E-5/yr. The response to RAI 1d gives a value of 2.04E-5/yr with a truncation value of 1E-9 for PRA Model Revision #5 (designated as Revision 0 [10/02] in the response to RAI 1.d.). The difference in magnitude between the two above CDFs (2.57E-5/yr & 2.04E-5 /yr) is due to the truncation limit that was set during quantification. A CDF value of 2.88E-5/yr was used in the SAMA cost benefit analysis. The use of incorrect multipliers reported in Table G.2-4 resulted in a higher total CDF of 2.88E-5/yr. As noted in response to question #14 below the use of the higher total CDF in the SAMA analysis is considered to be conservative.

12. (U2) The second paragraph of the response to RAI 1h states "The Level 2 portion of the IPE PRA for Millstone Unit 2 has not been updated but there has been some modifications of the individual bin definitions for consistency between the Unit 2 and Unit 3 PRAs." However, page E-F-23 of the ER states "Recent experimental results have shown that certain outcomes on the containment event tree are much less likely than previously thought. These changes were incorporated into the Level 2 model." These statements appear inconsistent. Please clarify and describe in more detail what was done.

RESPONSE TO QUESTION #12.

The statement on page E-F-23, "Recent experimental results...Level 2 model", should not have appeared in the submittal as it does not pertain to the Millstone Level 2 PRA. The first statement quoted in this question (from the second paragraph of the response to RAI 1h) is correct.

13. (U2) An example of how the RC and PDS conversions were made, and how Table F.2-4 was generated would help explain some remaining confusion regarding the conversion process. Take new RC M6, for example. According to Table 1h-3 in the RAI responses, RC M6 is composed of IPE RCs E-LM-R and E-MH-R. In the IPE (Table 4.9-5 of the IPE), TLCH contributes 0.04% and 37.7% to these two RCs. However, in the revised PRA (Table F.2-4 of the ER) TLCH contributes 73.8% of RC M6. It is noted that a number of IPE PDSs are not included in Tables 1h-1 and F.2-4 (for example, TEHA, TEHB, and TEHC, which are the dominant PDS in the IPE. Where are they assigned and is this the source of the difference noted above?

RESPONSE TO QUESTION #13.

Table 4.9-5 in the IPE has an error in the frequencies for PDS TLCH. The frequency for E-HH-R should be 1.16E-09/RY and consequently the total frequency for PDS TLCH is 1.07E-07/RY. This error was noted in year 2002 and the corrected value was used in the SAMA analysis, in particular in the source document for Table F.2-4 of the U2 submittal. The TLCH contributions to E-LM-R and E-MH-R, based on the corrected total frequency, are 0.008% and 73.6%, respectively. This is consistent within roundoff to the total contribution of TLCH to M6 of 73.8% listed in Table F.2-4.

Many changes have been made to the MP2 level 1 PRA model since the IPE submittal. At some point prior to the SAMA analysis, the nomenclature of the Plant Damage State (PDS) designations has changed slightly. Dominion believes that in part, this is due to a better understanding of phenomenon occurring in severe accidents such as direct containment heating (DCH). Since industry research has shown that DCH is not probable, this binning is no longer required. In addition, there were four plant damage states that had the same plant damage impact (one containment spray pump operating.) The primary difference among these four PDS was the availability of feed and bleed. So, the four plant damage states were collapsed into a single plant damage state. (i.e., the IPE PDSs TEHA, TEHB, TEHC, and TEHD were replaced by a new PDS TEH.) The IPE report for Unit 2 discusses the treatment of PDS TEH on pages 4-167 and 4-168.

There have not been any updates to the level 2 model since the IPE (except for binning); so it was necessary to map the current plant damage states back to the original plant damage states in order to define the appropriate conditional probability between PDS and RC (the so-called C-matrix). The current PDS was mapped to the IPE PDS TEHD as a representative conditional probability for core melt sequences. A review of Table 4.9-5 from the IPE report shows that the conditional probabilities for the original four PDS are about the same across the release categories except for TEHB, which is recovered in vessel.

In summary, the key point is that the total frequency from all of the core damage sequences is still mapped to a plant damage state. A second noteworthy point is that the difference in the calculated frequency between the current PDS (1.28E-05/yr) and the original PDS (2.22E-05/yr) is due to the level 1 model changes cited above.

14. (U3) Given that the original Table G.2-4 is incorrect (according to the response to RAI 2.c) and results in incorrect (but high) frequencies in several release categories, is the increase in CDF used in the cost benefit analysis also in error?

RESPONSE TO QUESTION #14.

The incorrect high release category frequencies reported in Table G.2-4 were used in the SAMA cost benefit analysis. As a result, the reduction in CDF was increased slightly. This, in turn, resulted in a higher benefit for each SAMA. In summary the use of these higher frequencies resulted in slightly higher benefit values and total CDF for each SAMA, which contributed to the overall conservatism of the analysis.

15. (U2 & U3) Clearly describe the PRA model modifications made to quantify the benefit for each SAMA evaluated.

RESPONSE TO NEW QUESTION #15

The following two tables have been created to more clearly describe the Units 2 and 3 PRA model modifications. These descriptions were added to the right column whose heading is titled "Revised PRA Model Modification Description".

MP2 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
3	Enhance Loss of RBCCW procedure to present desirability of cooling down RCS prior to seal LOCA.	Set basic events RCPSF, and %RB* in plant damage class cutsets to be successful.	Set RCP seal failure and loss of the RBCCW system to zero.
8	Eliminate RCP thermal barrier dependence on RBCCW, such that loss of RBCCW does not result directly in core damage.	Set basic events %RB* in plant damage class cutsets to be successful.	Set loss of the RBCCW system to zero.
10	Create an independent RCP seal cooling system, with dedicated diesel.	Set gate LOSC in master fault tree to be successful.	Eliminate the need for RCP cooling from the fault tree.
11	Create an independent RCP seal cooling system, without dedicated diesel.	Bounded by SAMA #10.	Bounded by SAMA #10.
22	Improve ability to cool RHR heat exchangers.	Set basic events RB?HX* in plant damage class cutsets to be successful.	Set RBCCW heat exchanger failures to zero.
34	Install a containment vent large enough to remove ATWS decay heat.	Set basic events RT* in plant damage class cutsets to be successful.	Set the electrical and mechanical reactor trip probabilities to zero.
35	Install a filtered containment vent to remove decay heat.	Set basic events CS* in plant damage class cutsets to be successful.	Set the containment spray component failures to zero.
36	Install an unfiltered hardened containment vent.	Bounded by SAMA #35.	Bounded by SAMA #35.
43	Create a reactor cavity flooding system.	Add containment release frequencies M5 and M7 to containment release frequencies M8 and M9 respectively and then set containment release frequencies M5 and M7 to zero.	Move contribution from release categories with intermediate and late containment failure and no containment spray available to release categories with intermediate and late containment failure <u>with</u> containment spray available. Set release categories with intermediate and late containment failure and no containment spray available to zero. Note that the basemat failure release categories are already zero.
44	Creating other options for reactor cavity flooding.	Bounded by SAMA #43.	Bounded by SAMA #43.
61	Use fuel cells instead of lead-acid batteries.	Set basic events SITE105* in plant damage class cutsets to be successful.	Set the failure to recover offsite power when DC power loss occurs to zero.
75	Create a river water backup for diesel cooling.	Set basic events AC?DGDGH7??Q and ACCDGDH7AB?N in plant damage class cutsets to be successful.	Set loss of EDG 'A' and 'B' and CCF of EDG 'A' and 'B' to zero.
77	Provide a connection to alternate offsite power source (the nearest dam).	Add to mutually exclusive logic a LOOP gate which is an OR of the LOOP initiators %3LNPPC, %LNPGR, and %LNPW.	Remove cutsets containing loss of the unit 3 cross-tie and grid and weather related LNPs from the base case. Set unit 3 cross-tie and grid and weather related initiators to zero.

MP2 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
81	Install a fast acting MG output breaker.	Set basic events %DCBSB201* in plant damage class cutsets to be successful.	Set 125VDC Buses 201A and 201B initiators to zero.
87	Replace steam generators with new design.	Set basic events %SGTR in plant damage class cutsets to be successful.	Set steam generator tube rupture initiator to zero.
93	Additional instrumentation and inspection to prevent ISLOCA sequences.	Set the containment release category frequency M1A to zero and set the rest of the containment release category frequencies equal to those in the base case.	Set the ISLOCA containment release category frequency to zero.
94	Increase frequency of valve leak testing.	Bounded by SAMA #93.	Bounded by SAMA #93.
99	Ensure all ISLOCA releases are scrubbed.	Bounded by SAMA #93.	Bounded by SAMA #93.
100	Add redundant and diverse limit switch to each containment isolation valve.	Bounded by SAMA #93.	Bounded by SAMA #93.
113	Provide portable generators to be hooked in to the turbine driven AFW, after battery depletion.	Set basic event OALTDAFW in plant damage class cutsets to be successful.	Set the operator failure to manually operate the turbine driven AFW pump after battery depletion to zero.
123	Provide capability for diesel driven, low pressure vessel makeup.	Set basic events SI?P1* in plant damage class cutsets to be successful.	Set failure of the LPSI pumps and CCF of the LPSI pumps to zero.
124_125	Provide an additional high pressure injection pump with independent diesel.	Set basic events HP?P2P41* and HP*MODP41* in plant damage class cutsets to be successful.	Set failure of the HPSI pumps and CCF of the HPSI pumps to zero.
127	Implement an RWST makeup water source.	Set basic events RW?TKT41*TN and RW1TKTRAINAQ in plant damage class cutsets to be successful.	Set probability of RWST rupture and RWST unavailability to zero.
150	Provide an additional I&C system (e.g., AMSAC).	Set basic events RTELEC and TTRIP in plant damage class cutsets to be successful.	Set electrical reactor trip and turbine trip to zero.
159	Install turbine driven AFW pump.	Set basic events FWXP9* in plant damage class cutsets to be successful.	Set failure of the turbine driven AFW pumps to zero.
161	Install isolation valves on pressurizer PORV.	Set basic event PORVCHLG in plant damage class cutsets to be successful.	Set probability of challenging a PORV to zero.
162	Install additional RBCCW pump.	Bounded by SAMA #8.	Bounded by SAMA #8.
165	Install independent RBCCW/ESFRS AOV similar to 2-RB-68.1A.	Set basic event RB1AVH681ANN in plant damage class cutsets to be successful.	Set failure of RBCCW/ESFRS AOV 2-RB-68.1A to open to zero.
166	Install additional MD AFW pump.	Set basic events FW1P8FWP9A?N and FW2P8FWP9B?N in plant damage class cutsets to be successful.	Set failure of the motor driven AFW pumps 'A' and 'B' to zero.
167	Automate feed and bleed.	Set basic event OAPBAF in plant damage class cutsets to be successful.	Set failure of operator to perform feed and bleed operation to zero.
170	Install redundant parallel valve equivalent to 2-CS-16.1A.	Set basic events CS1MVCS16ANN, CS1MVCS16ANQ, and CS1BKCS16AFF in plant damage class cutsets to be successful.	Set failure of MOV 2-CS-16.1A to open to zero.

MP2 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
172	Add a redundant 125VDC bus equivalent to bus 201A and 201B.	Set basic events %LDCA, %LDCB, and DC?BSB201?FN in plant damage class cutsets to be successful.	Set loss of 125VDC buses 201A and 201B initiators and bus faults to zero.
173	Install diverse bypass valve around AOV's SW-8.1A/B/C.	Set basic events SW?AVSW81?MM, SW?AVSW81?NN, SWCAV81BCMMM, and SWCAV81BCONN in plant damage class cutsets to be successful.	Set failure of AOVs 2-SW-8.1A/B/C to open and CCF to open to zero.
174	Install redundant valve in line for backup to valve RB-8.1A/B.	Set basic event RB1AVRB81AFF in plant damage class cutsets to be successful.	Set failure of AOV 2-RB-8.1A to close to zero.
175	Install redundant diverse bypass valve equivalent to 2-CS-16.1A/B.	Set basic events CS?MVCS16?NN, CS?MVCS16?NQ, CS?BKCS16?FF and CSCMVCS161NN in plant damage class cutsets to be successful.	Set failure of MOVs 2-CS-16.1A/B to open and CCF to open to zero.
176	Install additional SW AOV similar to SW-8.1A to provide a reliable flowpath.	Set basic event SW1AVSW81ANN in plant damage class cutsets to be successful.	Set failure of AOV 2-SW-8.1A to open to zero.
178	Install redundant valve equivalent to RB-210 to assure isolation from primary drain tank.	Set basic event RB2AVRB210FF in plant damage class cutsets to be successful.	Set failure of AOV 2-RB-210 to close to zero.
179	Automate RCP trip circuitry on loss of seal cooling.	Set basic event OAPRCPTRIP in plant damage class cutsets to be successful.	Set failure of operator to trip RCPs on loss of thermal barrier cooling to zero.
180	Install backup 125VDC ventilation.	Set basic event OADCRVENT in plant damage class cutsets to be successful.	Set failure of operator to recover 125VDC power ventilation to zero.
181	Install bypass lines around SW-8.1A/C to provide additional flow capability.	Set basic events SW1AVSW81ANN, SW2AVSW81CNN, and SWCAV81BCONN in plant damage class cutsets to be successful.	Set failure of AOVs 2-SW-8.1A/C to open and CCF to open to zero.
182	Automate the start and alignment of the RBCCW pump.	Set basic event OAPRBPUMP in plant damage class cutsets to be successful.	Set failure of operator to align stand-by RBCCW pump to zero.
183	Automate isolation feature of faulted SG.	Set basic event OASGI in plant damage class cutsets to be successful.	Set failure of operator to isolate faulted steam generator to zero.
184	Install redundant AFW Reg valve following Reg valve FTO.	Set basic event OABYPASS in plant damage class cutsets to be successful.	Set failure of operator to open AFW regulating bypass valve on failure of AFW regulating valve to open to zero.
185	Install redundant ESFRS fan equivalent to F-15B.	Set gates EVB023 and EVB025 as well as basic events EV1FNHV15ANQ, EV2FNHV15BNQ, and EVCFNF15ABNN in master fault tree to be successful.	Eliminate the need for ESFRS fan F-15B from the fault tree and set the unavailability of ESFRS fans F-15A and F-15B as well as their CCF to zero.
186	Install diverse strainers L-1A, B, C to all 3 SW pump discharge lines to prevent CCF.	Set basic events %SWSTSWABCNF and SW?STSWL1?NF in plant damage class cutsets to be successful.	Set failure of CCF of all 3 SW pump strainer initiator as well as CCF of strainers to operate to zero.
187	Automate start capability of Terry Turbine.	Set basic event OATDAFW in plant damage class cutsets to be successful.	Set failure of operator to start the terry turbine to zero.

MP2 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
188	Install more reliable reactor control rod assembly or a diverse boron injection system.	Set basic events RT* in plant damage class cutsets to be successful.	Set the electrical and mechanical reactor trip probabilities to zero.
189	Automate emergency boration of RCS.	Set basic event CHXAVCH192NN in plant damage class cutsets to be successful.	Set failure of the RWST isolation valve AOV 2-CH-192 to open to zero.
190	Install redundant line to RWST equivalent to 2-CH-192.	Set basic events CHXAVCH192NN and CHXSVCH192NN in plant damage class cutsets to be successful.	Set failure of the RWST isolation valve AOV 2-CH-192 to open as well as its air accumulator to operate to zero.
191	Add additional AFW bypass line with diverse reg valve to protect against CCF of existing valves 2-FW-43A and 43B.	Set basic events FW?AVFW43?N?, FW?AVFW43?FF, FW?SVFW43?NN, and FWCAVF43ABNN in plant damage class cutsets to be successful.	Set failure of the AOVs 2-FW-43A/B to open, CCF to open, as well as their air accumulators to operate to zero.
192	Install additional MOV on VCT outlet line similar to MOV-CH-501 for closure to assure boric acid flow to charging pump.	Set basic events CH1*501* in plant damage class cutsets to be successful.	Set all failures relating to MOV 2-CH-501 to close to zero.
193	Install additional AFW bypass line with diverse check valves and reg valves similar to check valves 2-FW-12A and 2-FW-12B and reg valves 2-FW-43A and 43B to SGs.	Set basic events FW?AVFW43?N?, FW?AVFW43?FF, FW?SVFW43?NN, FWCAVF43ABNN, FWCCVF12ABNN, and FWXCVF12??NN in plant damage class cutsets to be successful.	Set failure of the AOVs 2-FW-43A/B to open, their CCF to open, their air accumulators to operate, as well as CCF of CVs 2-FW-12A/B to open to zero.
195	Add additional MOV around valves 2-RB-68.1A&B.	Set basic events RB1AVH681AN?, RB2AVHV81BN? and RBCAVR81ABNN in plant damage class cutsets to be successful.	Set failures of AOVs 2-RB-68.1A/B to open and CCF to open to zero.

MP3 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
9	Provide additional SW pump that can be connected to either SW header.	Set basic events SW?P* in plant damage class cutsets to be successful.	Set failures of SW pumps and CCF of SW pumps to zero.
10	Create an independent RCP seal cooling system, with dedicated diesel.	Set gate LOSC in master fault tree to be successful.	Eliminate the need for RCP cooling from the fault tree.
11	Create an independent RCP seal cooling system, without dedicated diesel.	Bounded by SAMA #10.	Bounded by SAMA #10.
20	Procedural guidance for use of cross-tied CCW or SW pumps.	Substitute for gate SWA100 gate SWL100A which is an AND gate of SWA100 and SWB100A which is an OR gate of SWB100 and OASWXTIE (prob. 0.10). Substitute for gate SWB100 gate SWL100B which is an AND gate of SWB100 and SWA100B which is an OR gate of SWA100 and OASWXTIE (prob. 0.10).	Set failure of one train of SW equal to failure of that train and failure of the opposite train with an operator action to align the opposite train (prob. 0.10).
21	Loss of CCW or SW procedural enhancements.	Substitute for gate SWA100 gate SWL100A which is an AND gate of SWA100 and SWB100A which is an OR gate of SWB100 and OASWXTIE (prob. 0.10). Substitute for gate SWB100 gate SWL100B which is an AND gate of SWB100 and SWA100B which is an OR gate of SWA100 and OASWXTIE (prob. 0.10).	Set failure of one train of SW equal to failure of that train and failure of the opposite train with an operator action to align the opposite train (prob. 0.10).
34	Install a containment vent large enough to remove ATWS decay heat.	Set basic events RPSFAILURE, RXTRIPBKRCCF, STUCKROD10, and STUCKROD35 in master fault tree to be successful.	Set failure of RPS electrical components (except RX trip breakers), CCF of RX trip breakers, CCF of 10 or more control rods to insert, and CCF of 35 or more control rods to insert to zero.
35	Install a filtered containment vent to remove decay heat.	Set basic events HVCACAC2AB?2, RHXVMRHV43NX, RS*, SWCMSV50ABF1, and SWCMSV71ABF1 in plant damage cutsets to be successful.	Set CCF of recirculation ACU units to operate, misalignment of manual valve 3RHS*V43, loss of the recirculation spray system, CCF of 3SWP*MOV50A/B to close, and CCF of 3SWP*MOV71A/B to close to zero.
36	Install an unfiltered hardened containment vent.	Bounded by SAMA #35.	Bounded by SAMA #35.
43	Create a reactor cavity flooding system.	Add containment release frequencies M5, M7, M10, and M11 to containment release frequency M12 and then set containment release frequencies M5, M7, M10, and M11 to zero.	Move contribution from release categories with intermediate and late containment failure and no containment spray available to the release category with no containment failure. Also move contribution from release categories with basemat failure to the release category with no containment failure. Set release categories with intermediate and late containment failure and no containment spray available as well as those with basemat failure to zero.

MP3 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
44	Creating other options for reactor cavity flooding.	Bounded by SAMA #43.	Bounded by SAMA #43.
60	Provide additional DC battery capability.	Set basic events OSPRN1PC, OSPRN1GR, OSPRN2PC, and OSPRN2GR in plant damage class cutsets to be successful. Set basic events OSPRN1WR to 7.55E-02 and basic events OSPRN2WR to 1.19E-01.	Lengthened time for restoration of offsite power to become available to prolong DC battery life.
61	Use fuel cells instead of lead-acid batteries.	Bounded by SAMA #60.	Bounded by SAMA #60.
63	Improved bus cross tie ability.	Substitute for gate ACA34C gate ACX34C which is an AND gate of ACA34C and ACB34DC which is an OR gate of ACB34D and OAACXTIE (prob. 0.01). Substitute for gate ACB34D gate ACX34D which is an AND gate of ACB34D and ACA34CD which is an OR gate of ACA34C and OAACXTIE (prob. 0.01).	Set failure of one AC bus equal to failure of that bus and failure of the opposite bus with an operator action to align the opposite bus (prob. 0.01).
64	Alternate battery charging capability.	Bounded by SAMA #60.	Bounded by SAMA #60.
67	Create AC power cross tie capability across units.	Add basic event ALIGN_MP2 (prob. 0.02) under gate SBO1 which represents failure of the MP2 EDGs 'A' and 'B' or failure of the operator to correctly perform the AC cross-tie between Unit 2 and Unit 3.	Created cross-tie logic (prob. 0.02) with the MP2 EDGs in the fault tree.
73	Install gas turbine generators.	Set basic events AC?DG* in plant damage class cutsets to be successful.	Set failures of EDGs 'A' and 'B' and CCF of EDGs 'A' and 'B' to zero.
75	Create a river water backup for diesel cooling.	Bounded by SAMA #76.	Bounded by SAMA #76.
76	Use firewater as a backup for diesel cooling.	Add to mutually exclusive logic a MUT5 gate which is an AND gate of LOOP and SWAB100 which is an OR gate of SWA100 and SWB100.	Eliminated failures of SW supply to the EDGs from the fault tree.
77	Provide a connection to alternate offsite power source (the nearest dam).	Add to mutually exclusive logic a LOOP gate which is an OR of the LOOP initiators %LOOPGR, %LOOPPC, and %LOOPWR.	Eliminated failures of LOOP from the fault tree.
80	Create an auto-loading of the SBO diesel.	Set basic event OAPSBODG in plant damage class cutsets to be successful.	Set failure of the operator to correctly start and align the SBO diesel to zero.
87	Replace steam generators with new design.	Set gate SGTR in master fault tree to be successful.	Eliminate the possibility of SGTR events from the fault tree.
93	Additional instrumentation and inspection to prevent ISLOCA sequences.	Set the containment release category frequency M1A to zero and set the rest of the containment release category frequencies equal to those in the base case.	Set the ISLOCA containment release category frequency to zero.
94	Increase frequency of valve leak testing.	Bounded by SAMA #93.	Bounded by SAMA #93.
99	Ensure all ISLOCA releases are scrubbed.	Bounded by SAMA #93.	Bounded by SAMA #93.
100	Add redundant and diverse limit switch to each containment isolation valve.	Bounded by SAMA #93.	Bounded by SAMA #93.

MP3 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
112	Proceduralize local manual operation of AFW when control power is lost.	Set basic events OS* in plant damage class cutsets to 0.1.	Set all recoveries of offsite power to zero.
113	Provide portable generators to be hooked in to the turbine driven AFW train, after battery depletion.	Bounded by SAMA #112.	Bounded by SAMA #112.
120	Create passive secondary side coolers.	Set gate AFW in master fault tree to be successful.	Eliminated failures of the AFW system from the fault tree.
123	Provide capability for diesel driven, low pressure vessel makeup.	Set gates ECCS, ACC, and HPINJ in master fault tree to be successful.	Eliminated failures of the ECCS injection from the fault tree.
124_125	Provide an additional high pressure injection pump with independent diesel.	Set basic events SI?P* in plant damage class cutsets to be successful.	Set failures of HPSI pumps and CCF of HPSI pumps to zero.
138	Create automatic swapover to recirculation on RWST depletion.	Set basic events OAPREC* in plant damage class cutsets to be successful.	Set failure of operator to establish sump recirculation after a LOCA to zero.
156	Secondary side guard pipes up to the MSIVs.	Substitute gate SLBI for %SGTR and set gates SLBIA, SLBIB, SLBIC, and SLBID in master fault tree to be successful.	Eliminated failures of the SLB inside containment from the fault tree.
160	Install turbine driven AFW pump.	Set basic events FWXP* in plant damage class cutsets to be successful.	Set failures of the turbine driven AFW pumps to zero.
161	Install SBO diesel.	Set basic events AC?BG* in plant damage class cutsets to be successful.	Set failures of the SBO diesel to zero.
162	Install Charging system train.	Set basic events CH?P* in plant damage class cutsets to be successful.	Set failures of charging pumps and CCF of charging pumps to zero.
164	Install Safety Injection train.	Set basic events SI?P* in plant damage class cutsets to be successful.	Set failures of HPSI pumps and CCF of HPSI pumps to zero.
168	Automate Feed and Bleed.	Set basic events OAPBAF in plant damage class cutsets to be successful.	Set failures of operator to establish feed and bleed cooling to zero.
169	Improve boron injection reliability with new procedure and hardware.	Set gate EB in master fault tree to be successful.	Eliminate failures of emergency boration from the fault tree.
170	Add another AOV to isolate SW.	Set basic events SW?MV*50*, SW?MV*71*, SWCMS*50*, and SWCMS*71* in plant damage class cutsets to be successful.	Set failures of MOVs 3SWP*MOV50A/B and 3SWP*MOV71A/B to close, CCF of 3SWP*MOV50A/B to close, and CCF of 3SWP*MOV71A/B to close to zero.
171	Install another RSS parallel flow path.	Bounded by SAMA #172.	Bounded by SAMA #172.
172	Add a redundant train of RSS.	Set basic events RS?P* in plant damage class cutsets to be successful.	Set failures of RSS pumps and CCF of RSS pumps to zero.

MP3 PRA Model Modification for SAMA Evaluation

SAMA No.	Potential Improvement	PRA Model Modification	Revised PRA Model Modification Description
173	Add additional SW AOVs (ATC/ATO).	Set basic events SW?MV*50*, SW?MV*71*, SWCMS*50*, and SWCMS*71* in plant damage class cutsets to be successful.	Set failures of MOVs 3SWP*MOV50A/B and 3SWP*MOV71A/B to close, CCF of 3SWP*MOV50A/B to close, and CCF of 3SWP*MOV71A/B to close to zero.
175	Add a redundant DC bus.	Set basic events LVDCA, LVDCB, LVDC, and DC?BS* in plant damage class cutsets to be successful.	Set failures of vital 120VDC buses 301A1 and 301B1 to zero.
176	Add a redundant charging pump.	Set basic events CH?P* in plant damage class cutsets to be successful.	Set failures of the charging pumps and CCF of the charging pumps to zero.
177	Add a redundant block valve for the PORV.	Set gate STUCKPORV in master fault tree to be successful.	Eliminate failures of the PORVs to reseat from the fault tree.
178	Add redundant MSIVs.	Set gates MSI1 and MSLIO in master fault tree to be successful.	Eliminate failures of the MSIVs to close from the fault tree.
179	Add a redundant SW pump ventilation train.	Set gates HVASW10 and HVBSW10 in master fault tree to be successful.	Eliminate failure of the SW train 'A' and train 'B' pump cubicle ventilation from the fault tree.
180	Add a redundant valve in series to isolate the steam line dumps to condenser.	Set gate MSX200 in master fault tree to be successful.	Eliminate failures of the steam dump valves to the condenser from the fault tree.
182	Add redundant AC bus.	Substitute for gate ACA34C gate ACX34C which is an AND gate of ACA34C and ACB34DC which is an OR gate of ACB34D and OAACXTIE (prob. 0.01). Substitute for gate ACB34D gate ACX34D which is an AND gate of ACB34D and ACA34CD which is an OR gate of ACA34C and OAACXTIE (prob. 0.01).	Set failure of one AC bus equal to failure of that bus and failure of the opposite bus with an operator action to align the opposite bus (prob. 0.01).
183	Add redundant AFW flow path.	Set basic events FWCCV* in plant damage class cutsets to be successful.	Set CCF of the discharge and injection AFW check valves to open to zero.
184	Add redundant demineralized water storage tank (DWST).	Set basic events FW?TK* in plant damage class cutsets to be successful.	Set failure of the DWST to rupture to zero.