ATTACHMENT F

SEVERE ACCIDENT MITIGATION ALTERNATIVES

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Acronyms Used in Attachment F

AFW	auxiliary feedwater
AOP	abnormal operating procedure
AOV	air operated valve
ASME	American Society of Mechanical Engineers
ATWS	anticipated transient without scram
BAST	boric acid storage tank
BE	basic event
BWR	boiling water reactor
CAP	corrective action program
CC	component cooling
CCF	common cause failure
CCFP	conditional containment failure probability
CD	core damage
CDB	core damage bin
CDF	core damage frequency
CET	containment event tree
CL	cooling water system
CRD	control rod drive
CS	containment spray
CST	condensate storage tank
CVCS	chemical and volume control system
DDCLP	diesel-driven cooling water pump
DDFP	Diesel-driven fire pump
ECCS	emergency core cooling system
EDG	emergency diesel generator
EOF	emergency operations facility
EOP	emergency operating procedure
EPRI	electric power research institute
EPZ	emergency planning zone
F&O	fact and observation
FA	fire area
FC	fail closed
FHA	fuel handling accident
FIVE	Fire Induced Vulnerability Evaluation
FP	fire protection
FPS	fire protection system
FT	fault tree
FTC	fails to close
FTO	fails to open
FTRC	fails to remain close
FTRO	fails to remain open
FTR	fails to run
FTS	fails to start

Acronyms Used in Attachment F

GDC	general design criteria
GIS	geographic information system
HEP	human error probability
HHSI	high head safety injection
HPI	high pressure injection
HRA	human reliability analysis
HVAC	heating ventilation and air-conditioning
IA	instrument air
IPE	individual plant examination
IPEEE	individual plant examination – external events
IPEM	individual plant evaluation methodology
ISLOCA	interfacing system LOCA
LERF	large early release frequency
LOCA	loss of coolant accident
LODC	loss of DC power
LOOP	loss of off-site power
MAAP	modular accident analysis program
MACCS2	MELCOR accident consequences code system, version 2
MACR	maximum averted cost-risk
MCC	motor control center
MDAFW	motor driven AFW pump
MMACR	modified maximum averted cost-risk
MSLB	main steam line break
MSPI	Mitigating Systems Performance Index
MOV	motor operated valve
MSIV	main steam isolation valve
NEI	Nuclear Energy Institute
NMC	Nuclear Management Company
NPSH	net positive suction head
NRC	U.S. Nuclear Regulatory Commission
NSP	Northern States Power
OECR	off-site economic cost risk
PINGP	Prairie Island Nuclear Generating Plant
PRA	probabilistic risk assessment
PORV	pressure operated relief valve
PWR	pressurized water reactor
PZR	pressurizer
RAI	request for additional information
RCP	reactor coolant pump
RCS	reactor coolant system
RDR	real discount rate
RHR	residual heat removal
RPV	reactor pressure vessel

Acronyms Used in Attachment F

RRW	risk reduction worth
RWST	refueling water storage tank
SAMA	severe accident mitigation alternative
SBO	station blackout
SCBA	self-contained breathing apparatus
SETS	set equation transformation system
SG	steam generator
SGTR	steam generator tube rupture
SI	safety injection
SQUG	Seismic Qualification Utility Group
SRV	safety relief valve
SSD	safe shutdown
SSE	safe shutdown earthquake
SW	service water
SWGR	switchgear
TD	turbine driven
TDAFW	turbine driven auxiliary feedwater pump
TS	technical specifications
TSC	technical support center
USI	unresolved safety issue
VCT	volume control tank
WOG	Westinghouse Owners Group

SEVERE ACCIDENT MITIGATION ALTERNATIVES

The severe accident mitigation alternatives (SAMA) analysis discussed in Section 4.17 of the Environmental Report is presented below.

F.1 METHODOLOGY

The methodology selected for this analysis involves identifying SAMA candidates that have potential for reducing plant risk and determining whether or not the implementation of those candidates is beneficial on a cost-risk reduction basis. The metrics chosen to represent plant risk include the core damage frequency (CDF), the dose-risk, and the offsite economic cost-risk. These values provide a measure of both the likelihood and consequences of a core damage event.

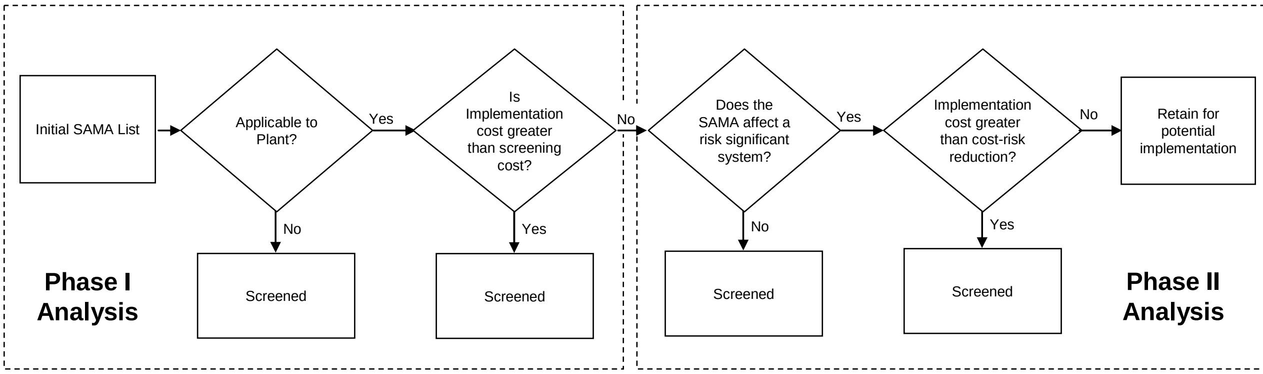
The SAMA process consists of the following steps:

- **PINGP Probabilistic Risk Assessment (PRA) Model** – Use the PINGP Internal Events PRA model as the basis for the analysis (Section F.2). Incorporate External Events contributions as described in Section F.5.1.8.
- **Level 3 PRA Analysis** – Use PINGP Level 1 and 2 Internal Events PRA output and site-specific meteorology, demographic, land use, and emergency response data as input in performing a Level 3 PRA using the MELCOR Accident Consequences Code System Version 2 (MACCS2) (Section F.3). Incorporate External Events contributions as described in Section F.5.1.8.
- **Baseline Risk Monetization** – Use U.S. Nuclear Regulatory Commission (NRC) regulatory analysis techniques to calculate the monetary value of the unmitigated PINGP severe accident risk. This becomes the maximum averted cost-risk that is possible (Section F.4).
- **Phase I SAMA Analysis** – Identify potential SAMA candidates based on the PINGP PRA Individual Plant Examination – External Events (IPEEE), and documentation from the industry and the NRC. Screen out SAMA candidates that are not applicable to the PINGP design or are of low benefit in pressurized water reactors (PWRs) such as PINGP, candidates that have already been implemented at PINGP or whose benefits have been achieved at PINGP using other means, and candidates whose estimated cost exceeds the maximum possible averted cost-risk (Section F.5).
- **Phase II SAMA Analysis** – Calculate the risk reduction attributable to each of the remaining SAMA candidates and compare to a more detailed cost analysis to identify the net cost-benefit. PRA insights are also used to screen SAMA candidates in this phase (Section F.6).

- **Uncertainty Analysis** – Evaluate how changes in the SAMA analysis assumptions might affect the cost-benefit evaluation (Section F.7).
- **Conclusions** – Summarize results and identify conclusions (Section F.8).

The steps outlined above are described in more detail in the subsections of this appendix. The graphic below summarizes the high level steps of the SAMA process.

SAMA Screening Process



Environmental impact statements and environmental reports are prepared using the graded approach in which impacts of greater concern and mitigation measures of greater potential value are studied with correspondingly greater effort and rigor. Accordingly, NMC used screening methods and less detailed feasibility investigative and cost estimation techniques for SAMA candidates having disproportionately high cost or low benefits. High level initial cost estimates for all Phase 1 SAMAs were developed by PINGP project department using plant basis and industry information.

F.2 PINGP PRA MODEL

The SAMA analysis is based on the 2006 PINGP Level 1 and Level 2, Revision 2.2 PRA models for internal events. The original Individual Plant Examination (IPE) model submitted in 1994 has received a number of technical updates to maintain design fidelity with the operating plant and reflect the latest PRA technology. This section provides an overview of the model revisions and technical upgrades, and provides a basis for conclusion that the PRA scope and quality is sufficient for this application.

The PINGP PRA model peer review was conducted in September 2000. The final report was prepared by Westinghouse, which was the lead in performing the PWR Utility peer assessment. The peer assessment identified five Level A Facts & Observations (F&Os) and 32 Level B F&Os. All A and B Level F&Os have been addressed and closed.

The following subsections provide more detailed information related to the evolution of the PINGP internal events PRA model and the current results. These topics include:

- PRA changes since the IPE
- Level 1 model overview
- Level 2 model overview
- PRA model review summary

Section F.5.1.8 provides a description of the process used to integrate external events contributions into the PINGP SAMA process; therefore, no specific discussion of the external events models is included in this section.

F.2.1 History of PINGP PRA Model Development

This section describes the IPE and identifies subsequent model changes that were implemented. The IPE, which included both Level 1 and Level 2 PRA analyses for Unit 1 only, is discussed in Section F.2.1.1. Revisions to the Level 1 PRA model since the IPE are discussed in Section F.2.1.2. Revisions to the Level 2 PRA model since the IPE are discussed in Section F.2.1.3. The current Level 1 and Level 2 (Rev. 2.2 (SAMA)), which was used for the SAMA evaluation, is described in Sections F.2.2 and F.2.3, respectively. Detailed descriptions of the changes for each revision are maintained as plant model documentation.

The historical nominal CDF and large early release frequency (LERF) results for PINGP are as follows:

PINGP Model	Model Revision Date	Unit 1 CDF (per rx-yr)	Unit 2 CDF (per rx-yr)	Unit 1 LERF (per rx-yr)	Unit 2 LERF (per rx-yr)
IPE (Rev. 0)	1994	5.0E-05	NA	NA	NA
Rev. 1.0	1996	2.4E-05	NA	3.8E-07	NA
Rev. 1.1	1999	2.35E-05	NA	3.8E-07	NA
Rev. 1.2	2001	2.20E-05	NA	6.9E-07	NA
Rev. 2.0	2002	2.19E-05	2.52E-05	3.88E-07	3.90E-07
Rev. 2.1	2005	1.47E-05	1.63E-05	5.74E-07	5.74E-07
Rev. 2.2	2006	9.81E-06	1.13E-05	5.14E-08	1.35E-07
Rev. 2.2 (SAMA)	2006	9.79E-06	1.21E-05	8.79E-08	1.75E-07

This section reviews the PRA model development from the IPE to the current Revision 2.2 model, including model enhancements and dominant accident classes.

F.2.1.1 IPE (Level 1 and Level 2, Revision 0)

The PINGP IPE was submitted to the NRC by letter dated March 1, 1994 to respond to Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities – 10CFR 50.54(f)." The NRC sent requests for additional information (RAI) to Northern States Power Company on December 21, 1995. The NRC accepted the IPE by letter dated May 16, 1997. The NRC letters noted that the IPE submittals met the intent of Generic Letter 88-20, "Individual Plant Examination for Severe Accident Vulnerabilities – 10CFR 50.54(f)", dated November 23, 1988.

The first full-scope PRA analysis done for PINGP was that performed to satisfy the IPE requirements, and was completed in February 1994. This was a study to determine vulnerabilities to severe accidents from at-power operation. It was based on a Level 1 and Level 2 PRA model performed for Unit 1. Unit 2 vulnerabilities were qualitatively evaluated based on the Unit 1 results and consideration of asymmetries in plant design and operation that exist between the units. The study found no vulnerabilities to severe accidents at the PINGP. Previously, a limited-scope Individual Plant Evaluation Methodology (IPEM) analysis was completed in 1992. The IPE PRA analysis started with the models built for the IPEM study, and additional details, including the Level 2 portions, were added to arrive at the full scope analysis. The initial data collection effort for that analysis was performed for the period 1978 – 1987, except for the initiating event frequency analysis, which used plant trip information over the period 1975 – 1987. The IPE is now considered to be Revision 0 of the Level 1 and 2 PRA models.

The core damage frequency (CDF) calculated for the IPE was 5.0E-5/rx-yr. The contributions by initiating event were:

- Loss of coolant accident (LOCAs) (24%);
- Loss of off-site power (LOOP) including station blackout (SBO) (22%);
- Internal Flooding (21%);
- Transients excluding LOOP (19%); and
- Steam generator tube rupture (SGTR) (13%).

LERF was not quantified for the IPE. The total release frequency (the frequency of core damage followed by containment failure) was calculated to be 2.0E-5/rx-yr, giving a conditional containment failure probability (CCFP) of approximately 40% (69% including induced SGTR, which was addressed by an Emergency Operating Procedure (EOP) change almost as soon as the IPE was submitted). The dominant contributors to the CCFP were:

- Late containment failure due to overpressure following early core damage and vessel failure at high pressure (55%); and
- SGTR (35%)
- Other (10%).

F.2.1.2 Level 1 Model Revisions since the IPE

F.2.1.2.1 <u>Level 1, Revision 1.0</u>

Revision 1.0 of the Unit 1, Level 1 PRA model was completed in 1996. In addition to adding modeling for a few additional balance-of-plant systems (for example, the non-safeguards station air system and the steam dump and circulating water systems), this update included modeling for a number of significant changes to the plant safeguards electrical systems that were not installed at the time of the IPE submittal. Examples include elimination of sub-fed 480V motor control centers (MCCs), division of the two Unit 1 safeguards 480 V AC buses into four buses and relocation of those buses within the plant; and significant reliability upgrades for the DC power system. Component failure and unavailability data for six key systems were updated for the period 1986 through 1995, as were the initiating event frequencies. LOCA frequencies were reanalyzed to make them more plant-specific, using a pipe failure study technique developed by the Electric Power Research Institute (EPRI).

The CDF calculated for the Revision 1.0 PRA model was 2.4E-5/rx-yr. The contributions by initiating event were:

- LOCAs (5%);
- LOOP including SBO (34%);
- Internal Flooding (36%);
- Transients excluding LOOP (10%);
- SGTR (14%); and
- Other (1%).

The decline in the CDF compared with the Revision 1.0 (IPE) model results was primarily due to the development of plant-specific LOCA initiating event frequencies, credit given for the station air to instrument air cross-tie capability, and credit given for an electrical system upgrade and equipment relocation on Unit 1 that effectively eliminated the 480 V safeguards bus dependency on room ventilation.

F.2.1.2.2 Level 1, Revision 1.1

Revision 1.1 of the Unit 1, Level 1 model was completed in 1999. This was essentially the same model as Revision 1.0; however, a single top fault tree approach to the quantification of overall CDF was used, as was a standard truncation level of 1E-10. Previously, the PRA models were quantified using Set Equation Transformation System (SETS) software, which allowed different truncation levels for each individual core damage sequence. The total CDF for the Revision 1.1 model was calculated to be 2.35E-5/rx-yr, and the breakdown of the CDF by initiating event was similar to the Revision 1.0 model.

F.2.1.2.3 Level 1, Revision 1.2

Revision 1.2 of the Unit 1, Level 1 model was completed in 2001. Significant changes were incorporated during this revision. Many of these changes were based on comments received by the Westinghouse Owners Group (WOG) PRA Certification Team Review that took place in September 2000. Changes included:

- New LOCA break size groupings (small LOCA, medium LOCA, large LOCA);
- New LOCA break size frequencies based on generic data from NUREG/CR-5750;
- Update to several initiating event frequencies (LOOP, loss of DC (LODC));
- Inclusion of Offsite Power recovery actions for non-SBO events;
- Creation of initiating event trees for the cooling water system (CL), component cooling system (CC), and Instrument Air systems;
- Power operated relief valve (PORV) LOCA events were added;
- Changes to SBO success criteria (removal of diesel generator recovery);
- Random reactor coolant pump (RCP) Seal Failure initiating event was added;
- Updates to several system fault trees;
- Credit for the pressurizer PORV accumulator;
- Upgrade to the Human Reliability Analysis (key operator actions); and
- The mission time for the emergency diesel generators (EDG) and CL pumps were changed from 6 hours to 24 hours since offsite power recovery is credited.

The component failure rates from the 1995 update were reviewed against generic data. If significant differences were found and there was a large impact on the CDF, the component failure rate was updated. Only a few changes were made. Specifically, EDG D5 and D6 failure and unavailability data were changed based on the limited amount of operating experience available during the update period. Generic failure rates from NUREG/CR-4550 were used for the D5 and D6 EDGs.

The CDF calculated for the Revision 1.2 PRA model was 2.20E-5/rx-yr. The contributions by initiating event were:

- LOOP including SBO (23.9%);
- LOCAs (23.8%);
- Internal Flooding (22.5%);
- SGTR (14.8%); and
- Transients excluding LOOP (15.0%).

There was not a significant change in the overall CDF value compared with the Revision 1.1 model. However, the distribution of the accident sequences has changed significantly. The LOOP contribution decreased due to crediting offsite power recovery for the non-SBO sequences. The SGTR contribution increased due to re-analysis of the human error actions associated with this event. The LOCA contribution increased due to redefining the LOCA break sizes and the use of generic LOCA frequencies. The internal flooding contribution decreased due to crediting the Pressurizer PORV accumulator. The transient contribution increased due to several reasons since it encompasses many initiating events.

- The loss of feedwater transient increased due to changes in the human reliability analysis (HRA). (Key operator actions were re-analyzed based on conditional events, which resulted in a higher probability of failure. A key operator action in the loss of feedwater water transient affected by this includes: establishing feed and bleed conditional on restoring feedwater.);

- The normal transient contribution increased due to the modeling addition of challenging a pressurizer PORV during the transient and resulting in a PORV LOCA; and

- The contribution from a loss of CC and CL transients increased due to the addition of initiating event tree modeling for CL and CC systems.

F.2.1.2.4 Unit 1 and Unit 2 Level 1, Revision 2.0

Level 1, Revision 2.0 PRA model update was performed in order to obtain a working PRA model for Unit 2. Previously, all probabilistic risk analysis for Unit 2 have involved application of the Unit 1 model results, with modifications that attempted to consider the impact of asymmetries between the units. The update was also performed to correct some errors and make some enhancements to the existing Revision 1.2 PRA model. The model update was completed in 2002 and was built upon the Level 1 Revision 1.2 model. Major model changes included with this update are:

- Addition of Unit 2 frontline and support system logic modeling;

- Addition of Unit 2 accident sequence logic modeling;

- Inclusion of CDF and LERF calculations for Unit 2;

- Removal of the boric acid storage tank (BAST) input to the safety injection (SI) pumps suction logic. The primary suction supply is now only the refueling water storage tank (RWST);

- Enhancement of the existing quantification methodology, including incorporation of fault tree-based deletion of mutually exclusive events, including multiple initiating events;

- Modification to the charging pump system fault tree logic to include an operator action to restart the pumps after a LOOP event since they are not included in the sequencer logic;

- Use of the same common cause failure (CCF) event for the residual heat removal (RHR) pump discharge check valves in the injection, recirculation, and shutdown cooling modes;

- A new operator action to prevent load sequencer failure due to loss of cooling to the 4KV safeguards bus rooms (Bus 15, Bus 16, Bus 25, and Bus 26 rooms) were incorporated into the model. In conjunction with this change, a factor for the sequencer failure at elevated temperatures was added to the fault tree logic for the safeguards bus;

- Update to the logic modeling for the supply/exhaust fans 21, 22, 23, 24 which supply air to the Unit 2 safeguards bus rooms. The original modeling assumed that none of the fans were running (but one train is normally running). This modeling change assumed supply/exhaust fan sets 21 and 22 are normally running and supply/exhaust 23 and 24 are in standby. Therefore, the failure to start logic was only included for sets 23 and 24. The CCF to start basic events (BEs) for all four sets was removed from the model; and

- An incorrect and non-conservative mutually exclusive event related to the Screenhouse Flood Zone 2 Initiating event (I-SH2FLD) was removed from the logic. This resulted in an increase in the contribution of the Screenhouse Flood Zone 2 (SH2FLD) event to the overall results.

The CDF calculated for the Unit 1 Revision 2.0 PRA model was 2.19E-5/rx-yr. The contributions by initiating event were:

- LOOP including SBO (26.0%);

- LOCAs (22.4%);

- Internal Flooding (23.2%);

- SGTR (13.2%); and

- Transients excluding LOOP (15.2%).

There was not a significant change in the overall CDF value compared with the Revision 1.2 model. There were some changes in the distribution of the accident sequences. The LOOP contribution increased due to the additional cutsets (with higher probabilities) related to the LOOP event with a failure of the operator to start a charging pump and a loss of the CL pumps which lead to a RCP seal LOCA. The small LOCA contribution decreased (which results in a decrease in the LOCA contribution) due to the removal of the BAST as a supply source to the SI pumps. The SGTR contribution decreased due the new mutually exclusive logic incorporated into the model, specifically related to preventative maintenance on Emergency Diesel Generator (EDGs). The flood contribution increased due to the removal of a mutually exclusive event related to the Screenhouse Flood Zone 2 initiating event.

The CDF calculated for the Unit 2 Revision 2.0 PRA model was 2.52E-5/rx-yr. The contributions by initiating event were:

- LOOP including SBO (25.6%);
- LOCAs (19.4%);
- Internal Flooding (20.1%);
- SGTR (11.8%); and
- Transients excluding LOOP (23.1%).

There is not a previous Unit 2 model to which the results can be compared; however, Unit 2 can be compared to the Unit 1 results. Unit 2 CDF value is higher than the Unit 1 result, due to an increase in the LOOP and LODC Power Train A initiating events. The LOOP initiating event increase is due to the Unit 2 asymmetries associated with the auxiliary feedwater (AFW) system (Unit 2 motor driven AFW (MDAFW) pump powered from Train A verses Unit 1 MDAFW pump powered from Train B) and the emergency diesel generators system (D5 and D6 have higher CCF to start probability verses D1 and D2). These asymmetries result in LOOP event cutsets that have higher probabilities than the Unit 1 results. Also, since the Unit 2 MDAFW pump is powered from Train A, the LODC power Train A event has a larger impact on the Unit 2 CDF results (contributes almost 9% to the overall CDF). This initiator causes the transient portion of the Unit 2 CDF to increase to 23.1% verses 15.2% in the Unit 1 results. The internal flooding event probability remains virtually the same between the Unit 2 and Unit 1 results; however, due to the increase in Unit 2 CDF value, the contribution in the Unit 2 result is lower. This is also the case for the SGTR event.

F.2.1.2.5 Unit 1 and Unit 2 Level 1, Revision 2.1

Revision 2.1 of the Unit 1 and Unit 2, Level 1 model was completed in early 2005. Significant changes were incorporated during this revision. Changes include:

- Update to LOOP initiating event frequency including the addition of consequential LOOP;
- Updates to the RHR, SI, AFW, CL, CC, 125 VDC system, EDG, and instrument power system fault trees;
- Upgrade to the HRA for key operator actions and inclusion of misalignment and miscalibration events;
- Correction to the process used to model pre-initiator latent errors;
- Additional modeling of 120 V AC panel faults;
- Updated failure data for the EDG and AFW systems;
- Updated common cause values for the EDG and AFW systems; and
- Updated internal flooding analysis.

The CDF calculated for the Unit 1 Revision 2.1 PRA model was 1.47E-5/rx-yr. The contributions by initiating event were:

- LOCAs (53.5%);
- Transients excluding LOOP (20.8%);
- SGTR (14.2%);
- LOOP, including SBO (9.8%); and
- Internal flooding (1.7%).

There was a significant change in the overall Unit 1 CDF value compared with the Revision 2.0 model. The distribution of the accident sequences changed significantly. The LOOP contribution decreased due to recalculation of the LOOP initiating event frequency and new EDG common cause and failure data. The LOCA contribution increased due to re-analysis of the human error actions associated with these events. The internal flooding contribution decreased due to reanalysis of the pipe break frequencies and the flows from the break. The transient contribution changed due to several reasons since it encompasses many initiating events:

- Transients increased due to the addition of AFW recirculation line valve failure logic, which was added in the recent fault tree update. This added an extra failure mode for the AFW system;
- The normal transient contribution decreased due to the modeling addition of a factor for the percentage of time that a pressurizer PORV might lift following a transient initiating event; and
- The credit for the pressurizer PORV air accumulator was increased, which reduced the contribution of the loss of instrument air initiating event.

The CDF calculated for the Unit 2 Revision 2.1 PRA model was 1.63E-5/rx-yr. The contributions by initiating event were:

- LOCAs (48.3%);
- Transients excluding LOOP (27.2%);
- SGTR (12.8%);
- LOOP, including SBO (10.2%); and
- Internal flooding (1.5%).

There was a significant change in the overall Unit 2 CDF value compared with the Revision 2.0 model. The distribution of the accident sequences also changed significantly. The LOOP contribution decreased due to recalculation of the LOOP initiating event frequency and new EDG common cause and failure data. The SGTR contribution decreased due to re-analysis of the human error actions associated with this event. The LOCA contribution increased due to re-analysis of the human error actions associated with these events. The internal flooding contribution decreased due to reanalysis of the pipe break frequencies and the flows from the break. The transient contribution changed due to several reasons, as it encompasses many initiating events.

- Transients increased due to the addition of AFW recirculation line valve failure logic, which was added in the recent fault tree update. This added an extra failure mode for the AFW system;
- The normal transient contribution decreased due to the modeling addition of a factor for the percentage of time that a pressurizer PORV might lift following a transient initiating event; and

- The credit for the pressurizer PORV air accumulator was increased which reduced the contribution of the loss of instrument air and loss of A train DC initiating events. As the impact of loss of Train A DC is more significant to Unit 2 than it is to Unit 1 (see Section F.2.1.2.4), this change also reduced the difference in contribution to CDF from Transient events between the units.

F.2.1.2.6 Unit 1 and Unit 2 Level 1, Revision 2.2

The most recent major update to the Level 1 PRA models was the Rev. 2.2 model update.

Unit 1 Level 1 Rev. 2.2 Model

The Unit 1 Level 1 Rev. 2.2 model update incorporated a number of model upgrades and enhancements necessary for application of the model to the initial implementation of the Mitigating Systems Performance Index (MSPI) program in 2006, including closure of all remaining open Level B WOG Peer Certification Review findings. The most significant model improvements included:

- Minor updates to the fault tree models for several MSPI systems.
- Update to common cause failure (CCF) parameters using recent data and methodologies.
- Updates to plant and generic failure data, plant maintenance unavailability data, and initiating event frequencies.
- Inclusion of both quantitative and qualitative uncertainty analyses.

In addition, the initiating event frequency update reflected the installation of new steam generators for Unit 1. This change had relatively significant impact on the Level 1 results.

The contribution to core damage frequency (9.81E-06) due to initiating events shows that four initiators contribute 10% or more: Small LOCA – Loop A (25%), Small LOCA – Loop B (25%), Loss of Cooling Water (18%), and Loss of Offsite Power (11%).

The Small LOCA initiating events are the top contributors to the CDF due to their relatively high initiating event frequencies (relative to larger-break LOCAs) and the fact that both methods of mitigation of the event (either Reactor Coolant System (RCS) cool down and depressurization and initiation of RHR shutdown cooling, or transfer to low head Emergency Core Cooling System (ECCS) recirculation) requires operator action. Common cause failures (across both safeguards trains) of component cooling water pumps and valves, and RHR system pumps also are significant contributors to the top Small LOCA sequences.

The CL system (analogous to an emergency service water system at other PWRs) is very important to plant risk at PINGP. CL provides equipment heat removal support for operation of both the high and low pressure ECCS systems. Any event that results in loss of the CL system (a Loss of CL initiating event) also removes the backup means of providing RCP seal cooling. Therefore, on a Loss of CL initiator, failure of seal injection from the Chemical and Volume Control System (CVCS) charging pumps will result in an unrecoverable RCP seal LOCA.

Loss of offsite AC power is significant due to its relatively high frequency and reliance upon the site emergency diesel generators (EDGs) and their support systems. The EDGs are complex machines that have many subsystems and have relatively high random failure rates (compared to other plant components, i.e., motor-operated pumps or valves, etc.). Typically, core damage sequences following this initiating event are a result of an eventual station blackout (SBO) condition, subsequent RCP seal failures and resulting RCS leakage without makeup capability. In some cutsets, power may be lost on one train, and equipment fails on the energized train, causing a loss of a critical function. Credit is taken for recovery of offsite power based on industry experience with the duration of loss of offsite power events. PINGP has the ability to manually cross-tie same-train 4kV buses across units (from the control room), and the EDGs have the capability to handle the loads that would be expected during a dual-unit LOOP. In addition, the Unit 1 and Unit 2 EDGs have different designs and manufacturers, and require different systems for cooling. Therefore, the contribution due to SBO is not as significant at PINGP as at some other PWRs.

Unit 2 Level 1 Rev. 2.2 Model

The Unit 2 Level 1 Rev. 2.2 model update incorporated all of the model upgrades and enhancements described above for the Unit 1 model, including all of those necessary to implement the MSPI program for Unit 2 in 2006, and closure of all remaining open Level B WOG Peer Certification Review findings. The only significant difference between the update for Unit 1 and the update for Unit 2 was that the initiating event frequency update does not reflect an installation of new steam generators for Unit 2. Steam generator replacement is planned for Unit 2 in 2013.

Unit 1 and Unit 2 are near-mirror images of each other with respect to design and operation. Therefore, as expected, the Level 1 PRA results (CDF and contributions by initiating event) are very similar between the units. The contribution to core damage frequency (1.13E-05) due to initiating events shows that four initiators contribute 10% or more: Small LOCA – Loop A (21%), Small LOCA – Loop B (21%), Loss of Cooling Water (16%), and Loss of Offsite Power (10%). The discussion presented in this section of each of these top contributors to the Unit 1 CDF applies to the Unit 2 results as well.

The most significant asymmetries between the CDF results for Unit 1 and Unit 2 are in the contributions from the SGTR and Loss of Train A DC initiating events. The SGTR contribution for Unit 2 is significantly larger than it is for Unit 1 (10.0% of the total CDF vs. 2.0%, respectively), due to the fact that the steam generators in Unit 1 have undergone replacement recently while Unit 2 is still using its original steam generators. The Loss of Train A DC initiating event is more significant to the Unit 2 results (3.5% of the total CDF) than to the Unit 1 results (0.4% of the total CDF) due to the fact that DC control power for operation of the motor-driven Auxiliary Feedwater pump on Unit 2 is supplied from Train A, whereas control power for operation of the Unit 1 motor-driven AFW pump is supplied from Train B DC. Both units experience a reactor trip with loss of main feedwater on a loss of Train A DC (no loss of main feedwater on loss of Train B DC). Therefore, since AFW is required for secondary heat removal when main feedwater is lost, the Loss of Train A DC initiating event is more severe for Unit 2 than for Unit 1.

F.2.1.2.7 Unit 1 and Unit 2 Level 1, Revision 2.2 (SAMA)

The latest version of the Unit 1 and Unit 2 Level 1 PRA is the Rev. 2.2 model (SAMA). This was the version of the model used for the SAMA evaluation supporting this LRA submittal. For a discussion of the Level 1 Rev. 2.2 model (SAMA), see Section F.2.2.

F.2.1.3 Level 2 Model Revisions since the IPE

F.2.1.3.1 Level 2, Revision 1.0

Revision 1.0 of the Unit 1, Level 2 PRA model was completed in 1999, and was built upon the Level 1 Revision 1.0 model. In addition to the changes incorporated in the revision to the Level 1 model, the Level 2 update reflected credit for the potential for hot leg creep rupture phenomenon to facilitate vessel failure at low pressure for early core damage sequences and credit for a change to the emergency procedures that greatly reduced the risk from induced steam generator (SG) tube creep rupture events (these events were not modeled in the Revision 1.0 analysis). Also, credit for containment spray (CS) recirculation was removed from the model, since procedural guidance for operator initiation of the system in the EOPs was removed (based on a licensing-basis calculation that showed that containment pressure would be below the threshold requiring CS recirculation operation for any analyzed event after the RWST had reached low-low level).

The total release frequency (the frequency of core damage followed by containment failure) was calculated to be 8.8E-6/rx-yr, giving a conditional containment failure probability (CCFP) of approximately 38%.

The decline in the total release frequency was primarily due to the decline in the Level 1 CDF (from the Revision 0 to the Revision 1 analysis). The decline was slightly less than that seen in the CDF itself due to the relatively large CDF contribution to both measures from internal flooding events. The contribution of flooding events to the total release frequency remained relatively constant at about 35% (9E-6).

LERF was quantified for the Revision 1 Level 2 model. Early core damage sequences involving containment bypass (SGTR and interfacing system LOCA (ISLOCA) sequences) and containment isolation failure were considered to be those with the potential to produce a large early release. The calculated LERF was 3.8E-7/rx-yr. The contributors to the LERF by initiating event (sub-bullets provide a discussion of dominant sequences within these categories) were:

- ISLOCA (58% of LERF),
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction motor operated valves (MOVs) followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage. (41% of LERF),
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment. (17% of LERF);
- SGTR (15% of LERF),
    - SGTR followed by common cause failure of either the SI pumps (to start or run) or the RWST to SI suction MOVs to open, followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions. (14% of LERF); and
- Transient or LOCA core damage sequences followed by early containment failure (typically through hydrogen combustion) (25% of LERF),
    - AFW Pump/Instrument Air Compressor room internal flood (15% of LERF),
    - RCP seal LOCA involving loss of CL and Train A 4kV AC power (5% of LERF),
    - Loss of secondary heat sink with failure of operator action to perform bleed and feed operation (3% of LERF), and
    - Medium or large LOCA with failure of Emergency Core Cooling System (ECCS) recirculation (1% of LERF).
- Transient or LOCA core damage sequences followed by other early containment failure mechanisms (2% of LERF),

F.2.1.3.2 Level 2, Revision 1.1

No Level 2 or LERF model was developed with this designation (no update to the Level 2 models or to LERF was performed which used the Level 1, Revision 1.1 model as input). The basis for this was the nearly identical nature of the Revision 1.0 and Revision 1.1 Level 1 models, that is, no significant difference in the Level 2 results could exist based solely on the move to the Revision 1.1 model.

F.2.1.3.3 Level 2, Revision 1.2

A full Level 2 revision to correspond with the Level 1, Revision 1.2 model was not performed. However, the LERF results were updated based on the Level 1, Revision 1.2 model, and changes to the LERF calculation were made.

One change made to the Level 1 model incorporated in Revision 1.2 had a significant impact on the LERF results. The human error probability (HEP) for the failure of the operator to cool down and depressurize the RCS to shutdown cooling following a SGTR, originally a screening value with a very low probability, was increased by an order of magnitude. This change shifted the majority of the LERF contribution to SGTR sequences (from Interfacing System LOCA (ISLOCA) sequences).

Other than the changes to the underlying Level 1 model, the following changes were made to the LERF calculation itself:

1. Failure of containment isolation was modeled using a fault tree (FT) model for each unscreened containment penetration from the previous analysis. The previous LERF analysis used a point value estimate for the failure of containment isolation.

2. Core damage sequences involving early containment failure but without containment bypass (from the full Level 2 analysis) were excluded from the LERF result. As stated previously, a full Level 2 model update based on the Level 1 Revision 1.2 model was not performed. In addition, these sequences had been conservatively added to the LERF calculation in the absence of certainty about whether they met an industry standard definition of large, early release that was still in development. The American Society of Mechanical Engineers (ASME) PRA Standard defines a large early release as “the rapid, unmitigated release of airborne fission products from the containment to the environment occurring before the effective implementation of offsite emergency response and protective actions” (ASME 2005). Under this definition, it is not clear that these early containment failure sequences actually would lead to large early releases, since containment is not directly bypassed. The IPE source term analysis showed only the containment bypass events (induced-SGTR, ISLOCA) to result in the highest releases of volatile (non-noble gas) radionuclides.

SGTR events also involved large releases of volatiles, but was considered to be a late release. Containment isolation failure sequences involved early releases but the magnitude of the volatiles was categorized as medium. Also, the majority of these sequences were assumed to lead to early containment failure due to very conservative treatment of the hydrogen combustion phenomenon. However, position papers created for the IPE conclude that, even assuming worst-case hydrogen production conditions post core damage, pressures developed within the containment following a detonation of the hydrogen would not approach the ultimate failure pressure of the containment shell itself.

Evidence also exists that ignition sources energetic enough for detonation of the hydrogen do not exist within the containment. Even if containment failure were to occur by this mechanism, it is likely that the timing of the failure would be later than that specified in the LERF definition (time for implementation of protective action recommendations from the emergency plan response would be available due to the additional time required to pressurize containment to its ultimate failure pressure).

Therefore, the non-bypass early containment failure sequences were excluded from the LERF calculation (SGTR and containment isolation failure sequences were left in).

The calculated LERF for Revision 1.2 was 6.9E-7/rx-yr. The contributors to the LERF by initiating event were (sub-bullets provide a discussion of dominant sequences within these categories):

- SGTR (87% of LERF),
  - SGTR followed by common cause failure of either the SI pumps (to start or run) or the RWST to SI suction MOVs to open, followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions. (69% of LERF);
- ISLOCA (13% of LERF),
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment. (9% of LERF),
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage. (4% of LERF); and
- Other core damage sequences followed by failure of containment isolation (<1 % of LERF)

F.2.1.3.4 <u>Level 2, Revision 2.0</u>

A full Level 2 revision to correspond with the Level 1, Revision 2.0 model was not performed. However, the LERF results were updated based on the Level 1, Revision 2.0 model, and changes to the LERF calculation were made.

One change made to the Level 1 model incorporated in Revision 2.0 had a significant impact on the LERF results. The removal of the BAST as a supply source to the SI pump suction logic significantly reduced the contribution of the SGTR event to the LERF result.

Other than the changes to the underlying Level 1 model, the following changes were made to the LERF calculation itself:

- The containment isolation failure logic modeling (gate 1CIF and 2CIF) was expanded to include catastrophic leakage from the equipment hatch door, the fuel transfer tube, and open personnel or maintenance airlock doors.

The calculated LERF for the Unit 1 Revision 2.0 was 3.88E-7/rx-yr. The contributors to the LERF by initiating event were (sub-bullets provide a discussion of dominant sequences within these categories):

- SGTR (76% of LERF),
    - o STGR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions. (28% of LERF);
- ISLOCA (23% of LERF),
    - o Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment. (11% of LERF),
    - o Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage. (7% of LERF); and
- Other core damage sequences followed by failure of containment isolation (1% of LERF)

The calculated LERF for Unit 2 Revision 2.0 was 3.90E-7/rx-yr. The contributors to the LERF by initiating event were (sub-bullets provide a discussion of dominant sequences within these categories):

- SGTR (76% of LERF),

- STGR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions. (28% of LERF);

- ISLOCA (23% of LERF),
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment. (11% of LERF),
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage. (7% of LERF); and
- Other core damage sequences followed by failure of containment isolation (1% of LERF)

F.2.1.3.5 Level 2, Revision 2.1

A full Level 2 revision to correspond with the Level 1, Revision 2.1 model was not performed. However, an update to the LERF results based on the Level 1, Revision 2.1 model was performed. Other than the changes to the underlying Level 1 model, there were no changes made to the LERF model.

The calculated LERF for the Unit 1 Revision 2.1 was 5.74E-7/rx-yr. The contributors to the LERF by initiating event were (sub-bullets provide a discussion of dominant sequences within these categories):

- SGTR (54% of LERF),
    - STGR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions; and
- ISLOCA (45% of LERF),
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage, and
    - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment.
- Other core damage sequences followed by failure of containment isolation (<1% of LERF)

The resulting LERF is higher than the Revision 2.0 model because the HRA updates for the Revision 2.1 model resulted in a higher failure probability for the operator actions to cool down and depressurize the RCS. This resulted in a higher contribution from the ISLOCA sequences, and consequentially a higher LERF value.

The calculated LERF for the Unit 2 Revision 2.1 was 5.74E-7/rx-yr. The dominant contributors to the LERF were:

- SGTR (54% of LERF),
  - STGR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions; and
- ISLOCA (45% of LERF),
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage, and
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment.
- Other core damage sequences followed by failure of containment isolation (<1% of LERF)

The resulting LERF is higher than the Revision 2.0 model because the recent HRA updates for the Revision 2.1 model resulted in a higher failure probability for the operator actions to cooldown and depressurize the RCS. This resulted in a higher contribution from the ISLOCA sequences and consequentially, a higher LERF value.

F.2.1.3.6 Level 2, Revision 2.2

A full Level 2 revision to correspond with the Level 1, Revision 2.2 model was not performed. However, an update to the LERF results based on the Level 1, Revision 2.1 model was performed. Other than the changes to the underlying Level 1 model, there were no changes made to the LERF model.

The calculated LERF for the Unit 1 Revision 2.2 was 5.14E-8/rx-yr. The dominant contributors to the LERF were:

- ISLOCA (63% of LERF),
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve

  and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment, and
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage.

- SGTR (34% of LERF),
  - STGR followed by common cause failure of the CC pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions; and
  - STGR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions
- Other core damage sequences followed by failure of containment isolation (3% of LERF)

The resulting LERF is lower than the Revision 2.1 model because the several factors including a decrease in the SGTR frequency to account for the new steam generator installation. In addition, the Rev 2.2 model updated the component failure rates and common cause factors which resulted in a decrease in the failure rate associated with catastrophic leaks on containment penetration motor valves, and common cause multipliers associated with the RHR heat exchanger cooling water supply motor valves, RHR pumps and SI pumps, and Containment Isolation (CI) control valves. These components are important for mitigating LERF consequences.

The calculated LERF for the Unit 2 Revision 2.2 was 1.35E-7/rx-yr. The dominant contributors to the LERF were:

- SGTR (75% of LERF),
  - SGTR followed by common cause failure of the SI pumps (to start or run), followed by operator failure to cool down and depressurize the RCS to RHR shutdown cooling conditions; and
- ISLOCA (24% of LERF),
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs followed by operator failure to cool down and depressurize the reactor to limit RHR pump seal leakage, and
  - Catastrophic rupture or transfer open of two series RHR Hot Leg Suction MOVs, or rupture of two series SI injection check valves, or one SI injection check valve and the RHR shutdown cooling isolation MOV, followed by rupture of the low pressure RHR piping outside containment.
- Other core damage sequences followed by failure of containment isolation (1% of

LERF)

The resulting LERF is lower than the Revision 2.1 model because of several factors, including a decrease to the SGTR frequency due to an updated Bayesian analysis. In addition, the Rev 2.2 model updated the component failure rates and common cause factors which resulted in a decrease in the failure rate associated with catastrophic leaks on containment penetration motor valves, and common cause multipliers associated with the RHR heat exchanger cooling water supply motor valves, RHR pumps and SI pumps, and Containment Isolation (CI) control valves. These components are important for mitigating LERF consequences.

The most significant asymmetry between the LERF results for Unit 1 and Unit 2 is in the contribution from the SGTR initiating event. The SGTR contribution is significantly larger for Unit 2 than it is for Unit 1 (75% of the total LERF vs. 34%, respectively), due to the fact that the steam generators in Unit 1 have undergone replacement recently while Unit 2 is still using its original steam generators.

F.2.1.3.7 Level 2, Revision 2.2 (SAMA)

The current version of the Unit 1 and Unit 2 Level 2 PRA is the Rev. 2.2 model (SAMA). This revision, an update of the full Level 2 analysis, was the version of the model used for the SAMA evaluation supporting this LAR submittal. For a discussion of the Rev. 2.2 Level 2 model (SAMA), see Section F.2.3.

F.2.2 PINGP Level 1 PRA Model

The SAMA analysis is based on the PINGP Level 1 PRA Model of Record developed in 2006 (Rev. 2.2). As described in Section F.2.1.2.6, this model includes the changes and analysis that were required to support the Unit 1 steam generator replacement that occurred in 2004. In addition, all Level A and B Westinghouse Peer Certification comments (F&Os) have been dispositioned and those requiring model and/or documentation changes have been addressed with the issuance of this model.

In addition to the Level 1, Rev. 2.2 changes described in Section F.2.1.2.6, two additional changes were made to support the SAMA analysis (described in Sections F.2.2.1 and F.2.2.2). The Level 1 PRA model used for the SAMA evaluation is called the “Rev. 2.2 (SAMA)” model.

F.2.2.1 Unit 1, Level 1 Rev. 2.2 (SAMA)

The latest version of the Unit 1 Level 1 PRA is the Rev. 2.2 model (SAMA). This was the version of the model used for the SAMA evaluation supporting this LRA submittal. This model included one model correction that had a slight impact on Unit 1 CDF (final CDF decreased approximately 2E-8/yr, to 9.79E-6/yr). The correction was made to the Level 1 core damage sequence success logic for the Small LOCA event. As a result, a small number of illogical cutsets (previously retained) were deleted in the CDF metric for the SAMA model quantification.

The changes for Unit 1 only slightly alter the core damage frequency results by initiating event from that described for the Rev. 2.2 model in Section F.2.1.2.6. Four initiators contribute 10% or more: Small LOCA – Loop A (25%), Small LOCA – Loop B (25%), Loss of Cooling Water (18%), and Loss of Offsite Power (11%). This is shown graphically in Figure F.2-1.

The balance of the discussion provided in Section F.2.1.2.6 is also representative of the SAMA model results for Unit 1.

F.2.2.2 Unit 2, Level 1 Rev. 2.2 (SAMA)

The latest version of the Unit 2 Level 1 PRA is the Rev. 2.2 model (SAMA). This was the version of the model used for the SAMA evaluation supporting this LRA submittal. In addition to the model correction described above for Unit 1 (Section F.2.2.1), this model included one additional correction that had a slight impact on Unit 2 CDF (final CDF increased approximately 8E-7/yr, to 1.21E-5/yr).

The changes for Unit 2 only slightly alter the core damage frequency results by initiating event from that described for the Rev 2.2 model in Section F.2.1.2.6. Four initiators contribute 10% or more: Small LOCA – Loop A (22%), Small LOCA – Loop B (22%), Loss of Cooling Water (15%), and Loss of Offsite Power (10%). On Unit 2, the SGTR initiating events for Loop A (5%) and Loop B (5%) (together) also contribute 10% to the CDF. This is shown graphically in Figure F.2-2. The balance of the discussion provided in Section F.2.1.2.6 above is also representative of the SAMA model results for Unit 2.

Note that, at the time of the Rev. 2.2 model update, containment sump strainer modifications to address G.L. 2004-02 on Unit 2 had not been completed. These modifications have now been completed. Section F.7.4 discusses the results of an analysis to address the sensitivity of the SAMA results to this plant configuration change.

F.2.3 PINGP Level 2 PRA Model

The SAMA analysis is based on the PINGP Level 2 PRA Model of Record (Level 2 Revision 2.2 (SAMA)) that was developed in 2006. This model is an update of the Level 2, Rev. 1 model performed in 1999, and incorporates changes and analysis that were required to support the Level 1 Rev. 2.2 (SAMA) model updates. In addition, all PINGP Level A and B PRA model Westinghouse Peer Certification comments (F&Os) have been dispositioned and those requiring model and/or documentation changes have been addressed with the issuance of this model.

The containment response analysis (Level 2) evaluates the best estimate performance of the containment during a severe accident. The status of the containment safeguards systems is modeled to account for the effects of containment cooling and isolation. This model accounts for core damage sequences that cause a direct bypass of containment, such as a SGTR or inter-system LOCA. The design pressure of the PINGP containment is 46 psig, but based on a probabilistic evaluation of the containment structure, the mean expected failure pressure is 150 psig (165 psia). The 5% lower bound and 95% upper bound failure pressures are 136 psia and 191 psia, respectively. Thus the containment is relatively robust against failure due to overpressure.

The dynamic response to core debris expulsion as it is transported through the vessel cavity and through other containment compartments is analyzed to estimate the effects of direct containment heating and subsequent containment pressurization. Other severe accident effects, such as hydrogen generation and ignition are evaluated as to their likelihood in each sequence. The Level 2 analysis is used to predict the ability of the containment to mitigate severe accident challenges and, in the case of failure, to predict the timing of containment failure and subsequent radionuclide release for each release category.

As is typical of most large dry containments, the PINGP containment is robust against severe accident challenges, such as hydrogen burns and the effects of high pressure melt ejection. These failure mechanisms are calculated to produce pressure increases within the capability of the PINGP containment structure, and so are not likely to cause containment failure.

It is important to define a special group of release categories where the radionuclide release from the containment would occur prior to the initiation of evacuation planning and is of such a magnitude that the potential for some measurable health effects cannot be precluded. This variety of release is typically measured by the LERF. A large early release from the containment can occur from containment breach due to containment failure at the time of reactor vessel break or a bypass of containment due to such events as a steam generator tube rupture (SGTR), ISLOCA, or containment isolation failure. Typically it involves the rapid, unscrubbed release of airborne aerosol fission products to the environment with core damage occurring, or a containment failure pathway of sufficient size to release the contents of the containment within one hour, which occurs before or within 4 hours of vessel breach. One definition of LERF proposed in NUREG/CR-6595 is the “frequency of early failure and bypass containment failure modes that have a release fraction of iodine equal to or greater than about 10%”. Based on MAAP source term analysis for PINGP, the only release categories that meet these requirements include core damage with containment bypass scenarios (SGTR and ISLOCA). Pressure- and temperature-induced SGTR sequences are included in the LERF definition, but SGTR sequences that leads to late core damage following SG overfill are not included due to the long time available prior to depletion of the RWST and core uncovery. In addition to these scenarios, PINGP includes the frequencies of containment isolation failure release categories in the definition of LERF, as they represent scenarios involving core damage with early containment bypass.

F.2.3.1 Unit 1, Level 2 Rev. 2.2 (SAMA)

The large early release frequency (LERF) for unit 1 is calculated to be 8.79E-8 per year. Like the CDF, this numeric measure is used when applying the PRA results by evaluating relative changes, and together with CDF, are the two primary "risk metrics" used in describing PRA quantification results.

The dominant contributors to the LERF by initiating event were ISLOCA (36.7%), Small LOCAs (25.4%), and SGTR (18.5%). This is shown graphically in Figure F.2-3. The Small LOCA initiating event category (the dominant Level 1 initiator category) is more significant in the Rev. 2.2 SAMA model LERF analysis due to inclusion of induced SGTR modeling as an additional LERF contributor in this update. The balance of the discussion provided in Section F.2.1.3.6 is also representative of the SAMA model LERF results for Unit 1. The LERF must be understood in context of the overall Level 2 results. The conditional containment failure probability (CCFP) for Unit 1 is 0.26. This equates to a containment success probability of 0.74. Figure F.2-5 summarizes the contribution of the containment failure modes to the Unit 1 CCFP. Early containment bypass failures, occurring near the time of core damage and reactor vessel failure, and resulting in large fission product releases, represent only about 3% of the CCFP. Other non-bypass but early containment failure release classes make up only an additional 2% of the CCFP. Late containment bypass from slow developing SGTR scenarios (release category GLH) make up about 7% of the CCFP. The large majority of containment failure sequences are late failures that involve a significant time delay between core damage and containment failure of up to several days. Significant time is available to implement emergency measures to protect the public for the most likely severe accident scenarios (>90% of core damage sequences), significant time is available to implement emergency measures to protect the public. The amount of time available to implement emergency measures is significant when evaluating plant conditions using Level 2 results. For cases involving late failure of containment, the dominant cause of containment breach involves core damage sequences that end with the RWST being depleted and no long-term decay heat removal mechanism available. For these sequences, the containment fails due to gradual overpressure of the containment due to steam and non-condensable gas generation. Another significant cause of late containment failure is basemat failure resulting from long-term (greater than 3 days) concrete ablation by molten core material.

F.2.3.2 Unit 2, Level 2 Rev. 2.2 (SAMA)

The Unit 2 large early release frequency (LERF) is calculated to be 1.75E-7 per year. The Unit 2 LERF is larger than the Unit 1 LERF by about a factor of 2, primarily due to the assumed slightly higher potential for a SGTR initiating event on Unit 2. The Unit 1 steam generator replacement project was completed in 2004, while the Unit 2 steam generator replacement is planned for 2013.

The dominant contributors to the LERF by initiating event were SGTR (56.4%), ISLOCA (18.4%) and Small LOCAs (14.4%). This is shown graphically in Figure F.2-4. The Small LOCA initiating event category (the dominant Level 1 initiator category) is more significant in the Rev. 2.2 SAMA model LERF analysis due to inclusion of induced SGTR modeling as an additional LERF contributor in this update. The balance of the discussion provided in Section F.2.1.3.6 is also representative of the SAMA model LERF results for Unit 2.

The conditional containment failure probability (CCFP) for Unit 2 is 0.30. This equates to a containment success probability of 0.70. Figure F.2-6 summarizes the contribution of the containment failure modes, which make up the Unit 2 CCFP. The fraction of the CCFP from early containment bypass failures, about 5%, is slightly higher than for Unit 1 due to the higher SGTR initiating event frequency on Unit 2. The higher SGTR initiating event frequency for Unit 2 results also in a significantly larger fraction of the CCFP associated with late containment bypass sequences (28% vs. 7% for Unit 1). The remaining portion of the late containment failure results are similar to that discussed above for Unit 1.

F.2.4 PINGP Level 2 Release Categories

The solution of the numerous event trees results in the generation of a large number of accident sequences. Once developed, the accident sequences must be propagated through the containment safeguards assessment and the containment event tree to develop release categories. To reduce the burden on the analyst, the accident sequences can be grouped, commonly referred to as binning, into accident sequence categories.

The method of binning the accident sequences is much like that used to categorize the transient initiating events. A set of parameters is identified that can be used to define unique accident sequence classes. These parameters are typically defined based on the needs of the containment analysis. For example, one parameter commonly used in the binning process is the RCS pressure (high or low) at the time of core damage. The RCS pressure parameter is critical in the progression of potential Level 2 containment accident sequences. For example, a high pressure core melt sequence was defined as the primary system pressure being high enough to entrain the core debris out of the cavity upon vessel failure. A low pressure sequence was defined as the primary system pressure being low enough at vessel failure for the core debris to be retained in the cavity. This parameter, therefore, is typically chosen for binning accident sequences. Once the important parameters are identified the next step is to determine the physically possible combinations of the parameters. Each combination of the parameters defines an accident class or core damage bin (CDB).

Once the CDBs are finalized, the Level 1 event tree accident sequences are assigned to them by comparing the CDB parameters and the cutsets that comprise the specific accident sequences.

CDB information must be combined with the status of the containment safeguards systems to develop a complete accident sequence definition for containment assessment. This is done in the Containment Event Trees (CETs). The CETs provide a means for interfacing the core damage (Level 1) model with the containment safeguards functions, and the containment phenomenological processes. The CETs address the status of the containment systems to complete the system-level information needed by the Level 2 PRA analyst. The status of the containment systems is important in determining containment pressure challenges, source term composition, and other physical parameters associated with the Level 2 PRA. Additionally, the use of a CET that incorporates fault tree and event tree models allows the core damage sequence cutsets to be linked directly to the CET. The direct linking of the system model results in containment and core safety system dependencies being identified and explicitly addressed.

The CETs provide a convenient method to identify the various possible outcomes resulting from different combinations of CDBs, containment systems status, and containment phenomenological effects. The CET sequences are solved to determine the conditional probabilities for each CET outcome, each of which are mapped to specific release categories. Each of the release categories are given 4-letter designations identifying whether or not the reactor pressure vessel failed and at what pressure, whether or not the containment failed and by what mechanism, and timing of containment failure (if it occurred). Summing all the CET sequence frequencies for a release category class determines the frequency for that release category.

The CET end states correspond to the outcome of possible severe accident sequences. Each end point defines a different containment state with an associated radionuclide release. Simplifications can be attained by grouping sequences with similar release characteristics into release categories (at PINGP the CET end states and the release categories have similar 4-letter designators, although some release categories are considered bounding for other categories with respect to source term). A set of bounding release categories is defined such that all accidents assigned to the same category are assumed to have the same set of release fractions.

The main characteristics used to define the release categories are release energy, containment isolation failure size, timing of the release, and isotopic consumption.

Specific Modular Accident Analysis Program (MAAP) sequences were developed to mimic CET end states and the estimated releases determined. Like CET end states were grouped to minimize the number of MAAP sequences required. The MAAP code outputs fission product data which is used to group similar sequences according to time of release and radionuclide release. Of the 18 release categories, including 3 release categories in which the containment has remained intact (release of fission products is through containment leakage only), 10 bounding categories for source term analysis were identified.

The following paragraphs define each release category and related assumptions are defined in the following subsections. In addition, those release categories that were grouped with other, bounding categories for source term analysis are identified (note that those release categories calculated to have near-zero frequencies of occurrence are not discussed separately below).

F.2.4.1 Containment Intact (Release Categories X-XX-X, L-XX-X, H-XX-X)

These release categories represent the accident sequences in which the containment remains intact. The source term for this type of sequence is very small and limited to the containment design leakage rate. Category H-XX-X was selected as the bounding category and a representative sequence was chosen from that category for X-XX-X, L-XX-X and H-XX-X source term analysis. The total baseline frequency for these release categories is 7.28E-06/yr for Unit 1 and 8.52E-06/yr for Unit 2.

F.2.4.2 Release Category L-CC-L

This release category includes core damage sequences that are not arrested in-vessel (the core goes ex-vessel at low reactor pressure) and ex-vessel injection to quench the debris in the reactor cavity fails. Containment failure on overpressure occurs as a result of basemat penetration from core concrete interaction. The total baseline frequency for this release category is 2.82E-07/yr for Unit 1 and 3.39E-07/yr for Unit 2.

F.2.4.3 Release Category L-CI-E

This release category includes core damage sequences where the reactor vessel fails at low reactor pressure, with failure of containment isolation. Core damage from small LOCA sequences with failure of ECCS injection or recirculation dominates this release category. Successful hot leg creep rupture allows the debris to exit the vessel at low pressure. The release from the containment is scrubbed by either the containment sprays or a pool of water over the core debris. The total baseline frequency for this release category is 1.85E-10/yr for both Unit 1 and Unit 2.

F.2.4.4 Release Category L-DH-L

This release category includes core damage sequences in where the reactor vessel fails at low reactor pressure, with overpressure failure of containment due to steam generation and failure of containment pressure control (failure of containment fan coil units or ECCS recirculation to remove decay heat). Core damage from RCP seal LOCA sequences with failure of ECCS recirculation dominates this release category. Successful hot leg creep rupture allows the debris to exit the vessel at low pressure. The release from the containment is scrubbed by either containment spray or a pool of water over the core debris. The total baseline frequency for this release category is 1.92E-06/yr for Unit 1 and 1.97E-06/yr for Unit 2.

F.2.4.5 Release Category L-H2-E

This release category is similar to release category L-DH-L, except that the containment fails from early containment failure modes such as hydrogen combustion or in-vessel steam explosion with the reactor at low pressure. Core damage from RCP seal LOCA or small LOCA sequences with failure of ECCS recirculation dominates this release category. The total baseline frequency for this release category is 2.23E-08/yr for Unit 1 and 2.49E-08/yr for Unit 2.

F.2.4.6 Release Category H-DH-L

This category is similar to L-DH-L, except that hot leg creep rupture is not successful and the core debris exits the vessel at high pressure. Containment fails very late on overpressure due to steam generation and failure of containment pressure control (failure of containment fan coil units and ECCS recirculation to remove decay heat). The total baseline frequency for this release category is 3.09E-08/yr for Unit 1 and 3.14E-08/yr for Unit 2.

F.2.4.7 Release Category H-H2-E

This release category includes core damage sequences in where the reactor vessel fails at high reactor pressure, with overpressure failure of containment from early containment failure modes such as hydrogen combustion. ECCS injection is not successful for these sequences, and hot leg creep rupture does not successfully depressurize the reactor prior to vessel failure. The total baseline frequency for this release category is 2.32E-11/yr for both Unit 1 and Unit 2.

F.2.4.8 Release Category H-OT-L

This release category includes core damage sequences in which the reactor vessel fails at high reactor pressure, with late overtemperature or overpressure failure of containment due to inability to cool debris that may have relocated to the upper parts of containment. Neither ECCS injection nor RWST injection to the containment through containment spray is available throughout this scenario. The total baseline frequency for this release category is 4.89E-09/yr for Unit 1 and 5.87E-09/yr for Unit 2.

F.2.4.9 Release Category X-CI-E

This release category includes core damage sequences where containment isolation fails, but the reactor vessel does not fail (core damage is arrested in vessel due to successful ex-vessel cooling), leading to a lower source term than the other containment isolation failure release categories. The source term for this category is bounded by the L-CI-E case. The total baseline frequency for this release category is 6.55E-10/yr for Unit 1 and 7.32E-10/yr for Unit 2.

F.2.4.10 Release Category X-H2-E

This release category is similar to category L-H2-E, except that the reactor vessel does not fail (core damage is arrested in vessel due to successful ex-vessel cooling). The source term for this category is bounded by the L-H2-E case. The total baseline frequency for this release category is 3.39E-8/yr for Unit 1 and 4.03E-8/yr for Unit 2.

F.2.4.11 Release Category GEH

This release category involves core damage sequences due to SGTR with failure of high pressure injection from the Refueling Water Storage Tank (RWST). This results in early core damage at high pressure, with containment bypass. As these sequences bypass containment and occur early (prior to successful implementation of protective action recommendations), the frequency of this release category is considered to be a component of the LERF (large early release frequency). The source term for this category is bounded by the SGTR case. The total baseline frequency for this release category is 1.63E-8/yr for Unit 1 and 9.87E-8/yr for Unit 2.

F.2.4.12 Release Category GLH

This release category involves core damage sequences due to SGTR with successful high pressure injection from RWST, but failure of ruptured SG isolation, or SG overfill, followed by failure of alternative actions to cool down and depressurize the RCS results in late core damage at high reactor pressure, with containment bypass. Core damage is delayed for hours during this event due to the long time available prior to RWST depletion. The source term for this category is bounded by the SGTR case. The total baseline frequency for this release category is 1.78E-7/yr for Unit 1 and 1.03E-6/yr for Unit 2.

F.2.4.13 Release Category L-SR-E

This release category involves core damage sequences due to Pressure- or Temperature-Induced SGTR. These sequences involve high RCS pressure with at least one dry, depressurized SG leads to failure of the SG tubes and assumed containment bypass. This may result in a short-duration release, terminated when the steam generator relief valves reseat. However, assuming that the relief valves do not reseat, the source term is similar to the SGTR release category GEH. The frequency of this release category is considered to be a component of the LERF. The total baseline frequency for this release category is 3.85E-8/yr for Unit 1 and 4.34E-8/yr for Unit 2.

F.2.4.14 Release Category ISLOCA

This release category involves core damage sequences due to interfacing system LOCA (ISLOCA). ISLOCA results in loss of RCS inventory and failure of ECCS systems for makeup and/or recirculation, and ultimately core damage (assumed to be at high pressure) with containment bypass. Core damage and vessel failure are assumed to occur within one hour. Although the release is into the Auxiliary Building it is assumed to be essentially unscrubbed. The frequency of this release category is considered to be a component of the LERF. The total baseline frequency for this release category is 3.22E-8/yr for both Unit 1 and Unit 2.

F.3 LEVEL 3 PRA ANALYSIS

This section addresses the critical input parameters and analysis of the Level 3 portion of the probabilistic risk assessment. In addition, Section F.7.3 summarizes a series of sensitivity evaluations to potentially critical parameters.

F.3.1 Analysis

The MACCS2 code (NRC 1998) is used to perform the Level 3 PRA for the Prairie Island Nuclear Generating Plant. PINGP site specific parameters are used for population distribution and economic parameters using the NRC endorsed SECPOP2000 code (NRC 2003). Plant-specific release data included the time-dependent distribution of nuclide releases and release frequencies. The behavior of the population during a release (evacuation parameters) is based on plant decisions and when certain site-specific setpoints are reached. Other input parameters given with “Sample Problem A” from the MACCS2 manual formed the basis for the present analysis. These data are used in combination with site-specific meteorology to simulate the probability distribution of impact risks (both exposures and economic effects) to the surrounding 50-mile radius population as a result of the release accident sequences at PINGP.

Note regarding errors with the SECPOP2000 code: During performance of the PINGP analysis, three SECPOP2000 code errors were publicized, specifically: 1) incorrect column formatting of the output file, 2) incorrect 1997 economic database file end character resulting in the selection of data from wrong counties, and 3) gaps in the 1997 economic database numbering scheme resulting in the selection of data from wrong counties. All three errors have been addressed in the PINGP analysis (via industry-developed formatting fixes) such that selection of proper counties by SECPOP2000 has been confirmed and the MAACS2 outputs used to quantify MMACR have been verified to be correct.

F.3.2 Population

The population surrounding the PINGP site is estimated for the year 2034.

Population projections within 50 miles of PINGP are determined using SECPOP2000, (NRC 2003) utilizing a geographic information system (GIS). U.S Census block-group level population data is allocated to each sector based on the area fraction of the census block-groups in that sector. U.S. Census data from 1990 and 2000 are used to determine a ten year population growth factor for each of the 50-mile radius rings. The population growth factor for each ring is applied uniformly to all sectors in the ring to calculate the year 2034 population distribution.

Population distributions are given at distances to 1, 2, 3, 4, 5, 10, 20, 30, 40 and 50 miles from the plant and in the direction of each of the 16 compass points (i.e., N, NNE, NE……NNW).

The total year 2034 population estimate for the 160 sectors (10 distances × 16 directions) in the region is provided in Table F.3-2. The ten year population growth factor (in parenthesis) and distribution of the population is given for the 10-mile radius from PINGP and for the 50-mile radius from PINGP in Tables F.3-1 and F.3-2, respectively.

F.3.3 Economy

MACCS2 requires certain economic data (fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from dairy production, and property value of farm and non-farm land) for each of the 160 sectors. These values are calculated using the SECPOP2000 code (NRC 2003). SECPOP2000 utilizes economic data from the U.S. Department of Agriculture, "1997 Census of Agriculture" (USDA 1998) and from other 1998 and 1999 data sources. Economic values for up to 97 economic zones are calculated and allocated to each of the 160 sectors.

In addition, generic economic data that are applied to the region as a whole are revised from the MACCS2 sample problem input when better information is available. These revised parameters include per diem living expenses (applied to owners of interdicted properties and relocated populations), relocation costs (for owners of interdicted properties), and value of farm and non-farm wealth. These values are updated to the year 2006 value using the Consumer Price Index ratio.

PINGP MACCS2 economic parameters are listed on next page:

PINGP MACCS2 Economic Parameters

Variable	Description	PINGP Value
DPRATE[1]	Property depreciation rate (per yr)	0.2
DSRATE[1]	Investment rate of return (per yr)	0.12
EVACST[2]	Daily cost for a person who has been evacuated ($/person-day)	48.72
POPCST[2]	Population relocation cost ($/person)	9022.00
RELCST[2]	Daily cost for a person who is relocated ($/person-day)	48.72
CDFRM0[2]	Cost of farm decontamination for various levels of decontamination ($/hectare)	1015.00[4] 2256.00[4]
CDNFRM[2]	Cost of non-farm decontamination per resident person for various levels of decontamination ($/person)	5413.00[4] 14435.00[4]
DLBCST[2]	Average cost of decontamination labor ($/man-year)	63155.00
VALWF0[3]	Value of farm wealth ($/hectare)	2469.00
VALWNF[3]	Value of non-farm wealth ($/person)	130602.00

(1) DPRATE and DSRATE are based on NUREG/CR-4551 value (NRC 1990).
(2) These parameters for PINGP use the NUREG/CR-4551 value (NRC 1990), updated to the 2006 CPI value.
(3) VALWF0 and VALWNF are based on SECPOP2000 values for PINGP, updated to the 2006 CPI value.
(4) A value is provided for each level of the two levels of decontamination modeled. Two levels of decontamination is consistent with Sample Problem A.

F.3.4 Food and Agriculture

Food ingestion is modeled using the new MACCS2 ingestion pathway model COMIDA2 (NRC 1998a), consistent with Sample Problem A. The COMIDA2 model utilizes national based food production parameters derived from the annual food consumption of an average individual such that site specific food production values are not utilized. The fraction of population dose due to food ingestion is typically small compared to other population dose sources. For PINGP, approximately less than one percent of the total population dose is due to food ingestion.

F.3.5 Nuclide Release

MACCS2 requires input for 60 radionuclide. The core inventory at the time of the accident is based on a plant specific calculation and results provided in the PINGP USAR. PINGP USAR Appendix D, Rev. 18 Table D.1-1 provides the core inventory for 20 significant nuclides that correspond to MACCS2. The core inventory corresponds to end-of-cycle values (core average exposure of 50,000 MWD/MTU) for the PINGP core. Additional core inventory for the remaining 40 nuclides is obtained from MACCS2 Sample Problem A (NRC 1998a). The values for these 40 nuclides are adjusted to account for the PINGP power level (as compared to the Sample Problem A core power level). In addition, these values are increased by a factor of 1.39, which is the average increase of the PINGP 20 nuclides compared to those provided in Sample Problem A. Table F.3-3 provides a comparison of the MACCS2 PINGP core inventory and the Sample Problem A core inventory (as adjusted to account for the PINGP power level).

PINGP nuclide release categories are related to the MACCS categories as shown in Table F.3-4. All releases are modeled as occurring at a height of 62 meters (204'-4½") above grade elevation, which coincides with the top of the Containment Building (NMC 2007). The thermal content of each of the releases are assumed to be 1.0E+07 watts based on values provided in Sample Problem A and NUREG/CR-4551 (NRC 1990).

Two nuclide release sensitivity cases were performed to determine the effect of release height and thermal content assumptions. One sensitivity case modeled the releases occurring at ground level (0.0 meters). The second sensitivity case modeled the thermal content of each release to be the same as ambient (i.e., buoyant plume rise is not modeled). The results are discussed in Section F.7.3.4.

A final aspect to consider is the magnitude and timing of the radionuclide releases. Multiple release duration periods were defined which represented the time distribution of each category's releases. Release inventories of each of the multiple chemical forms of the cesium (Cs) and tellurium (Te) releases were available from the MAAP code output. Representative MAAP cases for each of the release categories were chosen based on a review of the Level 2 model cutsets and the dominant types of scenarios that contributed to the results. A brief description of each of those MAAP cases is provided in Table F.3-5, and a summary of the release magnitude and timing for those cases is provided in Table F.3-6.

F.3.6 Evacuation

A reactor scram (automatic shutdown) signal begins each evaluated accident sequence. A General Emergency is declared when plant conditions degrade to the point where it is judged that there is a credible risk to the public. Therefore, the timing of the General Emergency declaration is sequence specific and ranges from 42 minutes to 24.1 hours for the release sequences evaluated.

The MACCS2 User's Guide input parameters of 95 percent of the population within 10 miles of the plant [Emergency Planning Zone (EPZ)] evacuating and 5 percent not evacuating are employed. These values have been used in similar studies (e.g., Hatch (SNOC 2000) and Calvert Cliffs (BGE 1998)) and are conservative relative to the NUREG-1150 study, which assumed evacuation of 99.5 percent of the population within the EPZ. The evacuees are assumed to begin evacuating 90 minutes after a General Emergency has been declared and are evacuated at an average radial speed of 3.35

miles per hour (1.5 m/sec). This speed is the time weighted value accounting for season, day of the week, time of day, weather conditions, and special events. The evacuation time weighted average of 268 minutes is for the full 0-10 mile EPZ, an assumed 15 minute notification time, 15 minutes for evacuation preparation, and 60 minutes average departure time. (TCDS 2003)

One evacuation sensitivity case was performed to determine the impact of evacuation assumptions. The sensitivity case reduced the evacuation speed by a factor of two (to 0.75 m/sec), resulting in a total evacuation time that exceeded the longest evacuation time used for the PINGP evacuation analysis. The results are discussed in Section F.7.3.3.

F.3.7 Meteorology

Annual PINGP meteorology data from year 2003 is used in MACCS2 for the base case results. The year 2003 meteorological data set is utilized for the PINGP base case MACCS2 analysis based on the fact that the year 2003 provided the most complete data set, the highest population dose risk and offsite economic cost risk, and is judged to be the most conservative.

Year 2003, 2004, and 2005 meteorology data for the PINGP site contains 10, 22, and 60 meter wind speed, wind direction, and temperature tower data as well as site specific precipitation data. The 2003 PINGP meteorological data set contained 33 total hours of missing data, representing 0.38% of the hourly readings. The 2004 and 2005 PINGP meteorological data sets contained 70 and 65 total hours of missing data, respectively, representing 0.80% and 0.74% of the hourly readings. Therefore, the year 2003 provided the most complete data set.

The year 2003 meteorological data set contained eight gaps of missing data (33 hours, 0.38%). Traditionally, up to 10% of missing data is considered acceptable. Of the missing gaps, five gaps consisted of less than 6 hours and interpolation was used to fill in the missing meteorological data. Three gaps consisted of six hours or more of missing data (6 hr., 6 hr., and 7 hr. gaps). Missing meteorological data gaps of more than 6 hours were filled based on substituting data from the same time of day from the day just before or after the missing data in order to account for seasonal variations and the onset of severe weather. It is noted that MACCS results used in the SAMA analysis are the statistical mean of 349 weather sequences (each sequence contains 120 hours of data) chosen at random from pre-sorted weather bins. Due to the large number of samples analyzed, the adjustment of any particular weather sequence has negligible impact on the mean results.

PINGP MACCS2 analysis evaluated three representative meteorological data sets (Calendar years 2003, 2004, and 2005). The use of the most conservative data set (year 2003) accounts for any weather sequences. Based on the multiple years analyzed, minimum data gaps in the year 2003 meteorological data, and the sampling methodology used, the reported mean results are judged acceptable and appropriate for use in averted cost risk calculations.

Meteorological data is prepared for MACCS2 input as follows:

1. Wind speed and direction from the 10-meter sensor of the site tower were combined with precipitation (hourly cumulative). If the lower wind speed or direction is unavailable, mid and/or upper directions are used to estimate the wind speed or direction. Onsite precipitation from PINGP is utilized. Missing or suspect precipitation data is supplemented with data from the Minneapolis – St. Paul International Airport.
2. If a brief period (i.e., < 6 hr.) of missing data exists for all tower sensors, interpolation is used between hours.
3. For larger data voids (i.e., > 6 hr.), tower data from the previous or following day is utilized to fill data gaps (for the same time of day).
4. Atmospheric stability is calculated according to the vertical temperature gradient of the tower temperature data.
5. Atmospheric mixing heights are specified for morning and afternoon. These values were taken from the document *Mixing Heights, Windspeeds, and Potential for Urban Air Pollution throughout the Contiguous United States* (EPA 1972).

   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 A, pages A-1 and A-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."

For the PINGP MACCS2 analyses, these conditions mean that, only the afternoon mixing height is used since it is 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 meteorological data. These fixed boundary weather values are ignored by the code when an hourly meteorological data file is supplied by the user, as was the case in the MACCS2 runs for PINGP.

As noted above, site meteorological data for years 2004 and 2005 are also evaluated as sensitivity cases to ensure year 2003 data is an appropriate data set. The results are discussed in Section F.7.3.1.

F.3.8 MACCS2 Results

Table F.3-7 shows the mean off-site doses and economic impacts to the region within 50 miles of PINGP for each of ten release categories calculated using MACCS2. Mean off-site dose impacts are multiplied by the annual frequency for each release category and then summed to obtain the dose-risk and offsite economic cost-risk (OECR) for each unit. Table F.3-7 provides the Unit 1 and Unit 2 results, respectively.

F.4 BASELINE RISK MONETIZATION

This section explains how NMC calculated the monetized value of the status quo (i.e., accident consequences without SAMA implementation). NMC also used this analysis to establish the maximum benefit that could be achieved if all on-line PINGP risk were eliminated, which is referred to as the Maximum Averted Cost-Risk (MACR).

The calculations below have been performed using Unit 1 input. The same process used for the Unit 1 case is also used to establish the MACR for Unit 2.

Section F.4.6 summarizes the results for these cases.

F.4.1 Off-Site Exposure Cost

The baseline annual off-site exposure risk was converted to dollars using the NRC's conversion factor of $2,000 per person-rem, and discounted to present value using NRC standard formula (NRC 1997):

$$W_{pha} = C \times Z_{pha}$$

Where:

W_{pha} = monetary value of public health accident risk after discounting

C = $[1-\exp(-rt_f)]/r$

t_f = years remaining until end of facility life = 20 years

r = real discount rate (as fraction) = 0.03 per year

Z_{pha} = monetary value of public health (accident) risk per year before discounting ($ per year)

The Level 3 analysis showed an annual off-site population dose risk of 2.94 person-rem. The calculated value for C using 20 years and a 3 percent discount rate is approximately 15.04. Therefore, calculating the discounted monetary equivalent of accident dose-risk involves multiplying the dose (person-rem per year) by $2,000 and by the C value (15.04). The calculated off-site exposure cost for Unit 1 is $88,132 per person.

F.4.2 Off-Site Economic Cost Risk

The Level 3 analysis showed an annual off-site economic risk of $15,852 for Unit 1. Calculated values for off-site economic costs caused by severe accidents must be discounted to present value as well. This is performed in the same manner as for public health risks and uses the same C value. The resulting value is $238,408.

F.4.3 On-Site Exposure Cost Risk

Occupational health was evaluated using the NRC recommended methodology that involves separately evaluating immediate and long-term doses (NRC 1997).

For immediate dose, the NRC recommends using the following equation:

Equation 1:

$$W_{IO} = R\{(FD_{IO})_S - (FD_{IO})_A\}\{[1 - \exp(-rt_f)]/r\}$$

Where:

W_{IO} = monetary value of accident risk avoided due to immediate doses, after discounting

R = monetary equivalent of unit dose ($2,000 per person-rem)

F = accident frequency (events per year) (9.79E-06 (total CDF))

D_{IO} = immediate occupational dose [3,300 person-rem per accident (NRC estimate)]

$_S$ = subscript denoting status quo (current conditions)

$_A$ = subscript denoting after implementation of proposed action

r = real discount rate (0.03 per year)

t_f = years remaining until end of facility life (20 years).

Assuming F_A is zero, the best estimate of the immediate dose cost is:

$$W_{IO} = R\,(FD_{IO})_S\{[1 - \exp(-rt_f)]/r\}$$

$$= 2{,}000 * 9.79\text{E-}06 * 3{,}300 * \{[1 - \exp(-0.03*20)]/0.03\}$$

= \$972

For long-term dose, the NRC recommends using the following equation:

Equation 2:

$$W_{LTO} = R\{(FD_{LTO})_S - (FD_{LTO})_A\}\{[1 - \exp(-rt_f)]/r\}\{[1 - \exp(-rm)]/rm\}$$

Where:

W_{LTO} = monetary value of accident risk avoided long-term doses, after discounting, \$

D_{LTO} = long-term dose [20,000 person-rem per accident (NRC estimate)]

m = years over which long-term doses accrue (as long as 10 years)

Using values defined for immediate dose and assuming F_A is zero, the best estimate of the long-term dose is:

W_{LTO} = $R\,(FD_{LTO})_S\,\{[1 - \exp(-rt_f)]/r\}\,\{[1 - \exp(-rm)]/rm\}$

= $2{,}000*9.79E\text{-}06*20{,}000*\{[1 - \exp(-0.03*20)]/0.03\}\,\{[1 - \exp(-0.03*10)]/0.03*10\}$

= \$5,090

The total occupational exposure is then calculated by combining Equations 1 and 2 above. The total accident related on-site (occupational) exposure risk (W_O) for Unit 1 is:

W_O = $W_{IO} + W_{LTO}$ = (\$972 + \$5,090) = \$6,062 person-rem

F.4.4 On-Site Cleanup and Decontamination Cost

The total undiscounted cost of a single event in constant year dollars (C_{CD}) that NRC provides for cleanup and decontamination is \$1.5 billion (NRC 1997). The net present value of a single event is calculated as follows. NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$PV_{CD} = [C_{CD}/mr][1-\exp(-rm)]$$

Where:

PV_{CD} = net present value of a single event

C_{CD} = total undiscounted cost for a single accident in constant dollar years

r = real discount rate (0.03)

m = years required to return site to a pre-accident state

The resulting net present value of a single event is \$1.3E+09. The NRC uses the following equation to integrate the net present value over the average number of remaining service years:

$$U_{CD} = [PV_{CD}/r][1-\exp(-rt_f)]$$

Where:

PV_{CD} = net present value of a single event (\$1.3E+09)

r = real discount rate (0.03)

t_f = 20 years (license renewal period)

The resulting net present value of cleanup integrated over the license renewal term, \$1.95E+10, must be multiplied by the total CDF (9.79E-06) to determine the expected value of cleanup and decontamination costs. The resulting monetary equivalent for Unit 1 is \$191,000.

F.4.5 Replacement Power Cost

Long-term replacement power costs were determined following the NRC methodology in NRC, 1997. The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [\$1.2\times10^8/r] * [1 - \exp(-rt_f)]^2$$

Where:

PV_{RP} = net present value of replacement power for a single event, (\$)

r = 0.03

t_f = 20 years (license renewal period)

To attain a summation of the single-event costs over the entire license renewal period, the following equation is used:

$$U_{RP} \quad = \quad [PV_{RP} / r] * [1 - \exp(-rt_f)]^2$$

Where:

U_{RP} = net present value of replacement power over life of facility ($-year)

After applying a correction factor to account for PINGP's size relative to the "generic" reactor described in NUREG/BR-0184 (NRC 1997) (i.e., 560 megawatt electric/910 megawatt electric), the replacement power costs are determined to be 3.40E+09 ($-year). Multiplying 3.40E+09 ($-year) by the CDF (9.79E-06) results in a replacement power cost of $33,300 for Unit 1.

F.4.6 Total Cost-Risk

The calculations presented in Sections F.4-1 through F.4-5 provide the on-line, internal events based MACR for a single unit. Given that the PINGP SAMA analysis is performed on a site basis and must consider the external events contributions, further steps are required to obtain a site based maximum averted cost-risk estimate that accounts for external events. This estimate, which is referred to as the Modified Maximum Averted Cost-Risk (MMACR) is calculated according to the following steps:

1. For presentation purposes, round each unit's MACR to the next highest thousand,
2. Multiply each unit's rounded MACR from the previous step by a factor of 2 to account for External Events contributions (refer to Section F.5.1.8 for additional details related to the basis for this factor),
3. Add the Unit 1 and Unit 2 results from step 2 together to obtain the MMACR.

The table on the next page summarizes the results of this process.

PINGP MMACR DEVELOPMENT SUMMARY

Input	Unit 1	Unit 2
CDF (per year)	9.79E-06	1.21E-05
Dose-Risk (person-REM, single year)	2.94	8.43
OECR ($/yr)	15,900	63,300
Plant Net MWe	560	560
Output		
Offsite Exposure Cost-Risk	$88,100	$254,000
Offsite Economic Cost-Risk	$238,000	$953,000
Onsite Exposure Cost-Risk	$6,062	$7,461
Onsite Cleanup Cost-Risk	$191,000	$235,000
Replacement Power Cost-Risk	$33,300	$41,000
Total Unit MACR (Rounded to Next Highest Thousand)	$557,000	$1,490,000
Unit MMACR (Includes External Events (MACR x 2))	$1,114,000	$2,980,000
Site MMACR	$4,094,000	

F.5 PHASE I SAMA ANALYSIS

The Phase I SAMA analysis, as discussed in Section F.1, includes the development of the initial SAMA list and a coarse screening process. This screening process eliminated those candidates that are not applicable to the plant's design or are too expensive to be cost beneficial even if the risk of on-line operations were completely eliminated. The following subsections provide additional details of the Phase I process.

F.5.1 SAMA Identification

The initial list of SAMA candidates for PINGP was developed from a combination of resources. These include the following:

- PINGP PRA results and PRA Group Insights
- Industry Phase II SAMAs (review of the potentially cost effective Phase II SAMAs for selected plants)
- Prairie Island Nuclear Generating Plant Individual Plant Examination IPE (PINGP IPE) (NSP 1994)
- PINGP IPEEE (NSP 1998)

These resources are judged to provide a list of potential plant changes that are most likely to reduce risk in a cost-effective manner for PINGP.

In addition to the "Industry Phase II SAMA" review identified above, an industry based SAMA list was used in a different way to aid in the development of the PINGP specific SAMA list. While the industry SAMA review cited above was used to identify SAMAs that might have been overlooked in the development of the PINGP SAMA list due to PRA modeling issues, a generic SAMA list was used as an idea source to identify the types of changes that could be used to address the areas of concern identified through the PINGP importance list review. For example, if Instrument Air availability were determined to be an important issue for PINGP, the industry list would be reviewed to determine if a plant enhancement had already been conceived that would address PINGP's needs. If an appropriate SAMA was found to exist, it would be used in the PINGP list to address the Instrument Air issue; otherwise, a new SAMA would be developed that would meet the site's needs. This generic list was compiled as part of the development of several industry SAMA analyses and has been provided in Addendum 1 for reference purposes.

F.5.1.1 Level 1 PINGP Importance List Review

The PINGP PRA was used to generate a list of events sorted according to their risk reduction worth (RRW) values. The top events in this list are those events that would provide the greatest reduction in the PINGP CDF if the failure probability were set to zero. The events were reviewed down to the 1.02 level, which corresponds to about a 2 percent reduction in the CDF given 100 percent reliability of the event. If the dose-risk and offsite economic cost-risk were also assumed to be reduced by a factor of 1.02, the corresponding averted cost-risk would be about $22,000, which also accounts for the impact of External Events after applying a factor of 2. Similarly, the Unit 2 result was determined to be about $58,000. Both of these estimates are on the order of the dollar amount that would be expected to process a procedural change, i.e., no hardware modification. The lower end of implementation costs for SAMAs are expected to apply to procedural changes, which have previously been estimated to cost about $50,000 (CPL 2004). Given that the PINGP importance list was reviewed down to a level corresponding to an averted cost-risk of about $22,000 for Unit 1 and $58,000 for Unit 2, all events that are likely to yield cost beneficial improvements were addressed by this review process.

Tables F.5-1a and F.5-1b document the disposition of each event in the Level 1 PINGP RRW list for both Units 1 and 2, respectively. Note that no basic events were preemptively screened from the process even if they solely represent sequence flags. Whatever the event, the intent of the process is to determine if insights can be gleaned to reduce the risk of the accident evolutions represented by the events listed. However, unique SAMAs are not identified for all of the events in the RRW list. Previously identified SAMAs are suggested as mitigating enhancements when those SAMAs (or similarly related changes) would reduce the RRW importance of the identified event. It is recognized that in some cases, additional requirements may need to be imposed on the SAMA to get a reduction in the RRW value for the basic event listed. In these cases, if an existing SAMA can approximate such an impact, then it is considered to address the relevant event and provide a first order indication of the potential benefit. If warranted, a more detailed PRA analysis may then be required to provide a better estimate of the actual potential cost-benefit.

F.5.1.2 Level 2 PINGP Importance List Review

A similar review was performed on the importance listings from the Level 2 results that involved contributions to Large Early Release Frequencies (LERF). In this case, cutsets that contribute to LERF that exhibited a RRW $\geq$ 1.02 were reviewed for both Units 1 and 2 to identify any potential SAMA improvements.

The Level 2 RRW values were reviewed down to the 1.02 level. As described for the Level 1 RRW list, events below the 1.02 threshold value are estimated to yield an averted cost-risk less than that required for a procedural modification (approximately $50,000) and were not considered to be likely candidates for identifying cost effective SAMAs. As such, the events with RRW values below 1.02 were not reviewed. Tables F.5-2a and F.5-2b document the disposition of each event in the LERF PINGP RRW list for both Units 1 and 2. The same ground rules related to event disposition in the Level 1 importance tables were utilized in the Level 2 importance tables.

F.5.1.3 PINGP PRA Group Insights

A review of the current PRA model results and insights was conducted in order to identify any additional risk reduction opportunities that could be examined as potential SAMA improvements. This review did not include potential PRA modeling enhancements (as these changes only result in enhancements to the ability to measure plant risk), but rather plant changes that reduce risk (through hardware modifications, procedural enhancements, operator training improvements, etc.). The review indicated that the large majority of risk reduction opportunities available through implementation of individual plant changes are encompassed by the previously identified listing of SAMA improvements (most of these were identified from the importance list reviews for CDF and LERF based on the current PRA model of record, as described in Sections 5.1.1 and 5.1.2 above). There were no additional SAMA improvements identified by this review.

F.5.1.4 Industry SAMA Analysis Review

The SAMA identification process for PINGP is primarily based on the PRA importance listings/insights, the IPE, and the IPEEE. In addition to these plant specific sources, selected industry SAMA analyses were reviewed to identify any Phase II SAMAs that were determined to be potentially cost beneficial at other plants. These SAMAs were further analyzed and included in the PINGP SAMA list only if they were considered to be potentially cost beneficial for PINGP. The following subsections provide a more detailed description of the identification process.

While many of these SAMAs are ultimately shown not to be cost beneficial, some are close contenders and a small number have been shown to be cost beneficial at other plants. Use of the PINGP importance ranking should identify the types of changes that would most likely be cost beneficial for PINGP, but review of selected industry Phase II SAMAs may capture potentially important changes not identified for PINGP due to PRA modeling differences. Given this potential, it was considered prudent to include a review of selected industry Phase II SAMAs in the PINGP SAMA identification process.

The Phase II SAMAs from the following U.S. nuclear sites have been reviewed:

- V.C. Summer (SCE&GC 2002)
- H.B. Robinson (CPL 2002)
- Palisades (NMC 2005b)
- Dresden (Exelon 2003a)
- Quad Cities (Exelon 2003b)
- Brunswick (CPL 2004)
- Monticello (NMC 2005a)
- Susquehanna (PPL 2006)
- Browns Ferry (NRC 2005c)
- Calvert Cliffs (NRC 1999)
- D.C. Cook (NRC 2005b)

Five PWR and six boiling water reactor (BWR) sites were chosen from available documentation to serve as the Phase II SAMA sources. Most of the Phase II SAMAs from these sources are not included in the PINGP SAMA list. The industry Phase II SAMAs that were considered to have the potential to be cost effective for PINGP were independently identified through the PINGP importance list reviews. The remaining industry Phase II SAMAs were judged not to provide any significant benefit or added insight to the plant, or were addressed by SAMAs more suitable to PINGP's needs. These SAMAs were not considered further and no SAMAs unique to the review of the industry Phase II SAMAs were included in the PINGP SAMA list.

F.5.1.5 PINGP IPE Plant Improvement Review

The PINGP IPE generated a list of risk-based insights and potential plant improvements. Typically, changes identified in the IPE process are implemented and closed out; however, there are some items that may not have been completed due to high projected costs or other criteria. Because the criteria for implementation of a SAMA may be different than what was used in the post-IPE decision-making process, these recommended improvements are re-examined in this analysis. The following table summarizes the status of the potential plant enhancements resulting from the IPE process and their treatment in the SAMA analysis:

Item No.	Description of Potential Enhancement	Status of Implementation	Disposition
1.	Procedure revision to utilize the cross-tie from station air to instrument air. The station air compressors are cooled from loop B cooling water and would not be affected by a LOOP A CL pipe break. If the cross-tie could be accomplished within 1 hour after the flood initiator, main feedwater or bleed and feed cooling could be restored and core melt could be prevented.	Procedural modifications have been implemented.	No further review required.
2.	Revise procedure C35 AOP1, "Loss of Cooling Water Header A or B", to address the problem of closure of the turbine building cooling water header isolation valve and the subsequent loss of cooling water to the main feedwater lube oil coolers and condensate pump oil coolers. Analysis has shown that the main feedwater pumps can conservatively operate without cooling water for approximately 20 minutes before possible pump damage.	This recommendation was implemented through the disposition listed below for item #3.	No further review required.
3.	To limit the impact of AFW pump room flooding due to Cooling Water System header rupture, provide a means to either allow additional water flow out of the room or to segregate the room into two compartments.	Calculation ENG-ME-148, Rev. 1, "Cooling Water Header Pipe Failure Causing Flooding in the Auxiliary Feedwater Pump/Instrument Air Compressor Room", addressed this recommendation. This position paper documents the qualifications, design features and periodic inspections in place that provide confidence that the probability of occurrence of the pipe rupture is negligible. In addition to pipe replacements and upgrades that were performed in 1992, it is likely that operators or other personnel who periodically transit these rooms would notice a substantial piping leak.	No further review required.

Item No.	Description of Potential Enhancement	Status of Implementation	Disposition
4.	Emphasize in training the importance of bleed and feed and the operator actions that are necessary for success as bleed and feed is a significant contributor to the overall CDF.	Operator training, course outlines, and lesson plans have been revised to emphasize the importance of this and other IPE insights in the operation and maintenance of the plant.	No further review required.
5.	Emphasize in training the importance of the crosstie between the motor driven AFW pumps and the operator actions that are necessary for success as the AFW crosstie is a significant contributor to the overall CDF.	See implementation status for #4 above.	No further review required.
6.	Emphasize in training the importance of switchover to high and low head recirculation and the operator actions that are necessary for success as switchover to recirculation is a significant contributor to the overall CDF.	See implementation status for #4 above.	No further review required.
7.	Emphasize in training the importance of RCS cooldown and depressurization to terminate safety injection before ruptured steam generator overfill and the operator actions that are necessary for success as this action is a significant contributor to the overall CDF.	See implementation status for #4 above.	No further review required.
8.	Revise step 18 of FR-C.1, "Response to Inadequate Core Cooling", such that the operator checks for adequate steam generator level before attempting to start an RCP. If the RCPs are started with a "dry" steam generator with core exit thermocouples greater than 1200°F, hot gases could be pushed up into the steam generator tubes causing creep rupture of the tubes and a possible containment bypass if one of the steam generator relief valves were to lift.	Implemented.	No further review required.
9.	The in-core instrument tube hatches for both units should be secured open during normal operation. This could be accomplished by using a solid bar or other device, instead of a chain, to keep the hatch open but still prevent inadvertent entry during normal operation. Having this hatch open greatly improves the probability of recovering from a core damage event in-vessel (without vessel rupture), by allowing injection water from the RWST to flow into the reactor cavity and to provide cooling to the lower vessel head.	The hatch was replaced with a metal cage to allow water to flow freely.	No further review required.

F.5.1.6 PINGP IPEEE Plant Improvement Review

The PINGP IPEEE also generated a list of risk-based insights and potential plant improvements. Typically, changes identified in the IPEEE process are implemented and closed out; however, there are some items that may not have been completed due to high projected costs or other criteria. Because the criteria for implementation of a SAMA may be different than what was used in the post-IPEEE decision-making process, these recommended improvements are re-examined in this analysis. The following table summarizes the status of the potential plant enhancements resulting from the IPEEE process and their treatment in the SAMA analysis:

Item No.	Description of Potential Enhancement	Status of Implementation	Disposition
1.	Add fire wrap or other fire barrier material to the exposed length of cable 1DCB-1 (control power to Bus 16) above cable tray 1SG-LB22 in FA 32 (Unit 1 side AFW pump/instrument air compressor room). In the fire PRA, the critical component for this fire is the 12 AFW pump. Although this pump resides in FA 31, loss of control power to Bus 16 will result in loss of the automatic start of the pump.	Implemented.	No further review required.
2.	Add instructions to Fire Safety Procedure F5, Appendix D, for the operator to locally start an available roof exhaust fan to reestablish safeguards screenhouse ventilation. In many fire core damage sequences (fire may be initiated in a number of fire areas), the 121 cooling water pump and a roof exhaust fan are available, but since (in these sequences) the fan and pump are powered from the opposite train, the fan is not running. This leads to failure of the 121 CL pump due to lack of sufficient ventilation.	Subsequent review revealed that procedures already exist to accomplish this task for fires that cause loss of power from MCC 1AB1 or 1AB2. For this operator action, the fire areas of concern are FA 80 (480V Safeguards Swgr Room (Bus 111)), FA 81 (4kV Safeguards Swgr Room (Bus 15)), and FA 22 (480V Safeguards Swgr Room (Bus 121)).	No further review required.

Item No.	Description of Potential Enhancement	Status of Implementation	Disposition
3.	Add instructions to Fire Safety Procedure F5 App. D for the operator to manually open a suction supply valve to the 12 AF pump on a fire in FA 32 (Unit 1 side AFW pump/IA compressor room). On an air compressor large oil spill fire, the assumption is that the fire causes spurious closure of MV-32335 prior to loss of power from MCC 1A2. The cooling water supply valve MV-32027 could also be opened. An alternative would be to wrap the length of conduit for cable 1A2-6A that traverses FA 32.	Upon further review of the procedure, it was found that direction is included in F5 App. D for the operator to de-energize MCC 1A2 and manually operate as necessary the suction valves for 12 MDAFWP for a fire in FA 32. However, no credit was given to this operator action since it was postulated that the 12 MDAFWP discharge valves (MV-32381 and MV-32382) could spuriously close through a hot short on cable 1CB-52, which would have the same impact as the hot short on cable 1A2-6A for MV-32335. Therefore, it was decided to conservatively not credit this operator action.	No further review required.
4.	Ensure that existing training for manual fire suppression in the mitigation of fires in the control room and relay room (fire brigade to relay room) includes a discussion of the risk significance of this action in the prevention of core damage. If successful, this action prevents the need for shutdown outside the main control room.	Revisions were made to lesson plans to include this recommendation.	No further review required.
5.	Ensure that existing training for the operator task to shutdown the plant from outside the control room per F5 App. B includes a discussion of the risk significance of this action in the prevention of a core damage accident.	Revisions were made to lesson plans to include this recommendation.	No further review required.
6.	Ensure that existing training for the operator task to perform bleed and feed cooling of the RCS includes a discussion of the risk significance of this action in the prevention of a core damage event due to internal fires.	Revisions were made to lesson plans to include this recommendation.	No further review required.
7.	Ensure that training (lesson plans, outplant checkoffs, etc. as appropriate) exists for the operator task to perform DC panel switching in the battery room and relay room for a fire in FA 59. Training should include information relative to the importance of this action to stopping loss of inventory through the RCS vent solenoid valves.	Revisions were made to lesson plans to include this recommendation.	No further review required.

Item No.	Description of Potential Enhancement	Status of Implementation	Disposition
8.	Verify cable separation in the G-panel due to potential for a large fire internal to the panel to cause the loss of offsite and onsite power. Power would then have to be restored from the diesel generators from outside the control room. This recommendation is made only to provide added assurance of this critical assumption with respect to its impact on plant risk due to fires.	A visual inspection was performed on the G panel and confirmation was made on the proper design separation between trains. Additionally, proper separation of cables throughout the plant was verified.	No further review required.
9.	Upgrade the anchorage for the main Cardox tank for Relay Room automatic fire suppression. From walkdown activities, it was found that a potentially weak anchorage exists for the main CO2 storage tank in the Unit 1 Turbine Building. Suppression in the Relay Room is important due to the critical equipment in this room required for safe shutdown of the plant.	The installation of new anchors for the Cardox Tank was completed and documented under the plant design change process.	No further review required.
10.	Upgrade the anchorage for the diesel driven fire water pump batteries and its fuel oil day tank. From walkdown activities, it was found that a potentially weak anchorage exists for the diesel driven fire water pump batteries and fuel oil day tank in the plant Screenhouse. This is a concern in that seismic events of sufficient magnitude to cause a loss of offsite power could also render the diesel fire pump unavailable.	The installation of new anchors for the diesel driven fire water pump batteries and its fuel oil day tank was completed and documented under the plant design change process.	No further review required.

F.5.1.7 Use of External Events in the PINGP SAMA Analysis

The external events examination was conducted in three distinct phases: seismic, internal fires, and other external events. The following summarizes the conclusions of these assessments, including specific insights and recommendations. As a result of reviewing these historical analyses and their results, no additional SAMAs were identified that required further consideration for the Phase I analysis.

F.5.1.7.1 <u>Seismic Analysis</u>

Northern States Power (NSP) had originally planned to respond to Generic Letter 88-20, Supplement 4, by performing a seismic probabilistic risk assessment (PRA) for PINGP. By letter dated September 25, 1995, PINGP notified the NRC staff of a change in the manner in which the seismic IPEEE would be completed. This change was based on new information regarding large reductions in the seismic hazard estimates for sites in the eastern United States, as presented in NUREG-1488 (NRC 1993). This information was incorporated within Supplement 5 of Generic Letter 88-20, which provides the basis for NSP's decision to change the approach of completing the seismic IPEEE from a seismic PRA to a seismic margins assessment.

A portion of the effort for the PRA was accomplished (i.e., walkdowns and initial screening) when the NRC issued Supplement 5 to the Generic Letter. NSP elected to change its approach in accordance with Supplement 5 and completed the analysis of seismic events in the form of a reduced scope seismic margins assessment with the focus on a few known weaker, but critical, components. The majority of the components included in the assessment were determined to meet the screening criteria established in EPRI NP-6041-SL (EPRI 1991). This result in itself indicates that most of the components have a relatively high seismic capacity. The remaining components; i.e., those not meeting the screening criteria, were evaluated further and were determined to be: 1) adequate for the safe shutdown earthquake (SSE); 2) unnecessary due to the particular seismic failure mode and/or available plant equipment redundancy; or 3) were to be addressed under the closure of the PINGP SQUG program. Overall, it was concluded that there was no significant plant vulnerability to severe accidents attributable to seismic events at PINGP.

It should be noted that the seismic analysis conducted as part of the IPEEE program was done in conjunction with the efforts at PINGP to address seismic issues associated with the USI A-46 program (NRC 1987). Further, it was shown that many unscreened components that were not dispositioned in the USI A-46 program would not be expected to lead to the inability to cool the core if they were assumed to fail following a seismic event. In each case, additional random failures of equipment are necessary before inadequate core cooling would be expected.

Other significant conclusions of the seismic margins assessment include:

- The seismic walkdowns performed as part of the IPEEE found most of the components and structures reviewed to be seismically adequate (i.e., suitably anchored and/or seismically rugged). Those items that could be considered potentially vulnerable were subjected to the more rigorous seismic evaluation referred to above.
- Concrete block walls were either screened from further consideration because their failure would cause no adverse consequences, or they were further evaluated and found to have sufficient seismic capacity.
- The review of relays credited in the IPE revealed that there were relays beyond those considered in the SQUG program scope that had to be evaluated. However, it was determined that none of these relays were considered "bad actors".

- Few flat bottom tanks fell solely under the scope of the seismic IPEEE (i.e., SQUG had identified some tanks as outliers that were addressed under the closure of that program). Those that did were either screened or shown to have limited consequences should they fail.
- A review of containment response revealed no conditions unique to seismic events or that were not already evaluated as part of the internal events PRA (IPE).
- A recommendation from the seismic margins assessment was to restrain or remove wall hung ladders and scaffolding that were located near safety related equipment to reduce the impact of seismically induced relay chatter.

F.5.1.7.2 <u>Internal Fires Analysis</u>

The overall methodology used in the development of the PINGP Fire IPEEE conformed to the guidance provided by GL 88-20, Supplement 4 and detailed guidance provided by NUREG-1407 (NRC 1991), and has made use of past PRA experience, generic databases, and other defensible simplifications to the maximum extent possible. This methodology was summarized in the PINGP IPEEE submittal of September 1998. The PINGP fire study used an approach that combined the deterministic evaluation techniques from the Fire Induced Vulnerability Evaluation (FIVE) methodology with classical PRA techniques. The FIVE methodology provided a means of establishing fire boundaries as well as methods to evaluate the probability and the timing of damage to components located in a compartment involved in a fire. PRA techniques allow determination of compartment-specific core damage frequencies associated with fires within the various fire areas of the plant. For the PINGP Fire IPEEE, compartments were identified and evaluated, then quantified using the fault trees and event trees from the updated internal events PRA. The internal initiating events were evaluated to determine if they could also result from a fire. The relevant fire-induced initiating events and related fault trees were used to perform the quantification.

The core damage frequency resulting from fires was estimated to be less than 5E-5/yr. This total is on the same order of magnitude as the core damage frequency of the internal events PRA (Level 1, Rev. 1 – see Section F.2.1.2.1 above). It should be noted that these results included a number of conservative assumptions. For example, automatic and manual fire suppression techniques were not credited except in the control room, relay and cable spreading room, and the AFW pump rooms. Also, in most cases, fires were also assumed to completely engulf an area once ignited. In a few critical fire areas (FA), fire modeling was performed to more accurately predict the spread of credible fires occurring in those areas, and the scope of equipment affected by those fires. The areas that received fire modeling were the control room (FA 13), cable spreading and relay room (FA 18), both of the Auxiliary Feedwater/Instrument Air compressor rooms (FAs 31 and 32), the screenhouse basement (FA 41B), and the Unit 1 side Auxiliary Building 695' elevation (FA 58).

More than 89 percent of the plant risk associated with the internal fires can be traced to eight fire areas. These areas are the main control room (FA 13), Unit 1 side Auxiliary Feedwater/Instrument Air compressor room (FA 32), 480V safeguards switchgear room-Bus 111 (FA 80), 4160V safeguards switchgear room-Bus 16 (FA 20), Unit 1 Auxiliary Building elevation 715' (FA 59), Unit 2 Auxiliary Building elevation 695' (FA 73), the cable spreading and relay room (FA 18), and the Turbine Building ground and mezzanine floor (FA 69). Of these, the largest contributors to core damage frequency were fires originating in the main control room. Small fires in the panels that include the Main Feedwater system and Auxiliary Feedwater system controls that are successfully suppressed; along with large fires in the safeguards electrical panel (G-panel) dominated the risk from this fire area.

It should be noted that FA 73, Unit 2 Auxiliary Building elevation 695', did not receive detailed fire modeling, as did its Unit 1 counterpart fire area, FA 58. As a result, the core damage contribution from fires in FA 58 fell below the 1E-6/rx-yr reporting criteria, while the contribution from fires in FA 73 did not. If fire modeling had been applied to FA 73, it is expected that this fire area would have been shown to be even less significant to the Unit 1 Fire PRA results than FA 58.

Operator actions that dominated the fire PRA are associated with performing RCS bleed and feed operation, activation of the hot shutdown panel, local restoration of onsite power following station blackout from a control room G-panel fire, and manual fire suppression in the control room.

The principal finding of the IPEEE fire analysis is that there were no major vulnerabilities due to fire events at PINGP. Plant insights/improvements and their resolution were identified above in Section F.5.1.6, which also included two recommendations from the seismic/fire interactions review.

F.5.1.7.3 High Winds, Floods, and Others

The assessment of other external events in Appendix C of the IPEEE (NSP 1998) showed that there were no other credible external events besides fires and seismic activity that were a safety concern to the PINGP site. No vulnerabilities were identified, and the screening criteria contained in NUREG-1407 (NRC 1991) and Generic Letter 88-20 (Supplement 4) were satisfied for all events. Because there were no vulnerabilities found from this analysis, no changes to plant hardware or procedures were necessary.

F.5.1.7.4 Post-IPEEE External Hazards Review

In addition to the above summary of the PINGP IPEEE, an effort was made to review information since the conclusion of the original IPEEE in 1998 to determine if any outstanding issues exist that could warrant the implementation of any additional SAMAs with regard to external risk. Information for this review was obtained from inspection audits, RAIs, USAR changes, etc. Therefore, the following sources of information are outlined below with a summary of their review:

F.5.1.7.4.1 PINGP Response to RAIs from NRC regarding IPEEE Submittal (NSP 2000)

There were five major requests for additional information, with some containing multiple sub-topics of interest. Three of the requests can be categorized as related to seismic interactions, one related to non-seismic failures and human actions, and one related to seismic-induced fires. The responses from NMC involved detailed explanations and evaluations that satisfactorily address each of the questions, but none involving any structural or hardware modifications.

Since no outstanding items exist as a result of these RAIs, no new SAMAs are deemed necessary.

F.5.1.7.4.2 Response to Generic Letter 2003-01, "Control Room Habitability" (NMC 2003)

The purpose of this generic letter was to ensure that licensees are capable of meeting the applicable habitability regulatory requirements and the control room is designed, constructed, configured, operated, and maintained in accordance with the facility's design and licensing basis. One of the results found within this report is that inspections during the initial set of tests indicated that the seals for the doors that enter the control room envelope and the outside air isolation dampers could be a significant vulnerability. Thus, following initial testing, the seals on all the doors entering the control room envelope were replaced, and the outside air isolation dampers were replaced with bubble tight design dampers. Consistent with the current licensing bases, control room dose analyses were performed for the LOCA, the Main Steam Line Break (MSLB), and the Fuel Handling Accident (FHA). The LOCA dose analysis demonstrated that the dose to the Control Room operator satisfied General Design Criteria (GDC) 19 using 165 cfm unfiltered inleakage. The MSLB dose analysis demonstrated that the dose to the Control Room operator satisfied GDC-19 using 175 cfm unfiltered inleakage. An evaluation for the dose to the control room operator following a FHA demonstrated that the dose to the Control Room operator is less than the GDC-19 limits with unfiltered inleakage up to 700 cfm.

With regard to toxic chemicals, a probabilistic evaluation of chlorine and ammonia spills, determined that no automatic monitoring systems were required. Following NRC approval, the chlorine detection system was removed. PINGP used the guidance of Regulatory Guide 1.78 and 1.95 in determining the adequacy of operator protection in the event of a toxic chemical release. RG 1.95 recommended that a six hour air capacity for the SCBAs be readily available on site to ensure that sufficient time is available to transport additional bottled air from offsite locations. The regulatory guidance also stated that a minimum emergency crew should consist of those personnel required to maintain the plant in a safe condition, including orderly shutdown or scram (automatic shutdown) of the reactor. When a toxic gas event is detected, control personnel will place the Control Room ventilation in recirculation and don their SCBAs. PINGP can provide a minimum of six hours of air for 14 people: six Control Room operators, six out-plant operators and fire brigade, one chemist, and one shift manager. The breathing air supply consists of an auto-cascade air system with two Quick-Fill stations located on the missile shield wall outside the Control Room. The system also provides a redundant three hour supply of air in the event of an equipment failure on one of the stations. All SCBAs in the plant have Quick-Fill capability. Annually, Operations personnel must complete SCBA training and must don an SCBA and have it functional within 2 minutes for potential hazardous chemicals capable of entering the Control Room. With regard to reactor control capability in the event of smoke, it was concluded, using the guidance described in NEI 99-03, Rev. 1, Appendix A (NEI 2003), that a single smoke event originating from inside or outside the Control Room would not affect both the Control Room and the Hot Shutdown Panel areas. Plant Operators would be able to achieve and maintain safe shutdown (reactor control capability) from either the Control Room or the Hot Shutdown Panels if needed.

As a result, no areas of concern or outstanding vulnerabilities were identified regarding control room habitability; therefore, no additional SAMAs are warranted.

F.5.1.7.4.3 Prairie Island Nuclear Generating Plant, Units 1 and 2 NRC Tornado/Fire/Flood Integrated Inspection Report (NRC 2005a)

On June 30, 2005, the NRC completed an integrated inspection for Units 1 and 2. This inspection examined activities, selected procedures, records, observed activities, and personnel interviews. Based on the results of this inspection, the inspectors identified two external event-related findings. Both findings were determined to be of very low safety significance. As a result, no areas of concern or outstanding vulnerabilities were identified regarding this integrated inspection, and therefore, no additional SAMAs are warranted.

F.5.1.7.4.4 Prairie Island Nuclear Generating Plant, Units 1 and 2 NRC Triennial Fire Protection Baseline Inspection (NRC 2006)

Based on the results of this fire inspection, no significant outstanding vulnerabilities were identified that would warrant a specific SAMA to mitigate external risk. Two of the four findings identified during this inspection were determined to be of very low safety significance, and two are being addressed through the corrective action program and NFPA 805 implementation.

F.5.1.8 Quantitative Strategy for External Events

The quantitative methods available to evaluate external events risk at PINGP are limited, as discussed above. In order to account for the external events contributions in the SAMA analysis, the assumption that the risk posed by external and internal events is approximately equal was imposed to simplify the calculation of averted cost-risk based on external events accidents.

Continuing on with the assumption that the internal and external events risks are assumed to be equal, the MACR calculated for the internal events model has been doubled to account for external events contributions. As identified in Section F.4.6, this total is referred to as the MMACR. The MMACR is used in the Phase I screening process to represent the maximum achievable benefit if all risk related to on-line power operations was eliminated. Therefore, those SAMAs with costs of implementation that are greater than the MMACR were eliminated from further review. The second stage of this strategy was to also apply the doubling factor to the Phase II analysis. Any averted cost-risk calculated for a SAMA was multiplied by two to account for the corresponding reduction in external events risk. The difference in the averted cost-risk estimates between the base case and the proposed SAMA were then compared with implementation costs to determine whether a particular SAMA was cost beneficial.

F.5.2 Phase I Screening Process

The initial list of SAMA candidates is presented in Table F.5-3. The process used to develop the initial list is described in Section F.5.1.

The purpose of the Phase I analysis is to use high-level knowledge of the plant and SAMAs to preclude the need to perform detailed cost-benefit analyses on them. The following screening criteria were used:

- Applicability to the Plant: If a proposed SAMA does not apply to the PINGP design, it is not retained.
- Engineering Judgment: Using extensive plant knowledge and sound engineering judgment, potential SAMAs are evaluated based on their expected maximum cost and dose benefits; those that are deemed not beneficial are screened from further analysis.

Table F.5-3 provides a description of how each SAMA was disposition in Phase I. Those SAMAs that required a more detailed cost-benefit analysis are evaluated in Section F.6.

Detailed cost-estimates were developed, using an outside vendor, for the most viable candidates. These cost estimates included cost estimates related to the four project phases: Study, Engineering and Design, Implementation and Life Cycle. A summary of cost estimates by phase breakdown is included in Table F.5-3 to help determine which SAMAs should be retained for further analysis in Phase II.

F.5.2.1 SAMA 6 (Install Equipment to Automatically Isolate Auxiliary Building Flooding):

This SAMA attempts to address the risk of Auxiliary Building flooding, which is dominated by floods in the lowest level (Zone 7, the 695’ elevation, represented by initiating events I-AB7FLDA and I-AB7FLDB). The flooding is assumed to be due to a ruptured Cooling Water (CL) system pipe.

<u>Risk Benefit:</u>

For either unit, Auxiliary Building Zone 7 flooding initiating events account for only about 2% of the CDF and only about 1% of the LERF. Also, by definition, implementation of this SAMA will not provide any benefit in reducing the risk of SGTR-initiated events, which are an important component of the LERF.

<u>SAMA Implementation Cost:</u>

The cost and complexity of implementing this SAMA would be significant—involving system modifications that would entail extensive engineering support, specialized hardware and instrumentation, and regulatory analyses to support modifications to the facility. In order to minimize the cost of the modification, the existing ring header isolation MOVs would have to be used (those that currently split the ring header into two safeguards headers on an S-signal on either unit) in order to prevent a dual-unit outage to install new isolation valves. Under this design, however, isolation of an entire train of safeguards equipment (those supplied by CL) to stop the flooding event would leave both units susceptible to a single failure for important safety functions. Also, adding level instrumentation and automatic isolation logic in order to achieve the most risk benefit from this modification, additional logic to identify the affected CL header and trip the pumps supplying that header would have to be installed. If manual action to diagnose the situation and trip the right pumps is relied upon, a large portion of the risk benefit from this SAMA would not be realized. Also, at a minimum, one CC pump on each unit must be assumed to have failed as they are located in the CCHX room underneath each CL header.

Recommendation:

Screen this SAMA from further consideration.

F.5.2.2 SAMA 6a (Segregate Flooding Zones):

This SAMA attempts to address the risk of Auxiliary Building flooding (see SAMA 6 discussion above), which is dominated by floods in the lowest level (Zone 7, the 695' elevation, represented by initiating events I-AB7FLDA and I-AB7FLDB). However, this SAMA addresses the problem by building curbs or other barriers to physically protect trains of potentially affected equipment from each other. Currently the SI pumps are not separated from each other with respect to flooding hazards. The RHR pits (containing the RHR pumps and heat exchangers) are separated but would both flood nearly simultaneously when water level reaches top of curb. Other equipment affected on the 695' elevation include MCCs supplying power to the ECCS MOVs, which are not separated and would fail simultaneously impacting both trains. It may be possible to increase height of curb around RHR pits to provide extended time to flooding, or to increase the curb height for the RHR pits.

Risk Benefit:

The maximum risk benefit for this SAMA is low (see SAMA 6 discussion above).

SAMA Implementation Cost:

The cost of implementing this SAMA is estimated to be significantly greater than that of SAMA 6. Furthermore, this SAMA relies on operator action to identify and isolate the header with the break (the current, pre-SAMA implementation situation). With the higher likelihood of isolation failure due to operator vs. automatic action, a large portion of the risk benefit from this SAMA would not be realized. Also, even with successful operator action, the result is the loss of at least one train of safeguards equipment.

Recommendation:

Screen this SAMA from further consideration.

F.5.2.3 SAMA 8 (Install Additional Diesel Generator):

This SAMA addresses the risk of Station Blackout (SBO) events by installing an additional diesel generator that can be aligned should the onsite EDGs fail to provide power before offsite power can be restored. One option may be to provide an upgrade to the D3 and/or D4 non-safeguard diesel generators already onsite to provide a backup EDG supply.

Risk Benefit:

SBO is a significant contributor to CDF for both units (provides about 8% of the total CDF). However, it contributes <1% to the LERF, and approximately 1% to the frequency of all early containment failure sequences. All of the top SBO-related release categories involve sequences in which the containment and/or reactor vessel does not fail. The risk benefit of this SAMA is further reduced by the need for operator action (including local actions) for implementation.

SAMA Implementation Cost:

The cost of implementing this SAMA would be significant, involving (at a minimum) semi-permanent connection capability for D3 and/or D4 to the safeguards 4kV buses and analyses to show no degradation of the safeguards power supplies due to the modifications required. Procedures and operator training would need to be implemented to obtain much benefit from this SAMA. In addition, the reliability of D3 and D4 may need to be improved.

Recommendation:

Screen this SAMA from further consideration.

F.5.2.4 SAMA 13 (Install Automatic Sump Pump for Zone 7 AB Flooding):

This SAMA attempts to address the risk of Auxiliary Building flooding (see SAMA 6 discussion above), which is dominated by floods in the lowest level (Zone 7, the 695’ elevation, represented by initiating events I-AB7FLDA and I-AB7FLDB). However, this SAMA addresses the problem by installing a sump pump system that would remove water from the affected area, providing additional time for operator action to isolate the break.

Risk Benefit:

The maximum risk benefit for this SAMA is low (see SAMA 6 discussion above).

SAMA Implementation Cost:

The cost of implementing this SAMA would be about the same, or slightly less, than the cost of SAMA 6, however, as with SAMA 6a, this SAMA relies on operator action to identify and isolate the header with the break (the current, pre-SAMA implementation situation). Therefore, a large portion of the risk benefit from this SAMA would not be realized. Also, even with successful operator action, the result is the loss of at least one train of safeguards equipment.

Recommendation:

Screen this SAMA from further consideration.

F.6 PHASE II SAMA ANALYSIS

Not all of the Phase II SAMA candidates require detailed analysis. The Phase II process allows for the screening of SAMAs known to be related to non-risk significant systems or to components/functions with low importance rankings. Due to the nature of the PRA based process used to develop the PINGP SAMA list, there are limited avenues for SAMAs of this type to be included in the list. However, potential pathways do exist:

- Inclusion of unresolved proposed plant changes from previous PINGP risk analyses,
- Inclusion of SAMAs based on the results of conservative modeling methods.

While no calculations are required for eliminating a SAMA that is linked to a non-risk significant system or components, some quantitative efforts are usually required to screen SAMAs that were developed to address risk contributors based on conservative modeling techniques. These cases are identified in Table F.6-1 and discussed in detail in the SAMA specific subsections of F.6.

For the SAMAs requiring detailed analysis, a more detailed conceptual design was prepared along with a more detailed estimated cost. This information was then used to evaluate the effect of the candidates' changes upon the plant safety model.

The final cost-risk based screening method is defined by the following equation:

Net Value = (baseline cost-risk of plant operation (MMACR) – cost-risk of plant operation with SAMA implemented) – cost of implementation

If the net value of the SAMA is negative, the cost of implementation is larger than the benefit associated with the SAMA and the SAMA is not considered cost beneficial. The baseline cost-risk of plant operation was derived using the methodology presented in Section F.4. The cost-risk of plant operation with the SAMA implemented is determined in the same manner with the exception that the revised PRA results reflect implementation of the SAMA.

The implementation costs used in the Phase I and II analyses consist of PINGP specific estimates developed by plant personnel, as well as those from Sargent & Lundy for certain Phase II SAMAs (S&L 2007). The basic components of the cost estimates included relevant work activities across the following major project phases: study, analysis, design, implementation, and life cycle. Where possible, the economic benefit of implementing proposed SAMAs across both units and taking credit for certain duplicate work activities resulted in implementation costs for the second unit being reduced. To average this economic benefit across both units, the SAMA cost for each unit was figured by dividing the total expected cost by a factor of two. It should be noted that PINGP specific implementation costs do not account for any replacement power costs that may be incurred due to consequential shutdown time. Table F.5-3 provides implementation costs for each Phase I and II SAMA. Costs are delineated as ‘per unit’ and/or ‘total’ as appropriate.

Sections F.6.1 – F.6.14 describe the detailed cost-benefit analysis that was used for each of the remaining candidates. It should be noted that the release category results provided for each SAMA do not include contributions from the negligible release category.

F.6.1 SAMA 2: Alternate Cooling Water (CL) Supply

Loss of the Cooling Water (CL) system is a highly risk-significant initiating event. Provision of an additional, alternate means of supplying CL may reduce the risk associated with these events. Although crossties from the fire protection system (FPS) are available, these crossties were intended to supply CL to FPS, not the other direction. As a result, the amount of water flow available from the FP system to CL may not be sufficient to meet the CL system needs, even for one train of safeguards equipment. Therefore, this SAMA investigates the risk impact of installing a redundant CL pump train, diverse and independent from the existing pump trains (for example, a separate diesel-driven CL pump located in a building onsite that can be tied into the existing system and will start automatically on low system pressure).

Assumptions:

1. For the purposes of this SAMA, it is assumed that the existing diesel-driven fire pump (DDFP) in the basement of the Screenhouse is upgraded and piped such that it can supply both the needs of the FP system and needs of the CL system (as a backup CL system pump).

2. The SAMA 2 pump would remain diesel-driven, with fuel, cooling and ventilation requirements independent of the diesel-driven cooling water pumps (DDCLPs), and would otherwise be diverse enough from the design of the existing DDCLPs such that no CCF potential existed between these pumps.

3. The suction source of the SAMA 2 pump is assumed to be the same suction source currently available to the DDFP (Unit 1 side Circ Water Bay).

4. The SAMA 2 pump is assumed to start automatically on low system pressure (when all of the other pumps have failed – setpoint below the current DDCLP start setpoint).

5. For operating flexibility, it was assumed that the SAMA 2 pump unavailability for testing or maintenance and existing CL pump unavailability for testing or maintenance are not mutually-exclusive events.

SAMA 2 pump failure modeling:

1. The pump FTR BE probability was determined by summing the diesel-driver and pump-portion FTR BE probabilities for one of the existing DDCLPs.

2. The pump FTS BE probability was determined by summing the diesel-driver and pump-portion FTS BE probabilities for one of the existing DDCLPs.

3. A double-check valve design on the outlet of the SAMA 2 pump was assumed in order to prevent a significant failure likelihood from flow diversion through the non-running pump (no such modeling was included in the fault tree).

4. It is assumed that the SAMA 2 pump discharge will be piped into the CL header similar to the location of 121 CL pump discharge, between the A/B and C/D header isolation MOVs, such that the pump is able to supply either CL header A or B on a unit SI signal. The existing FT models failure of one of these header isolation valves to remain open, together with failure of the remaining pumps available to that header to provide flow. However, due to the low risk significance of these failures, no additional modeling (to include the SAMA 2 pump failures) was felt to be necessary as this would only drive down the frequency of these sequences.

5. The fuel supply design for the SAMA 2 diesel engine was assumed to be similar (but independent) to that of the existing DDCLPs.

6. No failure basic events were included for pump ventilation issues over its mission time to run. The pump was assumed to have minimal ventilation requirements due to its location within the large, open Screenhouse basement room (or the ventilation design was assumed to have high reliability).

7. The design of the pump was assumed to not have a requirement for external bearing water cooling as the existing safeguards pumps have (pump has a self-sealing or other reliable seal design).

8. The SAMA 2 pump was assumed to be susceptible to failure from Screenhouse flooding initiating events.

9. The SAMA 2 pump was assumed to NOT be available as a safeguards (Technical Specifications) replacement for the existing DDCLPs (as the 121 motor-driven pump

is) since it is modeled as taking suction from the circulating water bay (not the safeguards pump bay).

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 2 New Basic Events

Description	Probability	Comments
SAMA DIESEL CL PUMP UNAVAILABLE DUE TO CORRECTIVE MAINTENANCE	1.29E-03	Assumes same unavailability as 12, 22 CL pumps
SAMA DIESEL CL PUMP UNAVAILABLE DUE TO PREVENTIVE MAINTENANCE	1.58E-02	Assumes same unavailability as 12, 22 CL pumps
SAMA 2 DIESEL CL PUMP FAILS TO RUN (24 HR MISSION)	4.01E-02	Probability derived by summing event probabilities for
SAMA 2 DIESEL CL PUMP FAILS TO START	3.45E-03	Probability derived by summing event probabilities for
SAMA 2 DIESEL CL PUMP OUT OF FUEL	6.40E-03	Probability determined by summing all BEs under 12 DDCLP.
SAMA 2 PUMP CHECK VALVE 1 FAILS TO OPEN	5.00E-05	Standard check valve FTO probability.
SAMA 2 PUMP CHECK VALVE 2 FAILS TO OPEN	5.00E-05	Standard check valve FTO probability.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-Risk, and Offsite Economic Cost-Risk (OECR). The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	7.72E-06	2.73	$15,396
Unit 1 Percent Reduction	21.2%	6.8%	2.9%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.00E-05	8.22	$62,884
Unit 2 Percent Reduction	17.1%	2.5%	0.7%

SAMA 2 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.02E-06	1.82E-07	2.64E-07	2.27E-07	4.89E-08	3.22E-08	2.45E-09	4.84E-09	8.40E-10	2.32E-11	**7.72E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.01	0.59	1.29	0.10	0.73	0.00	0.00	0.00	0.00	**2.73**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$2	$900	$11,422	$646	$2,408	$0	$0	$18	$0	**$15,396**

SAMA 2 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.28E-06	2.18E-07	3.23E-07	1.16E-06	5.79E-08	3.22E-08	2.80E-09	5.82E-09	9.17E-10	2.32E-11	**1.00E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.01	0.72	6.63	0.12	0.73	0.00	0.00	0.00	0.00	**8.22**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$2	$1,101	$58,589	$765	$2,408	$0	$0	$19	$0	**$62,884**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 2 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$990,624	$123,376
Unit 2	$2,980,000	$2,856,908	$123,092

The SAMA 2 results indicate a relatively significant reduction in CDF. Most of the CDF reduction is due to the decrease in the frequency of release category L-DH-L (late vessel failure with late containment failure due to failure of containment heat removal); however, this category is not very significant to the overall risk from offsite releases.

Based on a $300,000 cost of implementation for each unit, the net value for this SAMA is -$176,624 ($123,376 - $300,000) for Unit 1 and -$176,908 ($123,092 - $300,000) for Unit 2, which implies that this SAMA is not cost beneficial for either unit.

F.6.2 SAMA 3: Provide Alternate Flow Path from RWST to Charging Pump Suction

In the PINGP PRA model, failure to maintain cooling to the reactor coolant pump (RCP) seal package is assumed to result in a small LOCA through the RCP seals. The normal means of providing seal cooling during plant operation is through RCP seal injection from the Chemical and Volume Control System (CVCS) charging pumps. Water for seal injection is taken from the Volume Control Tank (VCT) and pumped into the RCP seal packages by the charging pumps. On low VCT level, the charging pump suction is automatically supplied from the RWST (VCT isolation MOV closes and RWST MOV opens). The current plant design provides only one flow path from the RWST to charging. This SAMA investigates the risk benefit of adding a bypass line around the motor-operated valve that must open to supply charging pump suction flow from the RWST upon loss of VCT level (MV-32060 for Unit 1, MV-32062 for Unit 2).

Assumptions:

1. The bypass line for each unit is assumed to contain a normally closed, fail closed air-operated valve that opens on low VCT level (same instrumentation that provides open signal to the MOV).

2. The bypass line air operated valve (AOV) is assumed to be supplied with an air accumulator in the event that normal plant instrument air is lost (due to the high reliability of such an air supply system, no air dependency is modeled in the fault tree). The purpose of this design requirement is to eliminate the common

dependency of the Component Cooling Water (CC) system and the Instrument Air (SA) system on the Cooling Water (CL) system. As CC is a backup for seal cooling in the event of loss of seal injection flow from the charging pumps, the elimination of this dependency is critical to obtaining maximum value from this SAMA.

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 3 New Basic Events

Description	Probability	Comments
SAMA 3 AIR OPERATED VALVE FAILS TO OPEN	3.00E-03	Standard air-operated valve FTO probability.
SAMA 3 AIR OPERATED VALVE FAILS TO REMAIN OPEN	1.01E-05	Standard air-operated valve FTRO probability. Assumes standard 24-hour mission time.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	8.52E-06	2.83	$15,548
Unit 1 Percent Reduction	13.0%	3.4%	1.9%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.08E-05	8.32	$63,030
Unit 2 Percent Reduction	10.7%	1.3%	0.5%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 3 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.17E-06	7.85E-07	2.82E-07	2.29E-07	4.95E-08	3.22E-08	1.12E-08	4.89E-09	8.40E-10	2.32E-11	**8.52E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.05	0.63	1.30	0.11	0.73	0.00	0.00	0.00	0.00	**2.83**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$8	$961	$11,500	$653	$2,408	$0	$0	$18	$0	**$15,548**

SAMA 3 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.41E-06	8.14E-07	3.39E-07	1.17E-06	5.85E-08	3.22E-08	1.15E-08	5.87E-09	9.17E-10	2.32E-11	**1.08E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.05	0.76	6.64	0.13	0.73	0.00	0.00	0.00	0.00	**8.32**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$8	$1,157	$58,666	$772	$2,408	$0	$0	$19	$0	**$63,030**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 3 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,039,044	$74,956
Unit 2	$2,980,000	$2,903,346	$76,654

The SAMA 3 results are similar to the SAMA 2 results, although the magnitude of the reductions in CDF and LERF are slightly lower. Both SAMAs act to reduce the potential for RCP seal LOCA-induced core damage, however, addition of the diverse CL pump of SAMA 2 provides additional benefits that the more focused SAMA 3 does not provide. Most of the CDF reduction is due to the decrease in the frequency of release category L-DH-L (late vessel failure with late containment failure due to failure of containment heat removal), however, this category is not very significant to the overall risk from offsite releases. The small drop seen in release category L-SR-E (pressure or temperature-induced SGTR), a component of the LERF, is the most significant risk benefit associated with this SAMA.

Based on a $250,000 cost of implementation for each unit, the net value for this SAMA is -$175,044 ($74,956 - $250,000) for Unit 1 and -$173,346 ($76,654 - $250,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.6.3 SAMA 5: Diesel-Driven HPI Pump

SAMA 5 investigates the potential risk reduction for installing an additional diesel-driven, high pressure injection (HPI) pump that could use a large volume, cold suction source. The intent of this SAMA is to reduce the risk of Station Blackout events (by prolonging the time the plant can operate without AC power) and SGTR events (by providing a diverse means of providing high pressure injection from the RWST). No containment sump recirculation capability was assumed for this pump train.

Assumptions:

An additional, diesel-driven HPI pump train is assumed to be made available to the ECCS, in parallel to the two existing SI pumps on both units (the SAMA 5 pump would be common to both units).

The following additional assumptions are made regarding this pump train:

1. The initial suction source to the SAMA 5 pump train is assumed to be the RWST. However, it is assumed that the design allows for highly reliable, automatic transfer to an alternate supply (other unit RWST, BAST, SFP, etc.) on loss of RWST level. (NOTE: This design addresses SAMA 19a as well).
    a. Use of a river water source, while having the advantage of unlimited supply, is assumed to not be a viable alternative as it is not a borated water source.
2. The SAMA 5 pump train is assumed to be independent of the existing SI pumps both in design (including location) and operation such that the potential for common cause failures associated with all three HPI pump trains is negligible. The pump train is also assumed to be of a design that is diverse from the existing diesel CL pump trains.
3. The SAMA 5 pump train is assumed to be supplied with water for pump cooling by either train (header) of the site cooling water system (provides some diversity from the CC system means of equipment heat removal used by the existing SI pumps). A normally-open MOV is assumed for isolation (must remain open during pump mission time to run).
    a. Self cooling (through recirculation of borated RWST water) is not considered to be a viable alternative.
4. The SAMA 5 pump train is assumed to start on an S-signal for either train/either unit and run on recirculation until flow is lost from the SI pump trains on the affected unit. The shutoff head for the SAMA 5 pump train is slightly lower than the SI pumps, such that it will automatically supply HPI flow should flow from the SI pump trains on the affected unit be lost.
5. The SAMA 5 pump train is assumed to either be provided with a highly reliable ventilation system, or be located in a large volume such that pump train failures due to ventilation failures are not likely.

6. For operating flexibility, it was assumed that the SAMA 5 pump unavailability for testing or maintenance and existing SI pump unavailability for testing or maintenance are not mutually-exclusive events.

SAMA 5 pump failure modeling:

1. The SAMA 5 pump FTR BE probability was determined by summing the diesel-driver and pump-portion FTR BE probabilities for one of the existing DDCLPs.

2. The SAMA 5 pump FTS BE probability was determined by summing the diesel-driver and pump-portion FTS BE probabilities for one of the existing DDCLPs.

3. A check valve on the outlet of the SAMA 5 pump was assumed to be required in order to prevent a significant failure likelihood from flow diversion through the pump should it fail to start (no such modeling was included in the fault tree).

4. It is assumed that the SAMA 5 pump discharge will be piped into the high head safety injection (HHSI) header in the section of SI pump discharge piping common to both existing pump trains, such that the SAMA 5 pump is able to supply either the A or B HPI header on a unit SI signal.

5. The fuel supply design for the SAMA 5 diesel engine was assumed to be similar (but independent) to that of the existing DDCLPs.

<u>PRA Model Changes to Model SAMA:</u>

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 5 New Basic Events

Description	Probability	Comments
SAMA 5 HP INJECTION PUMP FAILS TO RUN	4.01E-02	Probability determined by summing the CLP diesel-driver and pump-portion FTR BE
SAMA 5 HP INJECTION PUMP FAILS TO START	3.45E-03	Probability determined by summing the CLP diesel-driver and pump-portion FTS BE
SAMA 2 DIESEL HPI PUMP UNAVAILABLE DUE TO CORRECTIVE MAINTENANCE	1.29E-03	Assumes same unavailability as 12, 22 CL pumps
SAMA 2 DIESEL HPI PUMP UNAVAILABLE DUE TO PREVENTIVE MAINTENANCE	1.58E-02	Assumes same unavailability as 12, 22 CL pumps
SAMA 2 DIESEL HPI PUMP OUT OF FUEL	6.40E-03	Probability determined by summing all BEs under 12 DDCLP.
SAMA 5 DIESEL HPI PUMP DISCHARGE CHECK VALVE FAILS TO OPEN	5.00E-05	Standard check valve FTO probability.
SAMA 5 PUMP COOLING WATER MOTOR OPERATED ISOLATION VALVE FTRO	4.80E-06	Standard motor-operated valve FTRO probability. Assumes standard 24 hour mission time.

Results of SAMA Quantification:

Implementation of this SAMA yields a slight reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.77E-06	2.39	$14,450
Unit 1 Percent Reduction	0.3%	18.4%	8.8%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.20E-05	7.37	$58,219
Unit 2 Percent Reduction	0.8%	12.6%	8.1%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 5 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.51E-06	1.92E-06	6.95E-08	2.21E-07	5.09E-08	3.22E-08	3.06E-08	5.45E-10	8.40E-10	0.00E+00	**9.77E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.16	1.26	0.11	0.73	0.00	0.00	0.00	0.00	**2.39**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$237	$11,098	$671	$2,408	$0	$0	$18	$0	**$14,450**

SAMA 5 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.74E-06	2.02E-06	7.99E-08	1.09E-06	5.99E-08	3.22E-08	3.11E-08	6.02E-10	9.17E-10	0.00E+00	**1.20E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.13	0.18	6.19	0.13	0.73	0.00	0.00	0.00	0.00	**7.37**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$272	$54,710	$791	$2,408	$0	$0	$19	$0	**$58,219**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 5 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,038,058	$75,942
Unit 2	$2,980,000	$2,757,390	$222,610

The SAMA 5 results show a reduction in the potential for core damage with containment bypass due to SGTR events. This is due to the ability to align an alternate, diverse pump train to supply RCS makeup following a SGTR, in the event that both safety injection pump trains are unavailable or failed. The independence of the pump from the component cooling system also provides a significant risk benefit. Also, the beneficial impact of this SAMA is greater for Unit 2, which has a higher potential for SGTR events (SGs have not been replaced on Unit 2 as they have on Unit 1). However, the high cost of this modification is not offset by the expected risk benefit from either unit.

Based on a $1,500,000 cost of implementation for each unit, the net value for this SAMA is -$1,424,058 ($75,942 - $1,500,000) for Unit 1 and -$1,277,390 ($222,610 - $1,500,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.6.4 SAMA 9: Analyze Room Heat-up for Natural/Forced Circulation (Screenhouse Ventilation)

The purpose of this SAMA is to investigate the risk benefit of implementing procedural practices (opening doors, installing portable fans) or a plant modification to improve ventilation for safeguards equipment in the screenhouse. In particular, failures of the ventilation system associated with the safeguards vertical cooling water (CL) pumps currently provide a significant contribution to plant core damage risk. This SAMA determines the maximum benefit achievable if the Screenhouse ventilation system reliability is improved.

<u>Assumptions:</u>

1. It is assumed that the implementation of this SAMA either:

    a. allows all combinations of running safeguards CL pumps to run for at least a 24-hour mission time without forced ventilation (and with room temperatures stable or trending lower at 24 hours), or

    b. increases the reliability of the Screenhouse ventilation system such that the potential for loss of running safeguards CL pumps provides a negligible contribution to plant risk.

2. For the purposes of SAMA cost estimation, it is assumed that a best-estimate room heatup analysis (the least expensive option) is chosen, and that the reanalysis provides results that adequately support Assumption 1a above.

<u>PRA Model Changes to Model SAMA:</u>

In order to model this SAMA, all of the PRA fault tree model logic associated with failures of the safeguards vertical CL pumps (12, 121, and 22) due to Screenhouse ventilation system failures was set to logical FALSE. This treatment demonstrates the maximum risk benefit of this SAMA.

<u>Results of SAMA Quantification:</u>

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	**Dose-Risk**	**OECR**
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	8.75E-06	2.83	$15,600
Unit 1 Percent Reduction	10.7%	3.4%	1.6%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.10E-05	8.32	$63,088
Unit 2 Percent Reduction	8.6%	1.3%	0.4%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 9 - Unit 1 Results By Release Category

Release Category	**H-XX-X**	**L-DH-L**	**L-CC-L**	**SGTR**	**L-H2-E**	**ISLOCA**	**H-DH-L**	**H-OT-L**	**L-CI-E**	**H-H2-E**	**Total**
Frequency_{BASE}	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
Frequency_{SAMA}	7.24E-06	9.47E-07	2.79E-07	2.29E-07	5.16E-08	3.22E-08	1.39E-08	4.89E-09	8.40E-10	2.32E-11	**8.75E-06**
Dose-Risk_{BASE}	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
Dose-Risk_{SAMA}	0.01	0.06	0.62	1.30	0.11	0.73	0.00	0.00	0.00	0.00	**2.83**
OECR_{BASE}	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
OECR_{SAMA}	$0	$9	$953	$11,531	$681	$2,408	$0	$0	$18	$0	**$15,600**

SAMA 9 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.49E-06	9.92E-07	3.38E-07	1.17E-06	6.06E-08	3.22E-08	1.44E-08	5.87E-09	9.17E-10	2.32E-11	**1.10E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.06	0.75	6.64	0.13	0.73	0.00	0.00	0.00	0.00	**8.32**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$10	$1,151	$58,700	$800	$2,408	$0	$0	$19	$0	**$63,088**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 9 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,051,254	$62,746
Unit 2	$2,980,000	$2,917,082	$62,918

The SAMA 9 risk reduction results are similar to the SAMA 3 results, both in magnitude and in release categories benefited. SAMA 9 also reduces the potential for seal LOCAs, as the availability of the CL system is enhanced, although it also has the potential to reduce the loss of cooling water (LOCL) initiating event frequency. The impact of eliminating the Screenhouse ventilation dependency is not as great as the impact of adding another diverse CL pump, however (SAMA 2).

Based on a $62,500 cost of implementation for each unit, the net value for this SAMA is $246 ($62,746 - $62,500) for Unit 1 and $418 ($62,918 - $62,500) for Unit 2, which implies that this SAMA is cost beneficial for both units.

F.6.5 SAMA 12: Alternate Component Cooling Water Supply

The Component Cooling Water (CC) system provides cooling for the ECCS and other safeguards components, and provides a backup to the Chemical and Volume Control System (CVCS) seal injection system for cooling the reactor coolant pump (RCP) seals. The purpose of this SAMA is to investigate the risk benefit of enabling an alternate means of supplying water to the Component Cooling Water (CC) system.

The most risk-significant events associated with the CC system are those in which the entire system is lost (loss of CC initiating event, or those initiated by other events, but in which both CC pump trains subsequently fail to supply flow for mitigation of the event).

Therefore, any alternate CC supply source should provide sufficient flow to support the removal of heat through the CC heat exchangers.

In addition to pump train failures, passive CC system piping and head tank faults contribute to potential for loss of the CC system, although only the head tank faults contribute significantly to the initiating event frequency. These passive faults must be isolatable in order to maintain flow to the supplied equipment.

Normal makeup to the CC system is from the reactor makeup water (RM) system. Makeup from RM system is low-volume and intended only for minor makeup requirements to the closed-loop CC system. Therefore, an alternate source of water is necessary for this SAMA. The CCW pumps and heat exchangers are located on the 695’ elevation of the Auxiliary Building. Available alternate supply sources in this location include headers include the CL and Fire Protection (FP) system piping. These alternate makeup sources are not closed loop systems. Therefore, use of these systems will require availability of a system outlet (note that this outlet flow will also provide additional heat removal for the system).

The CL system currently provides the ultimate heat sink for the CC system through the CC heat exchangers. Therefore, if the FP system is used as the alternate CC system supply the design should either provide an alternate means of system heat removal, or should ensure that a sufficient amount of flow is available to circulate water through the CC heat exchangers for significant heat removal to the CL system (to avoid rejection of an excessive amount of heat through the existing FP discharge piping). If the CL system is used as the alternate CC system supply the design may require the addition of CL pumping capacity to maintain design requirements.

<u>Assumptions:</u>

1. Neither the existing CL system nor the existing FP is assumed to be a viable source of alternate supply water to the CC system without additional flow capacity. One possibility may be to combine SAMA 2 (which investigates upgrading the existing diesel-driven fire pump and using it as an additional backup CL pump train) to this SAMA in order to achieve the benefits from both. For the purposes of this SAMA, the CL system upgrade, as described for SAMA 2, is assumed to have been performed (with SAMA 12 design requirements also incorporated).

2. It is assumed that an automatic means of supplying water from the alternate train upon loss of CC system flow (loss of flow, loss of pressure, and/or other signal, such as both CC pumps tripped) is available. A normally-closed MOV for each CC header (A or B) is assumed to be required to open in order to provide this supply. A

return MOV from each header is also assumed to be required to open to provide the return path from the CC system to the CL return header.

3. It is assumed that an attempt to limit the potential for MOV common cause failures, resulting in the loss of the entire alternate CC supply, is made in the SAMA 12 design process. Therefore, CCF of the CL supply and return MOVs to open are modeled across trains, but not across supply/return applications (i.e., the Train A and Train B supply MOVs are modeled as having the potential for CCF, but the Train A supply and Train B return MOVs are not).

4. Except for the loss of all CL initiating event (I-LOCL), failures involving flow from the CL system headers are not modeled under the alternate supply logic, because loss of flow from these headers will directly result in loss of the affected CC train (due to loss of CL flow to the associated CC heat exchanger). Due to flagging issues, the I-LOCL event must be included as a failure of the SAMA 12 alternate supply in order for the model to quantify correctly.

5. Internal flooding events in the 695' elevation of the Auxiliary Building are assumed to be due to failures of CL system piping in the CC pump/heat exchanger room. Therefore, these initiating events are included as failures of the SAMA 12 alternate CC supply.

6. Rupture of the CC surge tank on a given unit is modeled as a failure of all component cooling water for that unit in the current PRA revision (no credit is given for operator action to isolate the break and to operate either train of the CC system without an expansion volume). This assumption is maintained for the SAMA 12 quantification; however, if the CC surge tank failure is manually isolated (using the CC pump suction isolation MOVs, which can be operated from the control room), then the alternate SAMA 12 supply from the CL system should not be impacted. Credit for operator identification and manual isolation of the surge tank rupture event is given in the model.

PRA Model Changes to Model SAMA 12:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 12 New Basic Events

Description	Probability	Comments
OPERATOR FAILS TO ISOLATE CC SURGE TANK RUPTURE	5.00E-2	Standard HRA screening value.
UNIT 1 TRAIN A SAMA 12 SUPPLY MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 1 TRAIN A SAMA 12 SUPPLY MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 1 SAMA 12 CL TRAIN A AND B SUPPLY MOVs FTO DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
UNIT 1 TRAIN A SAMA 12 RETURN MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 1 TRAIN A SAMA 12 RETURN MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 1 SAMA 12 CL TRAIN A AND B RETURN MOVs FTO DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
MV-32200 (11 CC SURGE TANK TO 11 CC PUMP) FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
MV-32201 (11 CC SURGE TANK TO 12 CC PUMP) FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
MV-32200 & MV-32201 FTC DUE TO CCF (CC SURGE TANK ISOLATION MOVs)	6.21E-05	Standard motor operated valve FTC CCF probability.
UNIT 1 TRAIN B SAMA 12 SUPPLY MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 1 TRAIN B SAMA 12 SUPPLY MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 1 TRAIN B SAMA 12 RETURN MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 1 TRAIN B SAMA 12 RETURN MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 2 TRAIN A SAMA 12 SUPPLY MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 2 TRAIN A SAMA 12 SUPPLY MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 2 SAMA 12 CL TRAIN A AND B SUPPLY MOVs FTO DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
UNIT 2 TRAIN A SAMA 12 RETURN MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 2 TRAIN A SAMA 12 RETURN MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 2 SAMA 12 CL TRAIN A AND B RETURN MOVs FTO DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
MV-32211 (21 CC SURGE TANK TO 21 CC PUMP) FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
MV-32212 (21 CC SURGE TANK TO 22 CC PUMP) FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
MV-32200 & MV-32201 FTC DUE TO CCF (CC SURGE TANK ISOLATION MOVs)	6.21E-05	Standard motor operated valve FTC CCF probability.
UNIT 2 TRAIN B SAMA 12 SUPPLY MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 2 TRAIN B SAMA 12 SUPPLY MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
UNIT 1 TRAIN B SAMA 12 RETURN MOV FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
UNIT 2 TRAIN B SAMA 12 RETURN MOV FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	6.85E-06	2.67	$14,791
Unit 1 Percent Reduction	30.1%	8.9%	6.7%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	9.01E-06	7.74	$59,428
Unit 2 Percent Reduction	25.2%	8.2%	6.2%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 12 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	6.15E-06	1.63E-07	2.64E-07	2.17E-07	4.09E-08	3.22E-08	2.13E-09	4.84E-09	8.40E-10	2.32E-11	**6.85E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.01	0.59	1.24	0.09	0.73	0.00	0.00	0.00	0.00	**2.67**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$2	$900	$10,923	$540	$2,408	$0	$0	$18	$0	**$14,791**

SAMA 12 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	7.41E-06	1.95E-07	2.73E-07	1.10E-06	4.97E-08	3.22E-08	2.48E-09	4.87E-09	9.17E-10	2.32E-11	**9.01E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.01	0.61	6.27	0.11	0.73	0.00	0.00	0.00	0.00	**7.74**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$2	$931	$55,413	$655	$2,408	$0	$0	$19	$0	**$59,428**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 12 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$927,812	$186,188
Unit 2	$2,980,000	$2,677,868	$302,132

As expected, the results of the SAMA 12 risk benefit quantification exceed those of SAMA 2, as this alternative also assumes the implementation of SAMA 2, but also provides a backup supply of water to the CC header for safeguards equipment heat removal. A significant additional decrease is seen in CDF, primarily due to reduction in the frequency of loss of CC (LOCC) initiating events that lead to core damage without containment failure (release categories X-XX-X and L-XX-X). However, the significant benefit added by SAMA 12 is in the additional large drop in the frequency of release category GEH (SGTR with early core damage at high reactor pressure). This is due to the dependence of the high head injection system (SI system) on CC for equipment heat removal. SGTR events without high head injection capability are assumed to lead to the GEH accident class, unless the operators manage to depressurize the primary system to below the secondary side pressure (stop the primary to secondary leak) prior to overfilling the faulted steam generator. The beneficial impact of this SAMA is even greater for Unit 2, which has a higher potential for SGTR events (SGs have not been replaced on Unit 2 as they have on Unit 1).

Based on a $900,000 cost of implementation for each unit, the net value for this SAMA is -$713,812 ($186,188 - $900,000) for Unit 1 and -$597,868 ($302,132 - $900,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.6.6 SAMA 15: Portable DC Power Source

The reliability of Unit 2 Train A DC power (DC Panel 21) has a higher importance to the risk of a core damaging event on its dedicated unit (Unit 2) than do any of the other DC power trains. Loss of Train A DC on either unit results in the loss of all main feedwater, and the loss of instrument air to containment (important for bleed and feed operation of the RCS PORVs). However, unlike Unit 1, the Unit 2 motor-driven AFW pump (21 AFW pump), powered from 4160 V AC Bus 25, is also dependent on Train A DC for breaker control power. Therefore, on a loss of Unit 2 Train A DC power initiating event, if the Unit 2 turbine-driven AFW pump fails to start or run, only operator action is available to prevent core damage (local action to restore an AFW pump, or action from the control room to perform bleed and feed). Note that, on this event, the reliability of the bleed and feed action is potentially impacted as the PORV operation must rely on PORV air accumulators that have not been positively tested under a complete range of potential bleed and feed scenarios.

<u>Assumptions:</u>

1. It is assumed that the primary DC backup supply for 21 AFW pump breaker control power is provided by a battery bank, with a failure rate similar to the existing safeguards (i.e., 21 and 22) batteries.

2. The SAMA 15 battery bank is assumed to be operable whenever the 21 AFW pump is required to be operable.

3. The SAMA 15 battery bank has no common-cause failure potential with any of the existing safeguards batteries.

4. Due to the relatively high reliability of the battery source, no credit for the SAMA 15 battery charger as a DC power source is included in the modeling.

<u>PRA Model Changes to Model SAMA:</u>

As described above, the unavailability of the 21 AFW pump auto-start capability is the primary risk contributor on a loss of Unit 2 Train A DC power. Although a modification providing additional DC power backup to Panel 21 (possibly from an independent and remotely-located source) would be a more comprehensive means of implementing this SAMA, this would require a larger DC power supply and a potentially much more expensive modification than would providing Bus 25 control power. However, a study of the Unit 2 CDF cutsets shows that loss of DC control power to the other loads on this bus provides very little contribution to CDF (all DC power-related failures in the cutset file not associated with the loss of DC initiating event are panel circuit (fuse) failures unrelated to Bus 25 breaker control power). As the DC control power requirement is only required to close the breaker one time during an accident condition, this DC supply could be provided by a small battery bank receiving a continuous “trickle” charge during normal operation. Therefore, to simplify the PRA modeling of this SAMA, the backup DC power source will be applied to only the 21 AFW pump control power logic. The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 15 New Basic Events

Description	Probability	Comments
SAMA 15 BATTERY FAILS ON DEMAND	3.95E-04	Standard battery failure on demand probability.

Results of SAMA Quantification:

Implementation of this SAMA yields a slight reduction in the Unit 2 CDF, Dose-risk, and Offsite Economic cost-risk only. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.79E-06	2.93	$15,852
Unit 1 Percent Reduction	0.0%	0.0%	0.0%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.17E-05	8.41	$63,260
Unit 2 Percent Reduction	2.8%	0.3%	0.1%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 15 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**

SAMA 15 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.20E-06	1.96E-06	3.39E-07	1.17E-06	6.37E-08	3.22E-08	3.13E-08	5.87E-09	9.17E-10	2.32E-11	**1.17E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	6.65	0.14	0.73	0.00	0.00	0.00	0.00	**8.41**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$58,816	$841	$2,408	$0	$0	$19	$0	**$63,260**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 15 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,114,000	$0
Unit 2	$2,980,000	$2,960,676	$19,324

The SAMA 15 results show a modest drop in the CDF and LERF metrics for Unit 2, primarily in release categories that do not involve containment failure. This is expected as, although the loss of the main feedwater and AFW systems on a loss of Train A DC power is important to decay heat removal and prevention of core damage, one train of support systems remains available for containment heat removal. There is virtually no risk benefit provided to Unit 1 upon implementation of this SAMA.

Based on a $130,000 cost of implementation for each unit, the net value for this SAMA is -$130,000 ($0 - $130,000) for Unit 1 and -$110,676 ($19,324 - $130,000) for Unit 2, which implies that this SAMA is not cost beneficial for either unit.

F.6.7 SAMA 19: Upgrade RHR Suction Piping and Install Containment Isolation Valve

During plant shutdown conditions, the RHR shutdown cooling function on both units is facilitated by opening both of the two RHR pump suction MOVs in at least one of the parallel flowpaths (one from each RCS hot leg). All four of these hot leg suction isolation valves are located inside containment. A common 10” line passes through the containment, before dividing again at the suction to each RHR pump. The primary contributor to the risk of intersystem LOCA (ISLOCA) events is the catastrophic failure of the RCS hot leg-to-RHR suction MOVs during power operation, which exposes the low-pressure RHR suction piping and RHR pump seals outside containment (in the Auxiliary Building RHR pits) to RCS pressure. These events can result in large LOCAs outside containment that lead to core damage with direct containment bypass.

The RHR pump suction piping outside containment is designed for low pressure (<600 psig). RCS pressure is approximately 2235 psig during power operation. While the RHR piping likely would not rupture given exposure to RCS pressure (due to margin available in the as-built piping), the RHR pump seals are not likely to remain intact, and at least a small LOCA outside containment is the likely result. Manual valves for local isolation of the suction piping to each RHR pump are available. However, the valve handwheels are located in the RHR pits and environmental conditions in the area following rupture of the RHR pump seals are likely to prevent local operation of the valves. Also, the valves each isolate the suction to only one pump, so that both valves would have to be locally closed to stop the flow of reactor coolant out of the RHR pump seals. There is no automatic isolation valve available outside containment to prevent continuous loss of RCS inventory into the RHR pits inside the Auxiliary Building. The purpose of this SAMA is to investigate the risk benefit of upgrading the RHR suction piping and installing a normally open, automatic isolation valve in the 10" piping common to the suction of both RHR pumps outside containment.

Assumptions:

1. The SAMA 19 automatic isolation valve is assumed to be an MOV. Neither the design of this valve nor its power supply need be independent of the other hot leg suction valves, as the active and passive functions of this valve required during normal and emergency operation are opposite that required for other valves -- the active function required for this valve, to close, is only required if the other valves have failed to remain closed. For shutdown cooling operation, the valve is only required to remain open, while the other valves are required to open. For the purposes of this analysis, 480V MCC 1LA1 [2LA1] is assumed to be the power supply for the SAMA 19 MOV.

2. The signal providing automatic closure of the SAMA 19 MOV is high RHR pump suction pressure. Redundant pressure instrumentation that could be upgraded to provide this signal is available (2PT-620 and 2PT-621 [2PT-620 and 2PT-621]). As closure of this valve could impact operation of the shutdown cooling function, a 2/2 logic is assumed to be required for closure of the valve.

3. Successful automatic closure of the SAMA 19 MOV is not assumed to successfully prevent rupture of the RHR pump seals. However, this will stop the ISLOCA and allow the CVCS charging or high-head SI pumps to replace the lost RCS inventory, with decay heat removal through the steam generators. Therefore, the RHR pumps are assumed to be unavailable for recovery from the event following successful operation of the SAMA 19 MOV.

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 19 New Basic Events

Description	Probability	Comments
BISTABLE FOR PRESSURE CHANNEL PC-620 FAILS TO FUNCTION	7.46E-04	Standard bistable failure on demand probability.
BISTABLE FOR PRESSURE CHANNEL PC-621 FAILS TO FUNCTION	7.46E-04	Standard bistable failure on demand probability.
SAMA 19 MOV FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
PRESSURE TRANSMITTER 1PT-620 FAILS TO FUNCTION	2.52E-05	Standard pressure transmitter failure probability. Assumes standard 24-hour mission time.
PRESSURE TRANSMITTER 1PT-621 FAILS TO FUNCTION	2.52E-05	Standard pressure transmitter failure probability. Assumes standard 24-hour mission time.
SAMA 19 MOTOR OPERATED VALVE FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
SAMA 19 MOV FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
BISTABLE FOR PRESSURE CHANNEL PC-620 FAILS TO FUNCTION	7.46E-04	Standard bistable failure on demand probability.
BISTABLE FOR PRESSURE CHANNEL PC-621 FAILS TO FUNCTION	7.46E-04	Standard bistable failure on demand probability.
SAMA 19 MOV FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
PRESSURE TRANSMITTER 2PT-620 FAILS TO FUNCTION	2.52E-05	Standard pressure transmitter failure probability. Assumes standard 24-hour mission time.
PRESSURE TRANSMITTER 2PT-621 FAILS TO FUNCTION	2.52E-05	Standard pressure transmitter failure probability. Assumes standard 24-hour mission time.
SAMA 19 MOTOR OPERATED VALVE FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
SAMA 19 MOV FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.

<u>Results of SAMA Quantification:</u>

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.78E-06	2.56	$14,612
Unit 1 Percent Reduction	0.2%	12.6%	7.8%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.20E-05	8.05	$62,115
Unit 2 Percent Reduction	0.1%	4.5%	1.9%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 19 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	1.56E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.78E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	1.32	0.12	0.36	0.00	0.00	0.00	0.00	**2.56**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$11,709	$741	$1,165	$0	$0	$18	$0	**$14,612**

SAMA 19 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	1.56E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.20E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	6.66	0.14	0.36	0.00	0.00	0.00	0.00	**8.05**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$58,895	$860	$1,165	$0	$0	$19	$0	**$62,115**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 19 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,053,670	$60,330
Unit 2	$2,980,000	$2,919,486	$60,514

The results of the SAMA 19 sensitivity analysis show a relatively significant reduction in LERF risk metrics for both units. SAMA 19 provides risk benefit only to the ISLOCA release category, a component of the LERF. ISLOCA events that lead to core damage are also components of the CDF, but are small relative to the contributions from other initiating events. Although the reduction in the ISLOCA frequency is comparable between units, the percent change on Unit 1 relative to the LERF is higher, as Unit 2 LERF contains a larger component from SGTR-initiated core damage events (SGs have not yet been replaced on Unit 2 as they have on Unit 1).

Based on a $700,000 cost of implementation for each unit, the net value for this SAMA is -$639,670 ($60,330 - $700,000) for Unit 1 and -$639,486 ($60,514 - $700,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.6.8 SAMA 20: Close Low Head Injection MOVs to Prevent RCS Backflow to SI System

This SAMA investigates the risk benefit of changing the normal operation position of the low head reactor vessel injection motor-operated valves (MV-32064, MV-32065 [MV-32167, MV-32168]) from open to closed. These valves function as low head SI reactor vessel isolation valves and deliver RH system flow directly to the reactor vessel from the RH pumps following a large break LOCA. Two check valves are supplied in each injection line between the MOV and the reactor vessel. The check valves function as the containment isolation valves for the low head injection lines. As these lines interface directly between the RCS and the low head RHR system, they represent potential intersystem LOCA (ISLOCA) pathways.

The current PRA results show that low head injection line check valve rupture and failure to close events are significant contributors to the overall likelihood of an ISLOCA event. As ISLOCA events are assumed to lead directly to core damage with containment bypass, operating with these valves normally closed would provide a clear benefit to prevention of an offsite release due to an ISLOCA. However, operation with these valves normally closed requires that the valves automatically open following a LOCA event to supply flow to the reactor vessel if required. Therefore, failure of these valves to open would contribute to loss of low head injection capability during LOCA events.

The low head injection MOVs were originally maintained normally closed during power operation, but were changed to normally open in the mid-1990’s to eliminate concerns with pressure locking and thermal binding of the valves. An assessment of the risk benefit of this mode of operation was performed prior to the change. This pre-IPE evaluation, which focused on the change in core damage frequency (CDF), found the change in operating state for the valves to be risk-insignificant. However, the SAMA evaluation will focus on change in both CDF and LERF (large, early release frequency), and the changes in the offsite release category frequencies.

<u>Assumptions:</u>

1. It is assumed that failure of a low head injection MOV to remain closed would be alarmed in the control room. Therefore, the analysis does not assume exposure to failure during the whole operating cycle (mission time for failure to remain closed is the standard 24 hours).

2. The current double-check valve design of the low head injection lines is leak-tight such that the RHR piping upstream does not experience high pressures during

normal operation. Therefore, the analysis does not assume exposure of the low head injection MOVs (when operated normally closed) to catastrophic failure during the whole operating cycle (mission time for catastrophic failure when subjected to RCS pressure is the standard 24 hours).

PRA Model Changes to Model SAMA:

Basic events representing failures of the low head injection MOVs to open were added next to the valve “failure to remain open” basic events, wherever those events are currently located in the existing plant fault tree model. Common cause failures to open between the Train A and B MOVs on each unit were also modeled. Also, failures of the power supplies to the valves were included in the model, as the valves cannot be opened without AC power. The Train A MOVs (MV-32064 [MV-32167] are supplied with 480 V AC power from safeguards MCCs 1LA1 [2LA1] and the Train B MOVs (MV-32065 [MV-32168] are supplied from safeguards MCCs 1LA2 [2LA2]. Logic associated with loss of the train-associated S-signal was also included as failures of the valves to open.

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 20 New Basic Events

Description	Probability	Comments
MV-32064 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
MV-32064 AND MV-32065 (LOW HEAD INJECTION TO RX VESSEL) FAIL TO OPEN DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
MV-32065 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
MV-32167 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
MV-32167 AND MV-32168 (LOW HEAD INJECTION TO RX VESSEL) FAIL TO OPEN DUE TO CCF	1.23E-04	Standard motor operated valve FTO CCF probability.
MV-32167 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO OPEN	2.88E-03	Standard motor operated valve FTO probability.
MV-32064 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
MV-32064 (LOW HEAD INJECTION TO RX VESSEL) CATASTROPHIC LEAK	2.40E-07	Standard normally-closed MOV catastrophic failure probability. Assumes standard 24-hour mission time (see Assumption #2).

SAMA 20 New Basic Events

Description	Probability	Comments
MV-32065 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
MV-32065 (LOW HEAD INJECTION TO RX VESSEL) CATASTROPHIC LEAK	2.40E-07	Standard normally-closed MOV catastrophic failure probability. Assumes standard 24-hour mission time (see Assumption #2).
MV-32167 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
MV-32167 (LOW HEAD INJECTION TO RX VESSEL) CATASTROPHIC LEAK	2.40E-07	Standard normally-closed MOV catastrophic failure probability. Assumes standard 24-hour mission time (see Assumption #2).
MV-32168 (LOW HEAD INJECTION TO RX VESSEL) FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
MV-32168 (LOW HEAD INJECTION TO RX VESSEL) CATASTROPHIC LEAK	2.40E-07	Standard normally-closed MOV catastrophic failure probability. Assumes standard 24-hour mission time (see Assumption #2).

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.78E-06	2.60	$14,742
Unit 1 Percent Reduction	0.1%	11.3%	7.0%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.20E-05	8.09	$62,227
Unit 2 Percent Reduction	0.1%	4.1%	1.8%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 20 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	1.74E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.78E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	1.32	0.12	0.40	0.00	0.00	0.00	0.00	**2.60**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$11,706	$741	$1,298	$0	$0	$18	$0	**$14,742**

SAMA 20 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	1.74E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.20E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	6.66	0.14	0.40	0.00	0.00	0.00	0.00	**8.09**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$58,874	$860	$1,298	$0	$0	$19	$0	**$62,227**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 20 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,060,090	$53,910
Unit 2	$2,980,000	$2,925,354	$54,646

As ISLOCA is only a very small contributor to the CDF, the primary impact of this SAMA is in the reduction of the LERF risk metric. This reduction is significant for both units (again, the percent LERF change on Unit 1 is more significant than on Unit 2 due to the higher contribution from SGTR sequences on that unit).

Based on a $313,000 cost of implementation for each unit, the net value for this SAMA is -$259,090 ($53,910 - $313,000) for Unit 1 and -$258,354 ($54,646 - $313,000) for Unit 2, which implies that this SAMA is not cost beneficial for either unit.

F.6.9 SAMA 22: Provide Compressed Air Backup for Instrument Air to Containment

The risk significant function of the instrument air system supplying the containment is to support the operation of the RCS power-operated relief valves (PORVs) during bleed and feed operation for decay heat removal. On a loss of instrument air to containment, the PORVs are each supplied with air from separate backup air accumulators. These accumulators are sized for a certain number of valve operations during overpressure conditions following an accident (testing shows that the valves have capacity for 15 valve operating cycles, according to Section 5.6.1.B of Station and Instrument Air Design Basis Document, Rev. 4).

It is suspected that the air requirements during bleed and feed operations may be less than required for overpressure. However, the PRA model does not take full credit for the ability of these accumulators because their ability to supply sufficient air to support bleed and feed operation over the full range of RCS break sizes has not been verified (through testing or through engineering calculations). Bench testing of the valves for bleed and feed operation at operating pressures may not be practical. The risk benefit from this SAMA can be achieved by either:

a. Qualification of the existing accumulator air supply for bleed and feed operation, through either testing or analysis, or

b. Implementation of a plant modification that would provide a backup to the accumulators during normal plant operation to support bleed and feed operation. One possibility would be to tie into the nitrogen (or air) bottle source that supplies air to the LTOP system during outages.

<u>Assumptions:</u>

1. To estimate an upper bound on the risk benefit for this SAMA with a minimum cost, it was assumed that the PORVs accumulator air supply is successfully qualified for bleed and feed operation through analysis.

2. The upper bound on the risk benefit for this SAMA is represented in the model by setting the existing PRA failure basic events to logical FALSE.

<u>PRA Model Changes to Model SAMA:</u>

The only changes to the PRA necessary to model this SAMA were to reduce the probability of events representing failure of the PORV accumulator to provide sufficient air for bleed and feed operation. As described in Assumption #1, the PORVs accumulator air supply is assumed to be qualified for bleed and feed operation, such that the existing PRA failure basic events can be set to logical FALSE.

The table below shows the basic events that were modified to model this SAMA:

SAMA 22 Changes to Basic Events

Description	Original Probability	SAMA21 Probability
FAILURE OF PZR PORV AIR ACCUMULATOR FOLLOWING LOSS OF AIR	1.0E-01	[FALSE]
FAILURE OF PZR PORV AIR ACCUMULATOR FOLLOWING LOSS OF AIR	1.0E-01	[FALSE]

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.75E-06	2.89	$15,488
Unit 1 Percent Reduction	0.4%	1.4%	2.3%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.18E-05	8.25	$61,792
Unit 2 Percent Reduction	1.8%	2.2%	2.4%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 22 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.25E-06	1.92E-06	2.82E-07	2.25E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.75E-06**
Dose-$Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
Dose-$Risk_{SAMA}$	0.01	0.12	0.63	1.28	0.12	0.73	0.00	0.00	0.00	0.00	**2.89**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$11,342	$741	$2,408	$0	$0	$18	$0	**$15,488**

SAMA 22 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.33E-06	1.97E-06	3.39E-07	1.14E-06	6.45E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.18E-05**
Dose-$Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
Dose-$Risk_{SAMA}$	0.01	0.12	0.76	6.49	0.14	0.73	0.00	0.00	0.00	0.00	**8.25**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$57,337	$852	$2,408	$0	$0	$19	$0	**$61,792**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 22 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,098,650	$15,350
Unit 2	$2,980,000	$2,912,350	$67,650

Similar to the SAMA 21 results, the SAMA 22 results show the primary risk benefit to be the reduction in the frequency of release category L-SR-E (pressure and temperature-induced SGTR core damage sequences). There also is a small reduction in sequences that do not lead to containment failure (primarily core damage events due to failure of secondary decay heat removal and bleed and feed failure), although these categories do not significantly impact the risk of offsite release.

Based on a $39,000 cost of implementation for each unit, the net value for this SAMA is -$23,650 ($15,350 - $39,000) for Unit 1 and $28,650 ($67,650 - $39,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for Unit 1, but is cost beneficial for Unit 2.

F.6.10 Summary

All of the SAMAs reviewed showed at least some benefit with respect to the traditional CDF and LERF risk metrics. From a cost of implementation perspective, SAMA 9 provided a positive net value for both Units 1 and 2, while SAMA 22 returned a positive net value for only Unit 2. All other SAMAs returned a negative net value. SAMAs 9 and 22 are represented by engineering analyses and procedure modifications, which are both low cost options.

SAMA 9 attempts to show through engineering analyses and procedure modifications that loss of Screenhouse Ventilation is not expected to fail operation of the safeguards vertical cooling water (CL) pumps. Computer modeling of expected room temperatures due to maximum mechanical and electrical heat loads during summer operation is anticipated to show that running electrical equipment would continue to successfully operate for a 24 hour mission time, with minimal mitigative efforts by equipment operators, e.g., opening doors, dampers, etc.

SAMA 22 is meant to qualify the capacity of the backup air accumulators for adequate operation of the PORV during bleed and feed operation in removing heat from the primary system when the steam generators are unavailable. The assumed operating conditions are based on the expected sequence of operator actions found in emergency procedures. However, costs for any required procedural changes or plant modifications resulting from the analysis were not included in the cost estimate.

F.7 UNCERTAINTY ANALYSIS

The following three uncertainties were further investigated as to their impact on the overall SAMA evaluation:

- Use a discount rate of 7 percent, instead of 3 percent used in the base case analysis.
- Use the 95th percentile PRA results in place of the mean PRA results.
- Selected MACCS2 input variables.

F.7.1 Real Discount Rate

A sensitivity study has been performed in order to identify how the conclusions of the SAMA analysis might change based on the value assigned to the real discount rate (RDR). The original RDR of 3 percent, which could be viewed as conservative, has been changed to 7 percent and the modified maximum averted cost-risk was re-calculated using the methodology outlined in Section F.4.

Phase I SAMAs are not impacted by use of the 7 percent RDR. The Phase I screening process involved qualitative disposition of (11) SAMAs, and hence, no PRA requantification nor implementation cost data was generated for these SAMAs. Refer to Section F.5 and Table F.5-3 for a detailed analysis of each Phase I SAMA that was screened from further analysis.

The Phase II analysis was re-performed using the 7 percent RDR. Implementation of the 7 percent RDR reduced the MMACR by 28.4 percent compared with the case where a 3 percent RDR was used. This corresponds to a decrease in the MMACR from $1,048,000 to $750,000 for Unit 1 and from 2,706,000 to 1,938,000 for Unit 2.

The Phase II SAMAs are disposition based on PRA insights or detailed analysis. All of the PRA insights used to screen the SAMAs are still applicable given the use of the 7 percent real discount rate as the change only strengthens the factors used to screen them. The SAMA candidates screened based on these insights are considered to be addressed and are not investigated any further.

The remaining Phase II SAMAs were disposition based on the results of a SAMA specific cost-benefit analysis. This step has been re-performed using the 7 percent real discount rate to calculate the net values for the SAMAs. As shown below, the determination of cost effectiveness changed for one Phase II SAMA for both units when the 7 percent RDR was used in lieu of 3 percent. Since the margin by which SAMA 9 becomes “not cost beneficial” is less than $20,000, this is considered within the noise of statistical uncertainty. This does not mean that this SAMA would be screened from consideration if a 7 percent real discount rate were applied in the SAMA analysis since other factors, such as the 95th percentile accident frequency sensitivity analysis, can also influence the decision making process.

Unit 1 Summary of the Impact of the RDR Value on the Detailed SAMA Analyses

SAMA ID	Cost of Implementation	Averted Cost Risk (3 percent RDR)	Net Value (3 percent RDR)	Averted Cost Risk (7 percent RDR)	Net Value (7 percent RDR)	Change in Cost Effective-ness?
1	$4,250,000	$268,252	($3,981,748)	$186,958	($4,063,042)	No
2	$300,000	$123,376	($176,624)	$87,054	($212,946)	No
3	$250,000	$74,956	($175,044)	$53,680	($196,320)	No
5	$1,500,000	$75,942	($1,424,058)	$51,184	($1,448,816)	No
9	$62,500	$62,746	$246	$44,670	($17,830)	Yes
10	$2,866,000	$46,870	($2,819,130)	$34,054	($2,831,946)	No
12	$900,000	$186,188	($713,812)	$131,094	($768,906)	No
15	$130,000	$0	($130,000)	$0	($130,000)	No
17	$2,362,000	$88,030	($2,273,970)	$56,160	($2,305,840)	No
19	$700,000	$60,330	($639,670)	$39,456	($660,544)	No
19a	$1,935,000	$329,802	($1,605,198)	$222,090	($1,712,910)	No
20	$313,000	$53,910	($259,090)	$35,312	($277,688)	No
21	$3,000,000	$11,286	($2,988,714)	$7,480	($2,992,520)	No
22	$39,000	$15,350	($23,650)	$9,894	($29,106)	No

Unit 2 Summary of the Impact of the RDR Value on the Detailed SAMA Analyses

SAMA ID	Cost of Implementation	Averted Cost Risk (3 percent RDR)	Net Value (3 percent RDR)	Averted Cost Risk (7 percent RDR)	Net Value (7 percent RDR)	Change in Cost Effective-ness?
1	$4,250,000	$270,474	($3,979,526)	$188,620	($4,061,380)	No
2	$300,000	$123,092	($176,908)	$86,958	($213,042)	No
3	$250,000	$76,654	($173,346)	$54,550	($195,450)	No
5	$1,500,000	$222,610	($1,277,390)	$144,138	($1,355,862)	No
9	$62,500	$62,918	$418	$44,020	($18,480)	Yes
10	$2,866,000	$48,630	($2,817,370)	$34,154	($2,831,846)	No
12	$900,000	$302,132	($597,868)	$204,688	($695,312)	No
15	$130,000	$19,324	($110,676)	$13,352	($116,648)	No
17	$2,362,000	$488,118	($1,873,882)	$309,512	($2,052,488)	No
19	$700,000	$60,514	($639,486)	$39,352	($660,648)	No
19a	$1,935,000	$929,586	($1,005,414)	$601,740	($1,333,260)	No
20	$313,000	$54,646	($258,354)	$35,516	($277,484)	No
21	$3,000,000	$12,518	($2,987,482)	$8,426	($2,991,574)	No
22	$39,000	$67,650	$28,650	$43,452	$4,452	No

F.7.2 95th Percentile PRA Results

The results of the SAMA analysis can be impacted by implementing conservative values from the PRA's uncertainty distribution (i.e., failure probabilities associated with plant equipment and operator actions). If the best estimate failure probability values were lower than the "actual" failure probabilities, the PRA model could underestimate plant risk and yield lower than "actual" averted cost-risk values for potential SAMAs. Therefore, using the high end of the failure probability distribution is a means of assessing the possible effect of best-estimate failure probabilities being too low.

A Level 1 internal events model uncertainty analysis was performed for PINGP Units 1 and 2. Most plants incorporate only Level 1 analyses in their SAMA reports. The reason Level 2 analyses are not typically used is due to the differing degree of development and uncertainties between the two models. Specifically, the Level 1 model tends to represent the plant in a more thorough and comprehensive manner as opposed to the Level 2 model. Furthermore, there are more release contributors beyond those captured by LERF. As such, for the purposes of the 95th percentile analysis, only Level 1 results are used in the uncertainty process. The results of the Level 1 calculation are provided below:

In performing the sensitivity analysis, each of the SAMA PRA model changes (the Phase I and II SAMAs identified in Table F.5-3) were used in determining the appropriate value for the 95th percentile since different events and failure frequencies may be more important when comparing one model change with another. For those SAMAs that required the addition of new basic events, no new uncertainty distributions were assigned since the design and implementation of each SAMA was arbitrary and was defined by the analysis assumptions. The results of this uncertainty analysis, therefore, show the expected statistical uncertainty of the CDF risk metrics under the assumption that each SAMA was designed and implemented as it was specified in this analysis. The analysis was run using the EPRI R&R Workstation UNCERT code (version 2.3a) using 25,000 trials for each simulation:

The results of these calculations are provided in the below tables. The term CDF_{pe} refers to the CDF point estimate for each unit, i.e., 9.79E-06 for Unit 1 and 1.21E-5 for Unit 2.

Summary of Unit 1 Uncertainty Distribution

Unit 1 SAMA	Mean	5%	50%	95%	Factor > CDF_{pe}	Std Dev
1	6.35E-06	1.87E-06	4.38E-06	1.56E-05	1.6	1.50E-05
2	8.20E-06	1.88E-06	4.60E-06	2.08E-05	2.1	3.50E-05
3	9.05E-06	2.26E-06	5.42E-06	2.34E-05	2.4	1.89E-05
5	1.07E-05	2.55E-06	6.42E-06	2.79E-05	2.8	2.91E-05
9	9.52E-06	2.28E-06	5.62E-06	2.51E-05	2.6	2.49E-05
10	9.76E-06	2.23E-06	5.64E-06	2.54E-05	2.6	2.76E-05
12	7.14E-06	1.38E-06	3.68E-06	1.91E-05	2.0	2.77E-05
15	1.08E-05	2.55E-06	6.41E-06	2.84E-05	2.9	3.89E-05
17	1.08E-05	2.54E-06	6.36E-06	2.80E-05	2.9	2.70E-05
19	1.08E-05	2.54E-06	6.35E-06	2.80E-05	2.9	4.44E-05
19a	7.30E-06	2.15E-06	5.05E-06	1.79E-05	1.8	1.23E-05
20	1.06E-05	2.54E-06	6.40E-06	2.79E-05	2.8	2.62E-05
21	1.08E-05	2.51E-06	6.35E-06	2.83E-05	2.9	2.89E-05
22	1.07E-05	2.54E-06	6.33E-06	2.82E-05	2.9	3.33E-05

Summary of Unit 2 Uncertainty Distribution

Unit 2 SAMA	Mean	5%	50%	95%	Factor > CDF_{pe}	Std Dev
1	8.62E-06	2.54E-06	6.02E-06	2.15E-05	1.8	1.11E-05
2	1.06E-05	2.58E-06	6.25E-06	2.79E-05	2.3	2.94E-05
3	1.15E-05	2.96E-06	7.17E-06	2.92E-05	2.4	2.75E-05
5	1.33E-05	3.25E-06	8.06E-06	3.45E-05	2.9	3.40E-05
9	1.21E-05	3.03E-06	7.33E-06	3.03E-05	2.5	4.37E-05
10	1.22E-05	2.93E-06	7.37E-06	3.20E-05	2.7	2.55E-05
12	9.51E-06	2.00E-06	5.34E-06	2.63E-05	2.2	2.84E-05
15	1.28E-05	3.17E-06	7.83E-06	3.33E-05	2.8	2.98E-05
17	1.29E-05	3.26E-06	7.95E-06	3.34E-05	2.8	4.65E-05
19	1.32E-05	3.33E-06	8.19E-06	3.46E-05	2.9	2.95E-05
19a	9.37E-06	2.79E-06	6.56E-06	2.29E-05	1.9	1.62E-05
20	1.32E-05	3.34E-06	8.15E-06	3.43E-05	2.8	3.68E-05
21	1.31E-05	3.26E-06	8.08E-06	3.31E-05	2.7	4.28E-05
22	1.26E-05	3.18E-06	7.93E-06	3.36E-05	2.8	2.33E-05

In general, the above tables reveal an average factor of about 2.5 greater than the respective point estimate CDF for each unit, which is in agreement with industry experience. Using the factors for each individual SAMA are determined to represent a more realistic and case-specific value than that obtained when applying one overall estimate for the 95th percentile. Therefore, for this analysis, the 95th percentile for each SAMA is used to examine Phase I and II impacts.

F.7.2.1 Phase I Impact

For the impacts on Phase I screening, use of the 95th percentile PRA results will increase the MACR and may reveal potential cost benefits due to implementing some of the high cost SAMAs originally screened in Table F.5-3. Therefore, five of the SAMAs (1, 10, 17, 19a, and 21) that were not evaluated in Phase II are presented here, following the same methodology and process as was used in Section F.6. The results of these SAMA evaluations are then used in Section F.7.2.3 to quantitatively determine any potential cost or risk benefits. However, due to their high implementation costs, the benefit gleaned from the implementation of these SAMAs must be extremely large in order to be cost beneficial.

F.7.2.1.1 SAMA 1: Recirculation Automatic Swap to Containment Sump

Following the injection phase of a LOCA, the Refueling Water Storage Tank (RWST) is emptied and the suction supply to the high and low head ECCS systems must be transferred to the containment sump. The transfer currently relies on operator action, including some local, manual actions. These operator actions are among the most risk-significant human actions modeled in the PRA. This SAMA investigates the risk benefit of installing control logic to automatically swap to recirculation mode of ECCS, drawing suction from containment sump prior to depletion of RWST. (Locally operators need to vent valve bonnets on Sump B to RHR MVs to prevent hydraulic lock. Also improper action by not closing RWST to RHR MVs first can potentially drain RWST back to Sump B).

Assumptions:

1. For the purposes of this SAMA, it was assumed that all of the existing ECCS equipment (piping, valves, breakers, pumps, etc.) that must actively change state to affect the transfer to recirculation still exists following implementation of the automatic switchover modification. The only difference is that the operator action required to initiate the transfer has been replaced by an automatic signal. Therefore, the failure rates of valves to open, pumps to start, etc. are not changed from the original Level 2 PRA analysis.

2. It is assumed that the automatic logic function producing the transfer-to-recirculation actuation signal is designed such that it is highly reliable. Although the final implementation is not likely to produce a system with a negligible failure rate, a “near zero” failure rate may be assumed for the purposes of this calculation (determination of the maximum risk benefit for the SAMA implementation).

PRA Model Changes to Model SAMA:

All operator actions associated with transfer to recirculation were set to logical FALSE to model the maximum risk benefit that could be obtained with this plant modification. The basic event changes are shown in the table below:

SAMA 1 Basic Event Changes

Original Probability	Sensitivity Probability (1)	Description
5.30E-02	FALSE	OPERATOR FAIL TO INITIATE HIGH HEAD RECIRC COND. ON EOPHXCONXY
5.30E-02	FALSE	OPERATOR FAILS TO INITIATE HH RECIRC COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION.
1.50E-01	FALSE	OPERATOR FAILS TO INITIATE HH RECIRC FOR SLOCA COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION.
3.60E-03	FALSE	OPERATOR FAILS TO INITIATE HIGH HEAD RECIRC. FOR A SMALL LOCA
9.50E-03	FALSE	OPERATOR FAILS TO INITATE HIGH HEAD RECIRC. FOR A MEDIUM LOCA
6.80E-02	FALSE	OPERATOR FAILS TO INITIATE LOW HEAD RECIRC. WHEN REQUIRED

(1) Basic Event set to logical FALSE to obtain maximum risk benefit for sensitivity case

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	5.40E-06	2.72	$14,225
Unit 1 Percent Reduction	44.9%	7.2%	10.3%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	7.62E-06	8.22	$61,702
Unit 2 Percent Reduction	36.8%	2.5%	2.6%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 1 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	2.90E-06	1.92E-06	2.82E-07	2.09E-07	2.33E-08	3.22E-08	3.09E-08	4.89E-09	1.23E-10	2.32E-11	**5.40E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.00	0.12	0.63	1.19	0.05	0.73	0.00	0.00	0.00	0.00	**2.72**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$10,527	$308	$2,408	$0	$0	$3	$0	**$14,225**

SAMA 1 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	4.10E-06	1.97E-06	3.39E-07	1.15E-06	3.22E-08	3.22E-08	3.14E-08	5.87E-09	2.00E-10	2.32E-11	**7.62E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	6.53	0.07	0.73	0.00	0.00	0.00	0.00	**8.22**
$OECR_{BASE}$	$0	$16	$1,007	$50,425	$669	$2,034	$0	$0	$16	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$57,689	$425	$2,408	$0	$0	$4	$0	**$61,702**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 1 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$845,748	$268,252
Unit 2	$2,980,000	$2,709,526	$270,474

The results of the SAMA 1 quantification show a large reduction in the CDF risk metrics for both units, and a corresponding decrease in the frequencies of a number of release categories. The release categories that showed the largest decrease in frequency relative to CDF were in those categories in which containment remained intact (category H-XX-X is considered to be bounding among these and represents all of the risk reduction from containment intact categories in the table above).

Based on a $4,250,000 cost of implementation for each unit, the net value for this SAMA is -3,981,748 ($268,252 - $4,250,000) for Unit 1 and -$3,979,526 ($270,474 - $4,250,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for both Units 1 and 2.

F.7.2.1.2 <u>SAMA 10: Alternate Means of Charging Pump Suction Transfer (VCT to RWST)</u>

The purpose of this SAMA is to investigate the risk benefit of improving the reliability of the automatic transfer of charging pump suction (from the VCT to the RWST on low VCT level). Specifically, this SAMA investigates installation of a third level transmitter and instrumentation channel, and logic change (from 2/2 to 2/3) for initiation of the automatic transfer.

Although level channel 1LT-112 [2LT-112] also supports automatic VCT makeup control, which is modeled in the PRA, no similar function was assumed for the new SAMA 10 level channel as this is not a risk significant function of the VCT level instrumentation.

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 10 New Basic Events

Description	Probability	Comments
BISTABLE SAMA 10 FAILS TO FUNCTION	7.46E-04	Standard bistable failure probability.
VC: LEVEL TRANSMITTER FAILS TO FUNCTION (SAMA 10)	1.90E-04	Standard level transmitter failure probability. Assumes standard 24-hour mission time.
VC: TWO LEVEL TRANSMITTERS FAIL DUE TO CCF (SAMA 10 AND 1LT-112)	8.04E-06	Standard level transmitter CCF probability. Assumes standard 24-hour mission time.
VC: TWO LEVEL TRANSMITTERS FAIL DUE TO CCF (SAMA 10 AND 1LT-141)	8.04E-06	Standard level transmitter CCF probability. Assumes standard 24-hour mission time.
BISTABLE SAMA 10 FAILS TO FUNCTION	7.46E-04	Standard bistable failure probability.
VC: LEVEL TRANSMITTER FAILS TO FUNCTION (SAMA10)	1.90E-04	Standard level transmitter failure probability. Assumes standard 24-hour mission time.
VC: TWO LEVEL TRANSMITTERS FAIL DUE TO CCF (SAMA 10 AND 2LT-112)	8.04E-06	Standard level transmitter CCF probability. Assumes standard 24-hour mission time.
VC: TWO LEVEL TRANSMITTERS FAIL DUE TO CCF (SAMA 10 AND 2LT-141)	8.04E-06	Standard level transmitter CCF probability. Assumes standard 24-hour mission time.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	8.95E-06	2.88	$15,711
Unit 1 Percent Reduction	8.6%	1.7%	0.9%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.12E-05	8.36	$63,197
Unit 2 Percent Reduction	7.1%	0.9%	0.2%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 10 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.10E-06	1.27E-06	2.82E-07	2.31E-07	5.19E-08	3.22E-08	2.10E-08	4.89E-09	8.40E-10	2.32E-11	**8.95E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.08	0.63	1.32	0.11	0.73	0.00	0.00	0.00	0.00	**2.88**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$12	$961	$11,628	$684	$2,408	$0	$0	$18	$0	**$15,711**

SAMA 10 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.34E-06	1.30E-06	3.39E-07	1.17E-06	6.09E-08	3.22E-08	2.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.12E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.08	0.76	6.65	0.13	0.73	0.00	0.00	0.00	0.00	**8.36**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$13	$1,157	$58,796	$804	$2,408	$0	$0	$19	$0	**$63,197**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 10 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,067,130	$46,870
Unit 2	$2,980,000	$2,931,370	$48,630

The SAMA 10 results are similar to the SAMA 3 results, as the concern addressed with this alternative is shared by both SAMAs (charging pump suction supply). Both SAMAs reduce the CDF primarily by reducing the potential for RCP seal LOCAs due to failures of the suction switchover from the VCT to the RWST on low VCT level. The magnitude of the SAMA 10 benefits are generally lower than the SAMA 3 benefits simply because the likelihood of level transmitter failure is lower than the likelihood of MOV failure.

Based on a $2,866,000 cost of implementation for each unit, the net value for this SAMA is -$2,819,130 ($46,870 - $2,866,000) for Unit 1 and -$2,817,370 ($48,630 - $2,866,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.7.2.1.3 SAMA 17: Bypass Around RHR Loop B Return Valves

The RHR to RCS Loop B return valve (MV-32066 [MV-32169]) is important to plant risk in two ways:

1. As a normally-closed, motor-operated valve located in the low pressure RHR return piping to the RCS, it represents a single failure point for shutdown cooling (SDC).

2. As a containment isolation valve for a system that interfaces with the RCS during power operation, its failure to remain closed (or catastrophic rupture) contributes to the potential for an ISLOCA.

The purpose of this SAMA is to investigate the risk benefit of including a bypass line with an isolation valve around the RHR Loop B return valve. The intent of this modification would be to reduce the risk associated with failure of the return valve to open.

Assumptions:

1. The modification design is assumed to prevent a significant increase in the potential for ISLOCA. For the purposes of this analysis, it is assumed that multiple normally-closed isolation valves are included in the bypass line (i.e., the primary, power-operated isolation valve, and a check valve). This would provide 3 valves for isolating the RCS from ISLOCA through the bypass line (SI-6-2 [2SI-6-2], the SAMA 17 bypass isolation power-operated valve, and the SAMA 17 bypass isolation check valve).

2. The RCS pressure interlock preventing inadvertent operation of the existing RHR Loop B isolation MOV are assumed to also apply to the SAMA 17 bypass MOV. However, the pressure transmitters providing signals for the interlock are assumed to operate from the opposite train (SAMA 17 MOV uses 1PT-419 [2PT-419] instead of 1PT-420 [2PT-420]). The potential for common cause failure of the pressure transmitters is included in the SAMA 17 MOV failure modeling.

3. The SAMA 17 power-operated isolation valve is assumed to be a motor-operated valve, using an opposite-train power supply than that used by MV-32066 [MV-32169]. In addition, the valve and its motor operator are assumed to be of a different make than MV-32066 [MV-32169] in order to minimize the risk contribution from common-cause failures. Use of an MOV instead of an AOV eliminates the dependence on instrument air inside containment (the reliability of the containment air supply is already a significant contributor to risk).

4. The SAMA 17 MOV is assumed to be powered from an AC source of the opposite train than that used by MV-32066 [MV-32169]. For the purposes of this analysis, the 480V MCC assumed to power the SAMA 17 MOV is 1LA2 [2LA2].

5. The SAMA 17 isolation check valve is assumed to be of a different make and design than the other RHR and SI injection check valves in order to minimize the risk contribution from common-cause failures.

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 17 New Basic Events

Description	Probability	Comments
SAMA 17 MOTOR OPERATED VALVE FAILS TO OPEN	3.00E-03	Standard motor operated valve FTO probability.
SAMA 17 MOTOR OPERATED VALVE FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
SAMA 17 CHECK VALVE FAILS TO OPEN	5.00E-05	Standard check valve FTO probability.
SAMA 17 MOTOR OPERATED VALVE FAILS TO OPEN	3.00E-03	Standard motor operated valve FTO probability.
SAMA 17 MOTOR OPERATED VALVE FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
SAMA 17 CHECK VALVE FAILS TO OPEN	5.00E-05	Standard check valve FTO probability.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.69E-06	2.68	$13,592
Unit 1 Percent Reduction	1.1%	8.5%	14.3%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.17E-05	6.98	$50,616
Unit 2 Percent Reduction	3.2%	17.2%	20.1%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 17 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.22E-06	1.92E-06	2.82E-07	1.88E-07	5.59E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.69E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	1.07	0.12	0.73	0.00	0.00	0.00	0.00	**2.68**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$9,450	$737	$2,408	$0	$0	$18	$0	**$13,592**

SAMA 17 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.39E-06	1.97E-06	3.39E-07	9.18E-07	6.45E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.17E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	5.22	0.14	0.73	0.00	0.00	0.00	0.00	**6.98**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$46,162	$851	$2,408	$0	$0	$19	$0	**$50,616**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 17 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,025,970	$88,030
Unit 2	$2,980,000	$2,491,882	$488,118

SAMA 17 provides a relatively slight reduction in the CDF values for Unit 1 and Unit 2 primarily due to the increased reliability of SDC on events involving small LOCAs and SGTR with successful high head injection. As the sequences which benefit from the SAMA 17 modification are those in which the SDC containment isolation MOV fails to open, the low-head RHR system and its support systems are likely to be available to support containment heat removal. The most significant benefit provided by this SAMA is to reduce the frequency of late core damage from SGTR events (accident class/release category GLH). The PRA model assumes that SDC must be functional for long term recovery from SGTR events involving operator failure to reduce RCS pressure to below SG pressure prior to SG overfill. Note that, as with SAMA 12, the beneficial impact of this SAMA is even greater for Unit 2, which has a higher potential for SGTR events (SGs have not been replaced on Unit 2 as they have on Unit 1).

Based on a $2,362,000 cost of implementation for each unit, the net value for this SAMA is -$2,273,970 ($88,030 - $2,362,000) for Unit 1 and -$1,873,882 ($488,118 - $2,362,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.7.2.1.4 <u>SAMA 19a: Replenish RWST from Large Water Source</u>

The RWST is the initial suction supply for the high and low pressure ECCS subsystems (SI and RHR pumps, respectively). When the RWST has been depleted following the injection phase of a loss of coolant accident, the ECCS trains are realigned for recirculation operation with suction taken from the containment sump. This realignment requires successful manual (and some local) operator actions. The time available to the operators to perform these actions varies from a few minutes to hours depending upon the size of the primary system break flow. Therefore, for LOCA accident sequences, it is clear that there would be some risk benefit for implementation of a plant change that would allow the time available for operator action to be extended.

For accidents which involve LOCAs outside containment however (i.e., steam generator tube rupture events, or intersystem LOCAs), recirculation is not an option. Intersystem LOCAs are risk significant for offsite releases, but typically the ECCS subsystem components cannot be expected to remain operable in these events for any significant length of time following the initiator (due to harsh environmental conditions produced in the Auxiliary Building). For SGTR events however, the ECCS subsystems (including the high pressure SI system) remain available and will inject the contents of the RWST into the RCS. In these events, quick operator action is required to cool down and depressurize the RCS to stop the leakage into the steam generator. If this action fails, then a period of hours is available to complete cooldown and depressurization and to initiate long term decay heat removal with RHR shutdown cooling before the RWST is completely emptied. Therefore, during a SGTR event, it would be beneficial to have the ability to replenish the RWST in order to give the operators more time to perform the required actions for initiation of long term decay heat removal.

This SAMA investigates the risk benefit of providing a reliable backup large water source for replenishing the RWST following an accident. Sources available onsite that could be connected (either through existing connections and piping or via a plant modification) include the Spent Fuel Pool (SFP), the opposite unit RWST, CVCS monitor tanks, CVCS holdup tanks, and CVCS boric acid storage tanks (BASTs). Each of these sources would likely require a pump (i.e., SFP pump, RWST purification pump, CVCS monitor tank pump, etc.) to ensure that the inventory is successfully transferred to the RWST on the affected unit.

For the purposes of this analysis, the opposite unit RWST is chosen as the alternate source, as it is already designed as a supply for ECCS injection. Piping a pump to assist in the water transfer operation, and procedural guidance to allow transfer of one RWST to another are currently available (see procedure C16, Rev. 46). However, the existing equipment and procedure are not designed for post-accident operations and will likely need to be upgraded to support this SAMA.

<u>Assumptions:</u>

1. For the purposes of this analysis, it is assumed that modifications to the plant are made such that the RWST refill is highly likely to be successful, including pump(s), piping and valves necessary to perform the transfer.

2. For the purposes of this analysis, it is assumed that the RWST refill is accomplished using operator action that can be performed from the control room using proceduralized actions to start a pump and operate two power-operated valves (both valves must operate for success; one must open and the other must close).

3. For the purposes of this analysis, it is assumed that the benefit for RWST refill is limited to an enhanced probability of operator success in transferring to high head recirculation and in cooling down and depressurizing the RCS and initiating shutdown cooling for SGTR events. Other benefits (such as increased time for repair of failed equipment, etc.) are not credited in this analysis.

4. Due to the short time available and requirement for other local operator actions performed at the same time, a minimum amount of credit for RWST refill is taken for Medium LOCA and Large LOCA scenarios (50% reduction in transfer to recirculation failure probability). Due to the significantly longer time available, it is assumed that a larger amount of credit can be applied to all other scenarios requiring ECCS injection (order of magnitude reduction in failure probabilities for transfer to high head recirculation and SGTR RCS cooldown, etc. operator actions).

5. The pump and valves required to actively function to support the RWST refill operation are assumed to be motor-operated, with power from a safeguards electrical source (MCC 1T1, the AC source for 121 SFP pump).

6. The potential that the SAMA19a operator action may be conditional upon the transfer to recirculation or SGTR recovery actions was not investigated in detail for this analysis. As SAMA19a involves an operator action performed from the control room, which is applied to sequences involving failure of other operator actions that are at least partially performed from the control room, there are issues of dependency between the failure rates of these actions. Preliminary quantification runs for this SAMA indicate that it provides very little benefit if no credit is given for sequences involving other dependent operator actions, as these failures are the dominant means of failing the transfer function. For the purposes of this SAMA, it is assumed that the issue of HRA dependency is resolved in the design and implementation of SAMA19a to the extent that all dependence can be covered by multiplying the standard 5E-2 HRA screening value by a factor of 2 (HRA applied = 1E-1).

7. Credit for improvement of the manual transfer to containment spray recirculation (CSR) was not given for this SAMA. Previous analyses have shown that failure of CSR is not a large risk contributor to the PINGP Level 2 results.

PRA Model Changes to Model SAMA:

The table below provides a listing of the new basic events included in the PRA model for this sensitivity analysis:

SAMA 19a New Basic Events

Description	Probability	Comments
OPERATOR FAILS TO PERFORM SAMA19a (REFILL RWST) WHEN REQUIRED	1.00E-01	Standard HRA screening value, multiplied by 2 (to account for dependency; all actions assumed to be performed from CRM)
SAMA19a MOTOR OPERATED VALVE #1 FAILS TO OPEN	3.00E-03	Standard motor operated valve FTO probability.
SAMA19a MOV #1 FAILS TO REMAIN OPEN	4.80E-06	Standard motor operated valve FTRO probability. Assumes standard 24-hour mission time.
SAMA19a MOTOR OPERATED VALVE #2 FAILS TO CLOSE	2.94E-03	Standard motor operated valve FTC probability.
SAMA19a MOV #1 FAILS TO REMAIN CLOSED	4.80E-06	Standard motor operated valve FTRC probability. Assumes standard 24-hour mission time.
SAMA19a OPERATOR ACTION SUCCESS CREDIT (OTHER THAN LG/MED LOCA)	1.00E-01	See Assumption #4.
SAMA19a SUCCESS CREDIT FOR HI HEAD RECIRC TRANSFER (LG./MED. LOCAs)	5.00E-01	See Assumption #4.

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	6.46E-06	2.39	$11,184
Unit 1 Percent Reduction	34.1%	18.4%	29.4%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	8.37E-06	6.09	$42,874
Unit 2 Percent Reduction	30.6%	27.8%	32.3%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 19a - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	4.02E-06	1.92E-06	2.82E-07	1.46E-07	3.33E-08	3.22E-08	3.09E-08	4.89E-09	1.23E-10	2.32E-11	**6.46E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	0.83	0.07	0.73	0.00	0.00	0.00	0.00	**2.39**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$7,355	$439	$2,408	$0	$0	$3	$0	**$11,184**

SAMA 19a - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	5.23E-06	1.97E-06	3.39E-07	7.70E-07	4.22E-08	3.22E-08	3.14E-08	5.87E-09	2.00E-10	2.32E-11	**8.37E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	4.38	0.09	0.73	0.00	0.00	0.00	0.00	**6.09**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$38,729	$557	$2,408	$0	$0	$4	$0	**$42,874**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 19a Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$784,198	$329,802
Unit 2	$2,980,000	$2,050,414	$929,586

The results of the SAMA 19a sensitivity analysis show a large drop in both the CDF and LERF risk metrics for both units. This CDF reduction is primarily due to the high importance of the transfer to recirculation operator action in preventing core damage following a LOCA. The LERF reduction is due to a significant reduction in the frequency of L-SR-E release category sequences as failure of the recirculation transfer leads to core damage at high pressure. The percent LERF change on Unit 1 is more significant than on Unit 2 due to the higher contribution from SGTR sequences on Unit 2 (SGs have not been replaced on that unit).

Based on a $1,935,000 cost of implementation for each unit, the net value for this SAMA is -$1,605,198 ($329,802 - $1,935,000) for Unit 1 and -$1,005,414 ($929,586 - $1,935,000) for Unit 2, which implies that this SAMA is <u>not</u> cost beneficial for either unit.

F.7.2.1.5 SAMA 21: Increase Reliability of PORV Closure

The RCS PORVs are designed to open to relieve RCS pressure during overpressure conditions. The valves are then required to reclose when pressure is reduced to below the valve set pressure (there is essentially no dead band associated with the PINGP PORV design). In the PRA model, failure of either PORV on a unit to reclose following a pressure challenge is assumed to result in a “PORV LOCA” initiating event, an event having an accident progression similar to a small-break LOCA event.

PORV failure-to-reclose events are significant contributors to the LERF, as certain initiating events (particularly MSLB events) involve pressure challenges that also involve secondary side depressurization. If the PORV failure leads to core damage at high RCS pressure, the potential exists for a pressure-induced SGTR which would provide a fission product release pathway outside of containment.

Assumptions:

1. To estimate an upper bound on the risk benefit for this SAMA, it was assumed that a new or enhanced PORV design was implemented, such that the valve re-closure probability was reduced by an order of magnitude.

PRA Model Changes to Model SAMA:

The only changes to the PRA necessary to model this SAMA were to reduce the probability of events representing failure of the PORV to reclose.

The table below shows the basic events that were modified to model this SAMA:

SAMA 21 Changes to Basic Events

Description	Original Probability	SAMA21 Probability
PORV CV-31231 FAILS TO CLOSE	2.94E-03	2.94E-04
PORV CV-31232 FAILS TO CLOSE	2.94E-03	2.94E-04
PORV CV-31233 FAILS TO CLOSE	2.94E-03	2.94E-04
PORV CV-31234 FAILS TO CLOSE	2.94E-03	2.94E-04

Results of SAMA Quantification:

Implementation of this SAMA yields a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk. The results are summarized in the following table for Units 1 and 2:

	CDF	Dose-Risk	OECR
Unit 1_{Base}	9.79E-06	2.93	$15,852
Unit 1_{SAMA}	9.71E-06	2.91	$15,644
Unit 1 Percent Reduction	0.8%	0.7%	1.3%
Unit 2_{Base}	1.21E-05	8.43	$63,337
Unit 2_{SAMA}	1.20E-05	8.40	$63,114
Unit 2 Percent Reduction	0.7%	0.4%	0.4%

A further breakdown of the Dose-risk and OECR information is provided below according to release category.

SAMA 21 - Unit 1 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	7.28E-06	1.92E-06	2.82E-07	2.33E-07	5.61E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.79E-06**
$Frequency_{SAMA}$	7.20E-06	1.92E-06	2.82E-07	2.29E-07	5.57E-08	3.22E-08	3.09E-08	4.89E-09	8.40E-10	2.32E-11	**9.71E-06**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.63	1.32	0.12	0.73	0.00	0.00	0.00	0.00	**2.93**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.63	1.30	0.12	0.73	0.00	0.00	0.00	0.00	**2.91**
$OECR_{BASE}$	$0	$18	$961	$11,706	$741	$2,408	$0	$0	$18	$0	**$15,852**
$OECR_{SAMA}$	$0	$18	$961	$11,504	$735	$2,408	$0	$0	$18	$0	**$15,644**

SAMA 21 - Unit 2 Results By Release Category

Release Category	H-XX-X	L-DH-L	L-CC-L	SGTR	L-H2-E	ISLOCA	H-DH-L	H-OT-L	L-CI-E	H-H2-E	Total
$Frequency_{BASE}$	8.52E-06	1.97E-06	3.39E-07	1.17E-06	6.52E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.21E-05**
$Frequency_{SAMA}$	8.44E-06	1.97E-06	3.39E-07	1.17E-06	6.47E-08	3.22E-08	3.14E-08	5.87E-09	9.17E-10	2.32E-11	**1.20E-05**
$Dose\text{-}Risk_{BASE}$	0.01	0.12	0.76	6.66	0.14	0.73	0.00	0.00	0.00	0.00	**8.43**
$Dose\text{-}Risk_{SAMA}$	0.01	0.12	0.76	6.64	0.14	0.73	0.00	0.00	0.00	0.00	**8.40**
$OECR_{BASE}$	$0	$19	$1,157	$58,874	$860	$2,408	$0	$0	$19	$0	**$63,337**
$OECR_{SAMA}$	$0	$19	$1,157	$58,657	$854	$2,408	$0	$0	$19	$0	**$63,114**

This information was used in the cost-benefit calculation. The results of this calculation are provided in the following table.

SAMA 21 Net Value

Unit	Base Case Cost-Risk	Revised Cost-Risk	Averted Cost-Risk
Unit 1	$1,114,000	$1,102,714	$11,286
Unit 2	$2,980,000	$2,967,482	$12,518

As expected, the SAMA 21 results show the primary risk benefit to be the reduction in the frequency of release category L-SR-E (pressure and temperature-induced SGTR core damage sequences). This release category is a component of the LERF for both units, although the impact (percent change) on the Unit 1 LERF is larger than the change on Unit 2 due to the higher contribution from SGTR sequences on Unit 2 (as previously described).

Based on a $3,000,000 cost of implementation for each unit, the net value for this SAMA is -$2,988,714 ($11,286 - $3,000,000) for Unit 1 and -$2,987,482 ($12,518 - $3,000,000) for Unit 2, which implies that this SAMA is not cost beneficial for either unit.

F.7.2.2 Phase II Impact

As discussed above, the 95th percentile PRA results for each individual Phase II SAMA were used to determine the impact of the cost-benefit analysis for the proposed SAMA candidates. The uncertainty analyses that are available for the Level 1 model are not available (or not used) for the Level 2 and 3 PRA models. In order to simulate the use of the 95th percentile results for the Level 2 and 3 models, the same scaling factor calculated for the Level 1 results was applied to the Level 2 and 3 models. Because the MMACR calculations scale linearly with the CDF, dose-risk, and offsite economic cost-risk, the 95th percentile MMACR for each SAMA can be re-calculated by multiplying the base case by the 95th percentile for each of the individual SAMAs.

The Phase II SAMA list has been re-examined using the revised MMACR to identify SAMAs that would be re-characterized as cost beneficial, i.e., positive net value. Those SAMAs that were previously determined not cost beneficial due to costs of implementation that exceeded their associated MMACR are now potentially cost beneficial if the implementation costs are less than the revised MMACR. In this case, one additional Phase II SAMA (SAMA 22) becomes cost beneficial for Unit 1 and no additional SAMAs for Unit 2.

F.7.2.3 Summary

The following table provides a summary of the impact of using the 95th percentile PRA results on the detailed cost-benefit calculations that have been performed for Phase II SAMAs and those Phase I SAMAs identified above in Section F.7.2.1

Unit 1 Summary of the Impact of Using the 95th Percentile PRA Results

SAMA ID	Cost of Implementation	Averted Cost Risk (Base)	Net Value (Base)	Averted Cost Risk (95th Percentile)	Net Value (95th Percentile)	Change in Cost Effectiveness?
1	$4,250,000	$268,252	($3,981,748)	$429,203	($3,820,797)	No
2	$300,000	$123,376	($176,624)	$259,090	($40,910)	No
3	$250,000	$74,956	($175,044)	$179,894	($70,106)	No
5	$1,500,000	$75,942	($1,424,058)	$212,638	($1,287,362)	No
9	$62,500	$62,746	$246	$163,140	$100,640	No
10	$2,866,000	$46,870	($2,819,130)	$121,862	($2,744,138)	No
12	$900,000	$186,188	($713,812)	$372,376	($527,624)	No
15	$130,000	$0	($130,000)	$0	($130,000)	No
17	$2,362,000	$88,030	($2,273,970)	$255,287	($2,106,713)	No
19	$700,000	$60,330	($639,670)	$174,957	($525,043)	No
19a	$1,935,000	$329,802	($1,605,198)	$593,644	($1,341,356)	No
20	$313,000	$53,910	($259,090)	$150,948	($162,052)	No
21	$3,000,000	$11,286	($2,988,714)	$32,729	($2,967,271)	No
22	$39,000	$15,350	($23,650)	$44,515	$5,515	Yes

Unit 2 Summary of the Impact of Using the 95th Percentile PRA Results

SAMA ID	Cost of Implementation	Averted Cost Risk (Base)	Net Value (Base)	Averted Cost Risk (95th Percentile)	Net Value (95th Percentile)	Change in Cost Effectiveness?
1	$4,250,000	$270,474	($3,979,526)	$486,853	($3,763,147)	No
2	$300,000	$123,092	($176,908)	$283,112	($16,888)	No
3	$250,000	$76,654	($173,346)	$183,970	($66,030)	No
5	$1,500,000	$222,610	($1,277,390)	$645,569	($854,431)	No
9	$62,500	$62,918	$418	$157,295	$94,795	No
10	$2,866,000	$48,630	($2,817,370)	$131,301	($2,734,699)	No
12	$900,000	$302,132	($597,868)	$664,690	($235,310)	No
15	$130,000	$19,324	($110,676)	$54,107	($75,893)	No
17	$2,362,000	$488,118	($1,873,882)	$1,366,730	($995,270)	No
19	$700,000	$60,514	($639,486)	$175,491	($524,509)	No
19a	$1,935,000	$929,586	($1,005,414)	$1,766,213	($168,787)	No
20	$313,000	$54,646	($258,354)	$153,009	($159,991)	No
21	$3,000,000	$12,518	($2,987,482)	$33,799	($2,966,201)	No
22	$39,000	$67,650	$28,650	$189,420	$150,420	No

In reviewing the above results, none of the Phase I SAMAs identified in Section F.7.2.1 proved to be cost-beneficial at the 95th percentile. When the 95th percentile PRA results were applied to the Phase II SAMAs, only SAMA 22 for Unit 1 was shown to now be marginally cost effective. The use of the 95th percentile PRA result is not considered to provide the most rational assessment of the cost effectiveness of a SAMA; however, this additional SAMA should be considered for implementation to address the uncertainties inherent in the SAMA risk analysis, especially since its consideration for Unit 2 was shown to provide a cost benefit.

F.7.3 MACCS2 Input Variations

The MACCS2 model was developed using the best information available for the PINGP site; however, reasonable changes to modeling assumptions can lead to variations in the Level 3 results. In order to determine how certain assumptions could impact the SAMA results, a sensitivity analysis was performed on a group of parameters that has previously been shown to impact the Level 3 results. These parameters (and associated sensitivity cases) include:

- Meteorological data (PI2004; PI2005)
- Population estimates (PI30INC; PISIT00)
- Evacuation effectiveness (PISLOW)
- Radionuclide release characteristics (PIATM1; PIATM2)
- Recovery, decontamination, and resettlement factors (Intermediate Phase) (PICHR1, PICHR2)

The risk metrics produced by MACCS2 that are evaluated in the sensitivity analyses are the 50 mile population dose and the 50 mile offsite economic cost for Unit 2. (Similar impacts would be expected for Unit 1). The subsections below discuss the changes in these results for each of the sensitivity cases that are shown below. The final subsection, F.7.3.6, correlates the worst case changes identified in the sensitivity runs to a change in the site's averted cost-risk and discusses the implications of the sensitivity analysis on the SAMA analysis.

Case	Description	Unit 2 Pop. Dose Risk Δ Base (%)	Unit 2 Cost Risk Δ Base (%)
PI2003	Base Case (Year 2003 MET data)	--	--
PI2004	Year 2004 MET data	-1.5%	-4.7%
PI2005	Year 2005 MET data	-4.3%	-13.4%
PI30INC	Year 2034 population values increased uniformly 30% over base case.	28.6%	29.6%
PISit00	Year 2000 population based (Base Case is Year 2034)	-39.2%	-39.3%
PISlow	Evacuation speed decreased 50% to 1.67 mph, 0.75 m/sec (Base Case is 3.35 mph).	1.7%	0%
PIATM1	Release height set to ground level	2.3%	-5.8%
PIATM2	Plume thermal heat content set to ambient (i.e., buoyant plume rise not modeled)	negligible	-6.1%
PICHR1	Long Term Phase starts immediately after the Early Phase is over (No Intermediate Phase; Base Case is 6 month Intermediate Phase)	19.2%	-33.2%
PICHR2	1 Year Intermediate Phase following the Early Phase (Base Case is 6 month Intermediate Phase)	-15.3%	34.9%

F.7.3.1 Meteorological Sensitivity

In addition to the base case meteorological data (year 2003), data is also analyzed for the years 2004 and 2005. Analysis of these alternate data sets yielded population dose-risks and offsite economic cost-risks that are lower than the 2003 data by at least 1.5 percent and by as much as 13.4 percent.

As no particular criteria have been defined by the industry related to determining which meteorological data set should be used as a base case for a site, the year 2003 data is conservatively chosen for PINGP given that it yielded the largest results.

F.7.3.2 Population Sensitivity

Two population sensitivity cases (PI30INC, PISIT00) are analyzed to determine the dependence of population estimates on the MAACS2 results.

In case PI30INC, the baseline 2034 population is uniformly increased by 30 percent in all sectors of the 50-mile radius. This change increased the estimated population dose-risk and offsite economic cost by over 28 percent each.

A second population based sensitivity (PISIT00) is performed to determine the impact of using year 2000 census data rather than projecting to the end of the license renewal period (Year 2034). The baseline SAMA case is based on a population projection to year 2034 based on the population growth trends shown between the years 1990 and 2000. When year 2000 data is utilized, the overall dose-risk and OECR decrease, as expected. Specifically, the dose-risk and the OECR each decreased by about 39 percent.

The population sensitivity cases (PI30INC, PISIT00) demonstrate a significant dependence on population estimates. This is expected given that the population dose and offsite economic costs are primarily driven by the regional population.

F.7.3.3 Evacuation Sensitivity

One evacuation sensitivity case (PISLOW) is analyzed to determine the impacts associated with evacuation assumptions. While evacuation assumptions do impact the population dose-risk estimates, they do not impact MACCS2 offsite economic cost-risk estimates because MACCS2 calculated cost-risks are based on land contamination levels which remain unaffected by evacuation assumptions and the number of people evacuating.

For PINGP, evacuation assumptions have a relatively minor impact on dose-risk. A 50 percent decrease in the evacuation speed increased the dose-risk by only approximately 2 percent.

The evacuation sensitivity case (PISLOW) demonstrates minor population dose-risk impacts associated with evacuation assumptions due to the relatively slow base case PINGP evacuation.

F.7.3.4 Radioactive Release Sensitivity

The sensitivity cases PIATM1 and PIATM2 quantify the impact of the assumptions related to the height of the release and thermal energy of the plume, respectively. PIATM1 assumes that the release occurs at ground level rather than at an elevation that could correspond to a release through the stack or a break high in the reactor building. The lower release height shows a small increase in dose-risk of 2 percent and a reduction in OECR of over approximately 6 percent. Reducing the thermal plume heat content to ambient conditions has a similar impact. PIATM2 shows a negligible change (0 percent) in the dose-risk and a decrease of about 6 percent in the OECR.

F.7.3.5 Intermediate Phase Duration Sensitivity

The Intermediate Phase, as modeled by MACCS2, is the time period beginning after the early phase (one week emergency phase) and extends to the time when recovery actions such as decontamination and resettlement are started (long term phase). MACCS2 allows the habitation of land during the intermediate phase unless the projected dose criterion is exceeded. If the projected dose criterion is exceeded during the intermediate phase, the individual is relocated. MACCS2 allows an intermediate phase ranging from no intermediate phase to one (1) year. The Intermediate Phase related sensitivity cases (PICHR1 and PICHR2) show significant dependence in relation to economic impact, and are therefore discussed further:

- The No Intermediate Phase case (PICHR1) is developed based on the NUREG-1150 modeling approach. However, the 33 percent reduction in economic cost estimates based on the approach are judged too optimistic in that the land decontamination efforts are modeled as starting one week after the accident (i.e., directly after the early phase ends) such that a significant portion of population relocation costs are omitted. For example, the costs associated with temporary housing while decontamination strategies are developed and decontamination teams are contracted are not accounted for without an intermediate phase. It is believed that NUREG-1150 studies omitted the intermediate phase because the MACCS2 intermediate phase coding was not validated at that time. A competing factor is that the population dose increases because people are allowed to re-occupy the land sooner (19 percent increase over the base case).
- The 1 Year Intermediate Phase case (PICHR2) is developed based on the maximum length of time allowed by MACCS2 for the intermediate phase. A long intermediate phase can be unrealistic in that re-occupation of the contaminated land is not performed during this phase even if contamination levels decrease (by natural radioactive decay) to levels which would allow it (i.e., resettlement is evaluated as part of the long term phase, not the intermediate phase). Therefore, population relocation costs may be over estimated using a long (i.e., one year) intermediate phase. An Intermediate Phase of one year shows a 35 percent increase in the OECR estimates compared with the six month (base case) Intermediate phase. However, the population dose decreased by 15 percent with a longer Intermediate Phase due to later resettlement on decontaminated land.

The six month intermediate phase (base case) is judged to be a best estimate approach in that it provides a reasonable time for both decontamination efforts and resettlement to begin. The sensitivity cases demonstrate that this six month modeling approach is mid-range of the modeling choices available and is used as the base case.

F.7.3.6 Impact on SAMA Analysis

Several different Level 3 input parameters are examined as part of the PINGP MACCS2 sensitivity analysis. The primary reason for performing these sensitivity runs is to identify any reasonable changes that could be made to the Level 3 input parameters that would impact the conclusions of the SAMA analysis. While the table in Section F.7.3 summarizes the changes to the dose-risk and OECR estimates for each sensitivity case, it is prudent to consider if any of these changes would result in the retention of the SAMAs that were screened using the baseline results.

Of all the MACCS2 sensitivity cases, the largest increase in the dose-risk is 29 percent in the population sensitivity case PI30INC (2034 population uniformly increased by 30%) while the largest increase in OECR is 35 percent in the intermediate phase duration sensitivity case PICHR2 (one year intermediate phase). While these are separate cases, the PINGP MMACR is recalculated using these results to determine the impact of using the worst case for each parameter simultaneously. The resulting Unit 2 MMACR is a factor of 1.24 greater than the base case, which is less than the average factor of 2.5 calculated in Section F.7.2 for the 95th percentile individual SAMA PRA model results. Therefore, the 95th percentile PRA results sensitivity is considered to bound this case and no SAMAs would be retained based on this sensitivity that were not already identified in Section F.7.2.

F.7.4 Unit 2 Containment Sump Sensitivity Analysis

As described in Section F.2.2.2, the Unit 2 SAMA probabilistic analysis results were quantified using the Unit 2, Level 1 Rev. 2.2 (SAMA) model. At the time of the Rev. 2.2 model update, containment sump strainer modifications to address G.L. 2004-02 on Unit 2 had not been completed. However, during the Unit 2 refueling outage in Fall 2006 (prior to the submittal of this LAR), the containment sump modifications were completed. Therefore, a sensitivity analysis is considered necessary to demonstrate the impact of this significant plant modification to the results of the Unit 2 SAMA analysis.

The containment sump strainer modifications implemented in Unit 1 and Unit 2 are very similar in design and operation. Therefore, in order to perform this sensitivity analysis, the reliability (assumed plugging failure rate) for the Unit 2 sump strainers was reduced to match the failure rate of the Unit 1 sump strainers (reduced by an order of magnitude). The probabilistic analyses for each of the Phase II SAMAs were re-performed, and the results used to regenerate new averted cost values for each of the SAMAs.

The results of the sensitivity analysis showed the change in averted costs were on the order of a few thousand dollars or less for most of the identified Phase II SAMAs when accounting for a more reliable sump strainer for Unit 2. However, this did not change the overall outcome for Unit 2 regarding whether or not a particular SAMA was cost-beneficial. The change in averted costs due to the implementation of a more reliable containment sump strainer for Unit 2 is judged to be within the statistical uncertainty of the SAMA analysis.

The Unit 2 Level 1 PRA model used for the SAMA analysis is therefore deemed slightly conservative in the sense that the modeled reliability of the strainer is less than the actual plant configuration following the Fall 2006 outage. However, the sensitivity analysis showed that this does not affect the applicability of using the existing Level 1 model for Unit 2.

F.8 CONCLUSIONS

The benefits of revising the operational strategies in place at PINGP and/or implementing hardware modifications can be evaluated without the insight from a risk-based analysis. Use of the PRA in conjunction with cost-benefit analysis methodologies has, however, provided an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected impact on a larger future population. The results of this study indicate that of the identified potential improvements that can be made at PINGP, a few are cost beneficial based on the methodology applied in this analysis and warrant further review for potential implementation. It should be noted that the following conclusions were drawn based on the use of a 3% RDR, which is viewed as a more appropriate discount rate. However, if a 7% RDR were used, there would be fewer SAMAs identified as being cost-beneficial.

F.8.1 Unit 1 Conclusions

The base case analysis shows that implementation of the following SAMA for Unit 1 would be cost beneficial:

- SAMA 9: Analyze Room Heat-up for Natural/Forced Circulation (Screenhouse Ventilation)

SAMA 9 is a potentially cost beneficial enhancement at PINGP. This SAMA represents engineering analyses and possible procedure modifications that loss of Screenhouse Ventilation is not expected to fail operation of the safeguards vertical cooling water (CL) pumps. Computer modeling of expected room temperatures due to maximum mechanical and electrical heat loads during summer operation is anticipated to show that running electrical equipment would continue to successfully operate for a 24 hour mission time, with minimal mitigative efforts by equipment operators, e.g., opening doors, dampers, etc.

The 95th percentile PRA results showed that the following additional SAMA was cost beneficial for Unit 1:

- SAMA22: Provide Compressed Air Backup for Instrument Air to Containment

SAMA 22 is a cost-effective change for PINGP, given the results of the sensitivity analysis involving 95th percentile PRA values (see Section F.7.2). This SAMA deals with analyzing the actual capability of the backup air accumulators for adequate operation of the PORV during bleed and feed operation in removing heat from the primary system when the steam generators are unavailable. On a loss of instrument air to containment, the PORVs are each supplied with air from separate backup air accumulators. However, it is suspected that the air requirements during bleed and feed operations may be less than that required for overpressure conditions. Previous analyses involving these air accumulators included conservative assumptions and operating conditions that implied PORV operation would be compromised given a loss of the normal air supply. Therefore, a more realistic analysis of the PORV backup air accumulators, using the expected procedural sequence of operator actions, is expected to show that additional hardware modification is unnecessary. However, costs for any required procedural changes or plant modifications resulting from this analysis were not included in the SAMA cost estimate (S&L 2007).

F.8.2 Unit 2 Conclusions

The base case analysis shows that implementation of the following two SAMAs for Unit 2 would be cost beneficial:

- SAMA 9: Analyze Room Heat-up for Natural/Forced Circulation (Screenhouse Ventilation)
- SAMA22: Provide Compressed Air Backup for Instrument Air to Containment

The discussion of these SAMAs in Section F.8.1 applies to Unit 2 as well.

The 95th percentile PRA results showed that there were no additional cost beneficial SAMAs for Unit 2.

F.9 TABLES

Table F.3-1
Estimated Population Distribution within a 10-Mile Radius of PINGP, Year 2034(2)

Sector	0-1 mile (1.84) (1)	1-2 miles (1.21) (1)	2-3 miles (1.00) (1)	3-4 miles (1.03) (1)	4-5 miles (1.02) (1)	5-10 miles (1.09) (1)	10-mile total
N	0	14	25	25	16	493	573
NNE	0	109	34	137	41	712	1033
NE	0	143	30	0	52	868	1093
ENE	0	0	9	0	30	553	592
E	0	0	134	0	100	461	695
ESE	0	0	0	81	124	2810	3015
SE	0	0	0	0	228	17066	17294
SSE	0	0	0	864	856	575	2295
S	0	91	0	856	228	311	1486
SSW	0	0	20	57	78	415	570
SW	0	0	20	1	140	409	570
WSW	0	0	47	0	0	347	394
W	142	0	0	26	70	716	954
WNW	1349	10	1	141	7	2377	3885
NW	208	19	0	18	0	647	892
NNW	125	0	0	34	0	999	1158
Total	1824	386	320	2240	1970	29759	36499

(1) Ten year radial population growth factor applied to year 2000 census data to develop year 2034 estimate.
(2) Population estimates are based on year 2000 census data as processed by SECPOP2000. Any minor differences from the population estimates and actual population are judged to have a negligible impact on the results given the MACCS2 modeling methodology.

Table F.3-2
Estimated Population Distribution within a 50-Mile Radius of PINGP, Year 2034[2]

Sector	0-10 miles	10-20 miles (1.18) [1]	20-30 miles (1.34) [1]	30-40 miles (1.10) [1]	40-50 miles (1.12) [1]	50-mile total
N	573	27938	36153	23733	17081	105478
NNE	1033	3290	17862	3660	12635	38480
NE	1093	8039	11719	6543	6963	34357
ENE	592	2167	6284	24257	12927	46227
E	695	1647	5869	6240	8427	22878
ESE	3015	2784	12460	7073	3564	28896
SE	17294	1555	9864	7079	4809	40601
SSE	2295	1988	5839	20093	62859	93074
S	1486	2771	21155	35417	61632	122461
SSW	570	1575	6412	3852	7529	19938
SW	570	3642	9064	23698	47250	84224
WSW	394	9691	53668	11743	14428	89924
W	954	4230	64056	53846	35935	159021
WNW	3885	21326	250009	460884	409761	1145865
NW	892	35228	445530	838915	749278	2069843
NNW	1158	5115	141140	134921	66497	348831
Total	36499	132986	1097084	1661954	1521575	4450098

(1) Ten year radial population growth factor applied to year 2000 census data to develop year 2034 estimate.
(2) Population estimates are based on year 2000 census data as processed by SECPOP2000. Any minor differences from the population estimates and actual population are judged to have a negligible impact on the results given the MACCS2 modeling methodology.

Table F.3-3
Comparison of PINGP MACCS2 Core Inventory and Sample Problem A

Entry	Nuclide[2]	Sample Problem A[1] (Bq)	PINGP MACCS2[3] (Bq)	Entry	Nuclide[2]	Sample Problem A[1] (Bq)	PINGP MACCS2[3] (Bq)
1	Co-58	1.56E+16	2.17E+16	31	Te-131m	2.26E+17	2.63E+17[3]
2	Co-60	1.19E+16	1.66E+16	32	Te-132	2.25E+18	2.41E+18[3]
3	Kr-85	1.20E+16	2.55E+16[3]	33	I-131	1.55E+18	1.70E+18[3]
4	Kr-85m	5.60E+17	4.07E+17[3]	34	I-132	2.28E+18	2.44E+18[3]
5	Kr-87	1.02E+18	7.77E+17[3]	35	I-133	3.28E+18	3.40E+18[3]
6	Kr-88	1.38E+18	1.07E+18[3]	36	I-134	3.60E+18	3.66E+18[3]
7	Rb-86	9.13E+14	1.27E+15	37	I-135	3.09E+18	3.15E+18[3]
8	Sr-89	1.74E+18	2.41E+18	38	Xe-133	3.28E+18	3.40E+18[3]
9	Sr-90	9.37E+16	1.30E+17	39	Xe-135	6.16E+17	7.03E+17[3]
10	Sr-91	2.23E+18	3.10E+18	40	Cs-134	2.09E+17	7.40E+17[3]
11	Sr-92	2.32E+18	3.23E+18	41	Cs-136	6.36E+16	1.48E+17[3]
12	Y-90	1.01E+17	1.40E+17	42	Cs-137	1.17E+17	3.15E+17[3]
13	Y-91	2.12E+18	2.94E+18	43	Ba-139	3.04E+18	4.22E+18
14	Y-92	2.33E+18	3.24E+18	44	Ba-140	3.01E+18	4.18E+18
15	Y-93	2.64E+18	3.67E+18	45	La-140	3.07E+18	4.27E+18
16	Zr-95	2.67E+18	3.72E+18	46	La-141	2.82E+18	3.92E+18
17	Zr-97	2.78E+18	3.87E+18	47	La-142	2.72E+18	3.78E+18
18	Nb-95	2.53E+18	3.51E+18	48	Ce-141	2.73E+18	3.80E+18
19	Mo-99	2.95E+18	4.10E+18	49	Ce-143	2.66E+18	3.70E+18
20	Tc-99m	2.55E+18	3.54E+18	50	Ce-144	1.65E+18	2.29E+18
21	Ru-103	2.20E+18	3.05E+18	51	Pr-143	2.61E+18	3.63E+18
22	Ru-105	1.43E+18	1.99E+18	52	Nd-147	1.17E+18	1.62E+18
23	Ru-106	4.99E+17	6.94E+17	53	Np-239	3.13E+19	4.35E+19
24	Rh-105	9.89E+17	1.38E+18	54	Pu-238	1.77E+15	2.46E+15
25	Sb-127	1.35E+17	1.87E+17	55	Pu-239	4.00E+14	5.56E+14
26	Sb-129	4.77E+17	6.64E+17	56	Pu-240	5.04E+14	7.01E+14
27	Te-127	1.30E+17	1.70E+17[3]	57	Pu-241	8.49E+16	1.18E+17
28	Te-127m	1.72E+16	2.59E+16[3]	58	Am-241	5.60E+13	7.79E+13
29	Te-129	4.48E+17	5.18E+17[3]	59	Cm-242	2.15E+16	2.98E+16
30	Te-129m	1.18E+17	1.48E+17[3]	60	Cm-244	1.26E+15	1.75E+15

(1) Core inventory obtained from MACCS2 Sample Problem A, adjusted to account for the PINGP power level

(2) MACCS2 allows up to 60 nuclides input

(3) PINGP USAR Appendix D, Rev. 18 Table D.1-1 provides 20 significant nuclide core inventories. These values are converted from Curies to Becquerels (3.7E10 bq/ci) for input into MACCS2. The remaining 40 nuclides inventories are based on Sample Problem A, adjusted to account for the PINGP power level, and increased by the average increase over the Sample Problem A inventory of the 20 PINGP specific nuclides.

Table F.3-4
MACCS2 Release Categories vs. PINGP Release Categories

MACCS2 Release Categories	PINGP Release Categories[3]
1-Xe/Kr	Noble Gases
2-I	CsI
3-Cs	CsOH
4-Te	TeO2 (Sb[1] & Te2[2] are included)
5-Sr	SrO
6-Ru(Mo)	MoO2 (Mo is in Ru MACCS category)
7-La	La2O3
8-Ce	CeO2 (UO2[2] are included)
9-Ba	BaO

(1) The largest release fraction of the TeO2 and Sb category is used
(2) These release fractions are typically negligible.
(3) Fission product groups from Table F.3-6 are grouped into Release Categories for input into MACCS2.

Table F.3-5
Representative MAAP Level 2 Case Descriptions and Key Event Timings

Case	Release Category	NMC Release Class(es)(1)	Representative Case Description	Tcd(2) (Hrs)	Tvf(3) (Hrs)	Tcf(4) (Hrs)	Tend(5) (Hrs)	Noble Gas Fraction	CsI(6) Fraction
1	H-XX-X	1X-XX-X 1L-XX-X 1H-XX-X	Core Damage, No Containment Failure (containment leakage only); No Rx Vessel Failure -or- Rx Vessel Failure at Low Pressure -or- Rx Vessel Failure at High Pressure	2.54	4.00	N/A	48	1.00E-03	3.00E-06
2	H-H2-E	1H-CI-E 1H-H2-E	Core Damage, Rx Vessel Failure at High Pressure, Early Containment Failure Due to Containment Isolation Failure -or- Overpressure Due to Hydrogen Combustion (or DCH, In-Vessel/Ex-Vessel Steam Explosions, etc.)	2.54	3.99	3.99	48	6.60E-01	1.80E-02
3	L-H2-E	1L-H2-E 1X-H2-E	Core Damage, Early Containment Failure on Overpressure Due to Hydrogen Combustion (or DCH, In-Vessel/Ex-Vessel Steam Explosions, etc.; Rx Vessel Failure at Low Pressure -or- No Rx Vessel Failure	7.40	9.01	9.01	48	7.50E-01	2.30E-02
4	L-CI-E	1L-CI-E 1X-CI-E	Core Damage, Early Containment Failure Due to Containment Isolation Failure; No Rx Vessel Failure -or- Rx Vessel Failure at Low Pressure	7.79	9.38	N/A	48	6.90E-01	3.30E-02
5	H-OT-L	1H-OT-L	Core Damage, Rx Vessel Failure at High Pressure, Late Containment Failure on Overtemperature or Overpressure	2.54	4.00	40.00	64	9.10E-01	6.00E-04
6	L-CC-L	1L-CC-L	Core Damage, Rx Vessel Failure at Low RCS Pressure, Late Containment Failure due to Core Concrete Interaction	0.27	0.81	40.00	64	1.00E+00	1.80E-03
7	H-DH-L	1H-DH-L	Core Damage, Rx Vessel Failure at High Pressure, Late Containment Failure on Overpressure Due to Failure to Remove Decay Heat	2.54	3.99	40.00	64	1.00E+00	6.00E-05
8	L-DH-L	1L-DH-L	Core Damage, Rx Vessel Failure at Low Pressure, Late Containment Failure on Overpressure Due to Failure to Remove Decay Heat	7.17	9.96	40.00	64	1.00E+00	3.00E-05

Table F.3-5 (Continue)
Representative MAAP Level 2 Case Descriptions and Key Event Timings

Case	Release Category	NMC Release Class(es)[(1)]	Representative Case Description	Tcd[(2)] (Hrs)	Tvf[(3)] (Hrs)	Tcf[(4)] (Hrs)	Tend[(5)] (Hrs)	Noble Gas Fraction	CsI[(6)] Fraction
9	SGTR	1GEH 1GLH 1L-SR-E	Early Core Damage -or- Late Core Damage from Steam Generator Tube Rupture, Containment Bypass (RCS at High Pressure) -or- Pressure- or Temperature-Induced SGTR	24.12	26.31	N/A	48	9.60E-01	3.50E-01
10	ISLOCA	1ISLOCA	Early Core Damage at High or Low Pressure with Containment Bypass from Intersystem LOCA	0.38	0.86	N/A	48	1.00E+00	7.60E-01

Notes to Table F.3-5

(1) Unit 2 CETs and release categories are identical except for a “2” designator in the first character of each name

(2) Tcd - Time of core damage (maximum core temperature > 1800°F)

(3) Tvf - Time of vessel breach

(4) Tcf – Time of containment failure

(5) Tend – Time at end of run

(6) CsI – Cesium Iodide release

Table F.3-6
Prairie Island Source Term Summary

	Release Category									
	H-XX-X	H-H2-E	L-H2-E	L-CI-E	H-OT-L	L-CC-L	H-DH-L	L-DH-L	SGTR	ISLOCA
Bin Frequency										
Run Duration	48 hr	48 hr	48 hr	48 hr	64 hr	64 hr	64 hr	64 hr	48 hr	48 hr
Time after Scram when General Emergency is declared (3)	2.6 hr	2.6 hr	7.7 hr	8.1 hr	2.6 hr	.7 hr	2.6 hr	7.5 hr	24.1 hr	.8 hr
Fission Product Group:										
1) Noble										
Total Plume 1 Release Fraction	1.00E-03	6.60E-01	7.50E-01	6.90E-01	9.10E-01	1.00E+00	1.00E+00	1.00E+00	9.60E-01	1.00E+00
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	48.00	4.00	9.00	10.00	40.00	40.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										
2) CsI										
Total Plume 1 Release Fraction	3.00E-06	1.80E-02	2.30E-02	3.30E-02	6.00E-04	1.80E-03	6.00E-05	3.00E-05	3.50E-01	7.60E-01
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	64.00	40.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]						4.00E-03		5.50E-05		
Start of Plume 2 Release (hr)						40.00		40.00		
End of Plume 2 Release (hr)						64.00		64.00		
3) TeO2										
Total Plume 1 Release Fraction	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	0.00E+00	2.00E-10	0.00E+00	5.00E-06
Start of Plume 1 Release (hr)						40.00		40.00		2.00
End of Plume 1 Release (hr)						40.00		40.00		2.00
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										

Table F.3-6
Prairie Island Source Term Summary (Continued)

	Release Category									
	H-XX-X	H-H2-E	L-H2-E	L-CI-E	H-OT-L	L-CC-L	H-DH-L	L-DH-L	SGTR	ISLOCA
4) SrO										
Total Plume 1 Release Fraction	1.50E-08	1.50E-04	2.00E-05	2.50E-05	3.00E-07	5.00E-06	5.00E-07	1.00E-08	3.00E-04	2.50E-02
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	40.00	40.00	40.00	40.00	26.00	2.00
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										
5) MoO2										
Total Plume 1 Release Fraction	8.00E-07	8.00E-03	2.80E-04	7.00E-05	2.00E-05	1.60E-07	2.00E-05	3.00E-08	2.00E-04	8.00E-04
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	40.00	40.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										
6) CsOH										
Total Plume 1 Release Fraction	3.00E-06	1.80E-02	2.30E-02	3.30E-02	8.00E-04	4.00E-03	4.00E-05	7.00E-05	3.30E-01	7.60E-01
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	64.00	40.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]						1.20E-02		1.50E-04		
Start of Plume 2 Release (hr)						40.00		40.00		
End of Plume 2 Release (hr)						64.00		64.00		

Table F.3-6
Prairie Island Source Term Summary (Continued)

	Release Category									
	H-XX-X	H-H2-E	L-H2-E	L-CI-E	H-OT-L	L-CC-L	H-DH-L	L-DH-L	SGTR	ISLOCA
7) BaO										
Total Plume 1 Release Fraction	1.50E-07	1.80E-03	1.50E-04	2.00E-04	3.00E-06	4.00E-06	5.00E-06	1.50E-07	2.00E-03	1.40E-02
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	40.00	40.00	40.00	40.00	26.00	2.00
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										
8) La2O3										
Total Plume 1 Release Fraction	7.00E-07	4.50E-04	3.00E-07	1.00E-02	4.00E-07	2.00E-06	1.00E-06	2.00E-05	6.00E-04	1.10E-01
Start of Plume 1 Release (hr)	2.50	4.00	9.00	9.00	40.00	1.00	40.00	40.00	26.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	40.00	1.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]						3.80E-06				
Start of Plume 2 Release (hr)						40.00				
End of Plume 2 Release (hr)						64.00				
9) CeO2										
Total Plume 1 Release Fraction	7.00E-07	4.50E-04	1.20E-06	1.00E-02	4.00E-07	2.00E-06	1.00E-06	2.00E-05	6.50E-04	1.10E-01
Start of Plume 1 Release (hr)	2.50	4.00	9.00	9.00	40.00	1.00	40.00	40.00	26.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	40.00	1.00	40.00	40.00	26.00	0.80
Total Plume 2 Release Fraction[2]						6.50E-06				
Start of Plume 2 Release (hr)						40.00				
End of Plume 2 Release (hr)						40.00				

Table F.3-6
Prairie Island Source Term Summary (Continued)

	Release Category									
	H-XX-X	H-H2-E	L-H2-E	L-CI-E	H-OT-L	L-CC-L	H-DH-L	L-DH-L	SGTR	ISLOCA
10) Sb										
Total Plume 1 Release Fraction	2.80E-06	2.10E-02	2.50E-03	3.50E-03	1.50E-03	8.00E-03	1.00E-04	2.00E-05	6.80E-02	3.40E-01
Start of Plume 1 Release (hr)	2.50	4.00	9.00	8.00	40.00	40.00	40.00	40.00	24.00	0.80
End of Plume 1 Release (hr)	10.00	4.00	9.00	10.00	64.00	40.00	40.00	40.00	26.00	4.00
Total Plume 2 Release Fraction[2]						2.00E-02	5.00E-04	5.50E-05		
Start of Plume 2 Release (hr)						40.00	40.00	40.00		
End of Plume 2 Release (hr)						64.00	64.00	64.00		
11) Te2										
Total Plume 1 Release Fraction	0.00E+00	0.00E+00	1.20E-04	8.00E-05	0.00E+00	4.00E-03	0.00E+00	1.50E-07	2.00E-03	3.60E-01
Start of Plume 1 Release (hr)			9.00	9.00		40.00		40.00	28.00	0.80
End of Plume 1 Release (hr)			9.00	10.00		40.00		40.00	30.00	2.00
Total Plume 2 Release Fraction[2]								3.00E-07		
Start of Plume 2 Release (hr)								40.00		
End of Plume 2 Release (hr)								64.00		
12) UO2										
Total Plume 1 Release Fraction	0.00E+00	0.00E+00	6.00E-09	4.00E-09	0.00E+00	2.00E-08	0.00E+00	0.00E+00	1.00E-07	7.00E-05
Start of Plume 1 Release (hr)			9.00	9.00		40.00			28.00	0.80
End of Plume 1 Release (hr)			9.00	10.00		40.00			30.00	2.00
Total Plume 2 Release Fraction[2]										
Start of Plume 2 Release (hr)										
End of Plume 2 Release (hr)										

(1) Puff releases are denoted in the table by those entries with equivalent start and end times.

(2) Plume 2 release fraction is cumulative and includes the initial plume 1 release fraction
(3) General Emergency declaration based on time of core damage per Prairie Island EAL Reference Manual, Rev 0

Table F.3-7
MACCS2 Base Case Mean Results

Source Term	Release Category	Dose (p-sv)(1)	Offsite Economic Cost ($)	Unit 1 Freq. (/yr)	Unit 1 Dose-Risk (p-rem/yr)(1)	Unit 1 OECR ($/yr)	Unit 2 Freq. (/yr)	Unit 2 Dose-Risk (p-rem/ yr)(1)	Unit 2 OECR ($/yr)
1	H-XX-X	1.75E+01	1.35E+02	7.28E-06	1.27E-02	9.83E-04	8.52E-06	1.49E-02	1.15E-03
2	H-H2-E	2.12E+04	1.05E+10	2.32E-11	4.91E-05	2.43E-01	2.32E-11	4.91E-05	2.43E-01
3	L-H2-E	2.15E+04	1.15E+10	5.61E-08	1.21E-01	6.46E+02	6.52E-08	1.40E-01	7.50E+02
4	L-CL-E	3.40E+04	1.85E+10	8.40E-10	2.86E-03	1.55E+01	9.17E-10	3.12E-03	1.70E+01
5	H-OT-L	2.63E+03	4.74E+07	4.89E-09	1.29E-03	2.32E-01	5.87E-09	1.54E-03	2.78E-01
6	L-CC-L	2.26E+04	2.97E+09	2.82E-07	6.37E-01	8.37E+02	3.39E-07	7.67E-01	1.01E+03
7	H-DH-L	2.11E+02	1.02E+06	3.09E-08	6.53E-04	3.16E-02	3.14E-08	6.63E-04	3.21E-02
8	L-DH-L	6.68E+02	7.89E+06	1.92E-06	1.28E-01	1.52E+01	1.97E-06	1.32E-01	1.55E+01
9	SGTR	5.62E+04	4.32E+10	2.33E-07	1.31E+00	1.01E+04	1.17E-06	6.58E+00	5.06E+04
10	ISLOCA	2.26E+05	6.31E+10	3.22E-08	7.28E-01	2.03E+03	3.22E-08	7.28E-01	2.03E+03
FREQUENCY WEIGHTED TOTALS				**9.85E-06**	**2.94E+00**	**1.36E+04**	**1.21E-05**	**8.37E+00**	**5.44E+04**

(1) MAACS2 provides dose results in Sieverts (sv). The MAACS2 result is converted to rem (1 sv = 100 rem) for the Dose-Risk results to be used in Section F.4.

Table F.5-1a
Unit 1 Level 1 Importance List Review

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SLOCAXXCDY	1.90E-02	1.62	OPERATOR FAILS TO PERFORM RCS COOLDOWN AND DEPRESSURIZATION ON SMALL LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
0HRECIRCC2Y	5.30E-02	1.588	OPERATOR FAILS TO INITIATE HH RECIRC COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Install control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
1RCPSL	1.00E+00	1.352	RCP SEAL LOCA FLAG	This flag identifies the importance of all RCP seal LOCA contributors. RCP seal LOCA failures will be addressed elsewhere in this table. (No specific SAMA identified)
I-1-SLOCAA	1.80E-03	1.326	LOOP A SMALL LOCA INITIATOR	This initiator identifies all Loop A small LOCA initiating events and is based on industry data. The specific contributors that make SLOCAs important are addressed individually in this table. (No specific SAMA identified)
I-1-SLOCAB	1.80E-03	1.326	LOOP B SMALL LOCA INITIATOR	This initiator identifies all Loop B small LOCA initiating events and is based on industry data. The specific contributors that make SLOCAs important are addressed individually in this table. (No specific SAMA identified)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-LOCL	1.00E+00	1.22	LOSS OF COOLING WATER INITIATING EVENT FREQUENCY	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
1LVM32060XN	3.00E-03	1.141	VALVE MV-32060 FAILS TO OPEN	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. However, operator recovery actions may only provide limited benefit due to the high uncertainty involved. Consider installing air operated valve in parallel to provide continuous suction source of water from RWST. (SAMA 3)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-LOOP	3.20E-02	1.118	LOOP INITIATOR FREQUENCY	The importance of the LOOP initiator flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the PI LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. (No specific SAMA identified)
0SMP11XXXYR	9.55E-02	1.112	11 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SMP21XXXYR	9.55E-02	1.112	21 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
0FAILROSP1Y	2.88E-01	1.094	OPERATOR FAILS TO RESTORE OFFSITE POWER 1 HOUR AFTER SBO	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power. (SAMA 5) In addition, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed. (SAMA 7)
0SPD22XXXXR	3.91E-02	1.094	22 CL PUMP FAILS TO RUN (DIESEL DRIVER)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0FAILROSP6Y	1.71E-01	1.065	OPERATOR FAILS TO RESTORE OFFSITE POWER WITH OA7 SUCCESS AND HI FLOW RCP SEAL LE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power. (SAMA 5) The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed. (SAMA 7) Installation of a swing or SBO diesel would provide increased defense in depth and could be considered for LOOP conditions. (SAMA 8) Consider enhancing the PRA to credit recovery of operator failure based on TSC and EOF oversight. (No specific SAMA identified)
1NOCONLOCA	1.00E+00	1.052	NO CONSEQUENTIAL LOCA FLAG	This event is informational and categorizes those small LOCAs that do not involve stuck open relief valves. (No specific SAMA identified)
0SPD12XXXXR	3.91E-02	1.049	12 CL PUMP FAILS TO RUN (DIESEL DRIVER)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-1-TR4	9.10E-02	1.041	LOSS OF MFW INITIATING EVENT FREQUENCY	This initiating event frequency is based on plant operating experience and takes into account IPE recommendation no. 2 (see Section F.5.1.5). Equipment performance and reliability could be enhanced if key components were added to the MR. (No specific SAMA identified)
2AG7D5XXXXR	5.64E-02	1.04	D5 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel of a different design would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
0SED11RFEXS	4.80E-03	1.035	11 SAFEGUARDS SCREENHOUSE ROOF EXHAUST FAN FAILS TO START	Failure of safeguards screenhouse roof exhaust fans fails the associated cooling water pumps. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth without having to rely on the opposite train of cooling water. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (see SAMA 2) Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc. (SAMA 9)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1LBI112BXXE	7.46E-04	1.031	BISTABLE 1-LC-112BX FAILS TO FUNCTION	Failure of this level controller disables the RWST auto transfer feature, rendering the RWST unavailable as an alternate water source to the charging pumps. Alternate means of RWST transfer could be developed, either procedurally or via plant modification. For example, parallel level transmitter signal path that could prevent a spurious failure of any one signal rendering suction unavailable to the charging pumps. A 2 out of 2 level control logic would be required for auto transfer of charging pump suction. (SAMA 10)
1LBI141BXXE	7.46E-04	1.031	BISTABLE 1-LC-141BX FAILS TO FUNCTION	Failure of this level controller disables the RWST auto transfer feature, rendering the RWST unavailable as an alternate water source to the charging pumps. Alternate means of RWST transfer could be developed, either procedurally or via plant modification. For example, parallel level transmitter signal path that could prevent a spurious failure of any one signal rendering suction unavailable to the charging pumps. A 2 out of 2 level control logic would be required for auto transfer of charging pump suction. (SAMA 10)
0HRECIRCXXY	9.50E-03	1.03	OPERATOR FAILS TO INITATE HIGH HEAD RECIRC. FOR A MEDIUM LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-1-LOCC	1.00E+00	1.03	LOSS OF COMPONENT COOLING WATER INITIATING EVENT FREQUENCY	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. A release path will be required since FPS is not a closed system. (SAMA 12)
0RRECIRCXXY	6.80E-02	1.029	OPERATOR FAILS TO INITIATE LOW HEAD RECIRC. WHEN REQUIRED	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
2AG7D6XXXXR	5.64E-02	1.029	D6 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel of a different design would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
0SDCXXXXCCR	1.66E-03	1.026	12, 22 CL PUMPS FAIL TO RUN DUE TO CCF OF DIESEL DRIVERS	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SE211RFCCS	2.03E-04	1.025	11, 21 SAFEGUARDS SCREENHOUSE ROOF EXHAUST FANS FAIL TO START DUE TO CCF	Failure of safeguards screenhouse roof exhaust fans fails the associated cooling water pumps. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth without having to rely on the opposite train of cooling water. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (see SAMA 2) Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc. (SAMA 9)
0SPM121XXPM	1.39E-02	1.025	121 CL PUMP UNAVAILABLE DUE TO PREVENTIVE MAINTENANCE	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1AG5D2XXXXR	4.63E-02	1.025	D2 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel of a different design would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
I-1-TR1	7.00E-01	1.025	NORMAL TRANSIENT INITIATING EVENT FREQUENCY	The importance of the Normal Transient initiator provides limited information about plant risk given that the transient category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the PI Normal Transient frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve BOP work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. (No specific SAMA identified)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0AB7FLDISLY	3.30E-03	1.024	OPERATOR FAILS TO ISOLATE AUXILIARY BUILDING ZONE 7 FLOODING SOURCE	This initiator represents an internal flooding scenario that disables various safety-related components. Mitigation of this event can be accomplished via an automatic sump pump system to remove water if the operator fails to isolate Zone 7 of the Aux. Bldg. (SAMA 13) Consider installing waterproof (EQ) equipment (valves / level sensors) capable of automatically isolating the flooding source. (SAMA 6) Consider segregating this zone into 2 compartments to reduce the impact of a flood on both trains of SI and RHR. (SAMA 6a)
1AG5D1XXXXR	4.63E-02	1.024	D1 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel of a different design would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
0SPCHZXYCCR	3.50E-03	1.021	11 AND 21 HORIZONTAL CL PUMPS FAIL TO RUN DUE TO CCF (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1a
Unit 1 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SDM34137XN	2.88E-03	1.02	CD-34137 FAILS TO OPEN (11 SAFEGUARDS SCREENHOUSE ROOF EXHAUST DAMPER)	Failure of safeguards screenhouse roof exhaust fans fails the associated cooling water pumps. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth without having to rely on the opposite train of cooling water. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
1NOSBO	1.00E+00	1.02	NO STATION BLACKOUT FLAG	This flag provides information only on the nature of the cutset that leads to core damage (CD). The only information conveyed is that the accident sequence does not involve SBO. (No specific SAMA identified)

Table F.5-1b
Unit 2 Level 1 Importance List Review

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SLOCAXXCDY	1.90E-02	1.533	OPERATOR FAILS TO PERFORM RCS COOLDOWN AND DEPRESSURIZATION ON SMALL LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
0HRECIRCC2Y	5.30E-02	1.43	OPERATOR FAILS TO INITIATE HH RECIRC COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION.	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Install control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
I-2-SLOCAA	1.80E-03	1.287	LOOP A SMALL LOCA INITIATOR	This initiator identifies all Loop A small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
I-2-SLOCAB	1.80E-03	1.287	LOOP B SMALL LOCA INITIATOR	This initiator identifies all Loop B small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
2RCPSL	1.00E+00	1.279	RCP SEAL LOCA FLAG	This flag identifies the importance of all RCP seal LOCA contributors. RCP seal LOCA failures will be addressed elsewhere in this table. (No specific SAMA identified)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-LOCL	1.00E+00	1.172	LOSS OF COOLING WATER INITIATING EVENT FREQUENCY	Failure of the cooling water system may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
2LVM32062XN	3.00E-03	1.113	VALVE MV-32062 FAILS TO OPEN	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. However, operator recovery actions may only provide limited benefit due to the high uncertainty involved. Consider installing air operated valve in parallel to provide continuous suction source of water from RWST. (SAMA 3)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-LOOP	3.20E-02	1.106	LOOP INITIATOR FREQUENCY	The importance of the LOOP initiator flag provides limited information about plant risk given that the LOOP category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the PI LOOP frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve switchyard work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. (No specific SAMA identified)
0SMP11XXXYR	9.55E-02	1.089	11 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SMP21XXXYR	9.55E-02	1.089	21 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
0FAILROSP1Y	2.88E-01	1.084	OPERATOR FAILS TO RESTORE OFFSITE POWER 1 HOUR AFTER SBO	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power. (SAMA 5) Finally, the ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed. (SAMA 7)
0SGTRXXXCDY	9.20E-03	1.08	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS FOR A SGTR BEFORE SG OVERFILL	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2RSTSUMPBXF	7.20E-03	1.078	CONTAINMENT SUMP B STRAINER PLUGS DUE TO DEBRIS	This event inhibits or prevents recirculation from the containment sump to the RCS during a small LOCA condition. A potential SAMA could address the source of debris and removal or reinforcement of any equipment such that the likelihood of clogging is reduced. In addition, consideration of a different type of strainer, or multiple strainers, could provide added reliability of recirculation. (SAMA 24)
2NOCONLOCA	1.00E+00	1.077	NO CONSEQUENTIAL LOCA FLAG	This event is informational and categorizes those small LOCAs that do not involve stuck open relief valves. (No specific SAMA identified)
0SPD22XXXXR	3.91E-02	1.075	22 CL PUMP FAILS TO RUN (DIESEL DRIVER)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0FAILROSP6Y	1.71E-01	1.057	OPERATOR FAILS TO RESTORE OFFSITE POWER WITH OA7 SUCCESS AND HI FLOW RCP SEAL LE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP by prolonging the time the plant can operate without offsite AC power. (SAMA 5) The ability to cross-tie emergency 4kV AC buses would allow the operators to power functional equipment in divisions where the corresponding EDG has failed. (SAMA 7) Installation of a swing or SBO diesel would provide increased defense in depth and could be considered for LOOP conditions. (SAMA 8)
I-2-SGTRA	4.50E-03	1.049	21 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies all unit 2A steam generator tube rupture initiating events and is based on industry data. Therefore, mitigative actions will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)
I-2-SGTRB	4.50E-03	1.049	22 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies all unit 2B steam generator tube rupture initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2SGTRRLFFTC	5.00E-01	1.045	SG RELIEF FAILS TO CLOSE FOLLOWING SG OVERFILL (SGTR)	Reinforce operator training to isolate PORVs when symptoms reveal valves have failed to re-seat. This reduces the amount of radioactivity released to the environment. Consider replacing with more reliable or robust valves to better isolate following lifting. (SAMA 14)
2SGTRRLFSUC	5.00E-01	1.045	SUCCESSFUL SG RELIEF VALVE CLOSURE FOLLOWING SG OVERFILL (SGTR)	This event represents successful closure of SG relief valve following SG overfill. See above for additional information. (No specific SAMA identified)
2AG7D5XXXXR	5.64E-02	1.044	D5 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
0SGTRXXEC3Y	5.80E-03	1.042	OPERATOR FAILS IN USE OF ECA-3.1/3.2 FOLLOWING SG OVERFILL (SGTR)	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
0SPD12XXXXR	3.91E-02	1.041	12 CL PUMP FAILS TO RUN (DIESEL DRIVER)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-2-TR4	9.10E-02	1.035	LOSS OF MFW INITIATING EVENT FREQUENCY	This initiating event frequency is based on plant operating experience and takes into account IPE recommendation no. 2 (see Section F.5.1.5). Equipment performance and reliability could be enhanced if key components were added to the MR. (No specific SAMA identified)
0EOPHXCONXY	2.30E-02	1.034	OPERATOR FAILS TO LINE UP OTHER UNIT MDAFW PUMP	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installing a spare turbine-driven AFW pump per unit. This would increase reliability of AFW system for each unit. The new pumps would be dedicated to the corresponding unit with no cross-tie capability, thereby eliminating operator error for this action. Note - some operating PWRs have (3) AFW pumps per unit, which provide greater redundancy and defense in depth. (SAMA 18)
I-2-LODCA	8.80E-04	1.034	LOSS OF TRAIN A DC INITIATOR FREQUENCY	Consider a portable DC power source, such as a rectifier or skid-mounted battery pack that could be used for restoring DC control power to vital components, such as breakers, solenoid valves, etc. (SAMA 15)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2RVM32169XN	3.00E-03	1.032	MV-32169 FAILS TO OPEN	Failure of MV-32169 to open disables RHR Loop B return. Proper operation of this valve is most likely tracked via the MR. Consider replacing this MOV with a fail closed (FC) air-operated valve for improved reliability. This would eliminate CCF for inboard MOVs that currently exist on this flowpath. (SAMA 16) Alternatively, a bypass flowpath could be installed around inboard RHR Loop B return valves for improved defense in depth. (SAMA 17)
2AG7D6XXXXR	5.64E-02	1.031	D6 DIESEL GENERATOR FAILS TO RUN	Installation of a swing or SBO diesel would provide increased defense in depth and could be considered for loss of onsite emergency AC power sources. (SAMA 8)
2EPT22AFTXR	2.01E-02	1.031	22 AF PUMP FAILS TO RUN (TURBINE DRIVER PORTION)	Consider installing a spare turbine-driven AFW pump per unit. This would increase reliability of AFW system for each unit. The new pumps would be dedicated to the corresponding unit with no cross-tie capability, thereby eliminating operator error for this action. Note - some operating PWRs have (3) AFW pumps per unit, which provide greater redundancy and defense in depth. (SAMA 18)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SED11RFEXS	4.80E-03	1.028	11 SAFEGUARDS SCREENHOUSE ROOF EXHAUST FAN FAILS TO START	Failure of safeguards screenhouse roof exhaust fans fails the associated cooling water pumps. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth without having to rely on the opposite train of cooling water. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2) Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc. (SAMA 9)
2LBI112BXXE	7.46E-04	1.025	BISTABLE 2-LC-112BX FAILS TO FUNCTION	Failure of this level controller disables the RWST auto transfer feature, rendering the RWST unavailable as an alternate water source to the charging pumps (in the event cooling water is lost). Alternate means of RWST transfer could be developed, either procedurally or via plant modification (SAMA 10). Auto transfer logic improvements, such as improved level controller reliability could also be considered. (SAMA 11)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2LBI141BXXE	7.46E-04	1.025	BISTABLE 2-LC-141BX FAILS TO FUNCTION	Failure of this level controller disables the RWST auto transfer feature, rendering the RWST unavailable as an alternate water source to the charging pumps (in the event cooling water is lost). Alternate means of RWST transfer could be developed, either procedurally or via plant modification (SAMA 10). Auto transfer logic improvements, such as improved level controller reliability could also be considered. (SAMA 11)
I-2-LOCC	1.00E+00	1.025	LOSS OF COMPONENT COOLING WATER INITIATING EVENT FREQUENCY	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. A release path will be required since FPS is not a closed system. (SAMA 12)
0HRECIRCXXY	9.50E-03	1.024	OPERATOR FAILS TO INITATE HIGH HEAD RECIRC. FOR A MEDIUM LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)

Table F.5-1b Unit 2 Level 1 Importance List Review (Continued)				
Event Name	**Probability**	**Risk Reduction Worth**	**Description**	**Potential SAMAs**
I-2-TR1	7.00E-01	1.024	NORMAL TRANSIENT INITIATING EVENT FREQUENCY	The importance of the Normal Transient initiator provides limited information about plant risk given that the transient category is broad and includes several different contributors. These contributors are represented by other events in this importance list that better define specific failures that can be investigated to identify means of reducing plant risk. No credible means of reducing the PI Normal Transient frequency have been identified. Implementation of the Maintenance Rule is considered to address equipment reliability issues such that no measurable improvement is likely available based on enhancing maintenance practices. It may be possible to improve BOP work planning and/or practices, but a reliable means of quantifying the impact of these types of changes is not available. (No specific SAMA identified)
0RRECIRCXXY	6.80E-02	1.023	OPERATOR FAILS TO INITIATE LOW HEAD RECIRC. WHEN REQUIRED	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
I-2-MLOCAA	1.50E-05	1.023	LOOP A MEDIUM LOCA INITIATOR	This initiator identifies all Loop A medium LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-2-MLOCAB	1.50E-05	1.023	LOOP B MEDIUM LOCA INITIATOR	This initiator identifies all Loop B medium LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
0FDBLDOPATY	1.70E-01	1.022	OPERATOR FAIL TO ESTABLISH BLEED & FEED COND. ON RESTORING FEEDWATER	This is a conditional operator action failure probability that is dependent on failure of an earlier operator action. Restoration of AFW would render this event unnecessary. Therefore, consider installing a spare turbine-driven AFW pump per unit. This would increase reliability of AFW system for each unit. The new pumps would be dedicated to the corresponding unit with no cross-tie capability, thereby eliminating operator error for this action. Note - some operating PWRs have (3) AFW pumps per unit, which provide greater redundancy and defense in depth. (SAMA 18)
0SDCXXXXCCR	1.66E-03	1.022	12, 22 CL PUMPS FAIL TO RUN DUE TO CCF OF DIESEL DRIVERS	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0AB7FLDISLY	3.30E-03	1.02	OPERATOR FAILS TO ISOLATE AUXILIARY BUILDING ZONE 7 FLOODING SOURCE	This initiator represents an internal flooding scenario that disables various safety-related components. Mitigation of this event could be accomplished via an automatic sump pump system to remove water if the operator fails to isolate Zone 7 of the Aux. Bldg. (SAMA 13)
0SE211RFCCS	2.03E-04	1.02	11, 21 SAFEGUARDS SCREENHOUSE ROOF EXHAUST FANS FAIL TO START DUE TO CCF	Failure of safeguards screenhouse roof exhaust fans fails the associated cooling water pumps. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth without having to rely on the opposite train of cooling water. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2) Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc. (SAMA 9)

Table F.5-1b
Unit 2 Level 1 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SPM121XXPM	1.39E-02	1.02	121 CL PUMP UNAVAILABLE DUE TO PREVENTIVE MAINTENANCE	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-2a
Unit 1 Level 2 Importance List Review

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SLOCAXXCDY	1.90E-02	1.613	OPERATOR FAILS TO PERFORM RCS COOLDOWN AND DEPRESSURIZATION ON SMALL LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
I-1-ISLOCA	1.00E+00	1.579	INTERFACING SYSTEM LOCA INITIATING EVENT FREQUENCY	This initiator identifies all interfacing system LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
1NORVSTKOPN	8.35E-01	1.556	NO DEPRESSURIZATION DUE TO PORV/SRV STUCK OPEN DURING CYCLING	This event conveys information that the PORV did not fail to re-seat following pressure relief; therefore no failure mechanism involved. (No specific SAMA identified)
1TISGTRPROB	5.53E-03	1.501	2-LOOP W PWR TEMPERATURE-INDUCED SGTR PROBABILITY	This basic event represents a phenomenological event for Level 2 accident scenarios. It is based on Westinghouse PWR analyses. No SAMA required.
0HRECIRCC2Y	5.30E-02	1.281	OPERATOR FAILS TO INITIATE HH RECIRC COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION.	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
1HPIPERUP	4.00E-03	1.266	CONDITIONAL PROBABILITY OF LP PIPING RUPTURE WHEN EXPOSED TO RCS PRESSURE	This basic event represents a phenomenological event for Level 2 accident scenarios. (No specific SAMA identified)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1SGTRECD	1.00E+00	1.227	SGTR SEQUENCES INVOLVING EARLY CORE DAMAGE	This flag identifies the importance of SGTR sequences that involve early core damage. Component failures will be addressed elsewhere in this table. (No specific SAMA identified)
0SGTRXXCD1Y	5.00E-02	1.223	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS WITH SI FAILURE FOR A SGTR	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
I-1-SLOCAA	1.80E-03	1.146	LOOP A SMALL LOCA INITIATOR	This initiator identifies all Loop A small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
I-1-SLOCAB	1.80E-03	1.146	LOOP B SMALL LOCA INITIATOR	This initiator identifies all Loop B small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
1RVH32164XL	1.31E-04	1.105	MV-32164 (LP A HL TO RHR SUCTION) CATASTROPHIC LEAK (POWER TO VALVE REMOVED)	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1RVH32230XL	1.31E-04	1.105	MV-32230 (LP B HL TO RHR SUCTION) CATASTROPHIC LEAK	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)
I-1-SGTRA	7.98E-04	1.102	11 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies SGTR initiating events for 11 / 12 SG and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)
I-1-SGTRB	7.98E-04	1.102	12 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies SGTR initiating events for 11 / 12 SG and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)
1RVM32165XL	2.63E-03	1.099	MV-32165 (LP A HL TO RHR SUCTION) FAILS TO REMAIN CLOSED	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1RVM32231XL	2.63E-03	1.099	MV-32231 (LP B HL TO RHR SUCTION) FAILS TO REMAIN CLOSED	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)
1HVCSI95XXL	1.31E-03	1.092	CHECK VALVE SI-9-5 CATASTROPHIC LEAK	This check valve is in series with a second check valve (SI-9-3), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
1HVCSI96XXL	1.31E-03	1.092	CHECK VALVE SI-9-6 CATASTROPHIC INTERNAL LEAK	This check valve is in series with a second check valve (SI-9-4), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
1RCPSL	1.00E+00	1.088	RCP SEAL LOCA FLAG	This flag identifies the importance of all RCP seal LOCA contributors. RCP seal LOCA failures will be addressed elsewhere in this table. (No specific SAMA identified)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1HVCSI93XXL	1.31E-03	1.085	CHECK VALVE SI-9-3 CATASTROPHIC LEAK	This check valve is in series with a second check valve (SI-9-5), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
1HVCSI94XXL	1.31E-03	1.085	CHECK VALVE SI-9-4 CATASTROPHIC INTERNAL LEAK	This check valve is in series with a second check valve (SI-9-6), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
1PISGTRSECB	1.00E+00	1.084	PRESSURE-INDUCED SGTR PROBABILITY FOR MSLB/MFLB EVENTS WITH HIGH/DRY SG	This flag identifies pressure-induced SGTR scenarios due to high differential pressure across the SG tubes. Components related to this event will be addressed elsewhere in this table. (No specific SAMA identified)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-LOCL	1.00E+00	1.067	LOSS OF COOLING WATER INITIATING EVENT FREQUENCY	Failure of the cooling water system may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
1PORVLOCA	1.00E+00	1.053	TRANSIENT INDUCED PORV LOCA FLAG	This flag identifies those scenarios whereby the PORV fails to re-seat after opening to provide pressure relief. Due to the importance of this event, a SAMA can be developed to make PORV more reliable thereby reducing failure frequency. (SAMA 21)
0HRECIRCCMY	1.50E-01	1.052	OPERATOR FAILS TO INITIATE HH RECIRC FOR SLOCA COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
0PORVBLOCKY	5.00E-02	1.052	OPERATOR FAILS TO CLOSE BLOCK VALVE TO ISOLATE STUCK OPEN PORV	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SLOCAXCCDY	6.80E-02	1.051	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS COND. ON FAILURE TO ISOLATE PZR PORV	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
I-1-MSLBB-UP	4.41E-04	1.051	12 SG STEAMLINE BREAK UPSTREAM OF MSIV INITIATOR FREQUENCY	This initiator identifies 12 SG steamline break initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
1LVM32060XN	3.00E-03	1.048	VALVE MV-32060 FAILS TO OPEN	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. However, operator recovery actions may only provide limited benefit due to the high uncertainty involved. Consider installing air operated valve in parallel to provide continuous suction source of water from RWST. (SAMA 3)
1NOCONLOCA	1.00E+00	1.048	NO CONSEQUENTIAL LOCA FLAG	This event is informational and categorizes those small LOCAs that do not involve stuck open relief valves. (No specific SAMA identified)
1BCC01XXCCS	4.50E-05	1.043	#11 AND #12 CC PUMPS FAIL TO START DUE TO CCF	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. (SAMA 12)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
0SMP11XXXYR	9.55E-02	1.038	11 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
0SMP21XXXYR	9.55E-02	1.038	21 CL PUMP FAILS TO RUN (1 YEAR MISSION TIME)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)
0SPD22XXXXR	3.91E-02	1.029	22 CL PUMP FAILS TO RUN (DIESEL DRIVER)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures. (SAMA 2)

Table F.5-2a
Unit 1 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
1HSS1211CCS	2.99E-05	1.028	#11 AND #12 SI PUMPS FAIL TO START DUE TO COMMON CAUSE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure. (SAMA 5)
1PISGTRPROB	5.03E-04	1.028	2-LOOP W PWR PRESSURE-INDUCED SGTR PROBABILITY	This basic event represents a phenomenological event for Level 2 accident scenarios. It is based on Westinghouse PWR analyses. (No specific SAMA identified)
1V1PZRPORVF	1.00E-01	1.027	FAILURE OF PZR PORV AIR ACCUMULATOR FOLLOWING LOSS OF AIR	The station air and instrument air cross-tie has been proceduralized per IPE recommendation no. 1 (see Section F.5.1.5). Consider a portable air compressor to be used in the event of loss of air. Air compressor can be connected to air header to provide backup supply of air. (SAMA 22)
1HSS1112CCR	2.76E-05	1.026	#11 AND #12 SI PUMPS FAIL TO RUN DUE TO COMMON CAUSE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure. (SAMA 5)
1VA131231XC	2.94E-03	1.026	PORV CV-31231 FAILS TO CLOSE	This event identifies the PORV failing to re-seat after opening to provide pressure relief. Due to the importance of this event, a SAMA can be developed to make the PORV more reliable thereby reducing failure frequency. (SAMA 21)
1VA131232XC	2.94E-03	1.026	PORV CV-31232 FAILS TO CLOSE	This event identifies the PORV failing to re-seat after opening to provide pressure relief. Due to the importance of this event, a SAMA can be developed to make the PORV more reliable thereby reducing failure frequency. (SAMA 21)

Table F.5-2b
Unit 2 Level 2 Importance List Review

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2SGTRECD	1.00E+00	2.29	SGTR SEQUENCES INVOLVING EARLY CORE DAMAGE	This flag identifies the importance of SGTR sequences that involve early core damage. Component failures will be addressed elsewhere in this table. (No specific SAMA identified)
0SGTRXXCD1Y	5.00E-02	2.236	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS WITH SI FAILURE FOR A SGTR	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
I-2-SGTRA	4.50E-03	1.392	21 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies SGTR initiating events for 21 SG and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)
I-2-SGTRB	4.50E-03	1.392	22 SG STEAM GENERATOR TUBE RUPTURE INITIATING EVENT FREQ.	This initiator identifies SGTR initiating events for 22 SG and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario. (SAMA 19a)
0SLOCAXXCDY	1.90E-02	1.256	OPERATOR FAILS TO PERFORM RCS COOLDOWN AND DEPRESSURIZATION ON SMALL LOCA	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2NORVSTKOPN	8.35E-01	1.256	NO DEPRESSURIZATION DUE TO PORV/SRV STUCK OPEN DURING CYCLING	This event conveys information that the PORV did not fail to re-seat following pressure relief. Therefore, since there is no failure mechanism involved, no SAMA required. (No specific SAMA identified)
2TISGTRPROB	5.53E-03	1.236	2-LOOP W PWR TEMPERATURE-INDUCED SGTR PROBABILITY	This basic event represents a phenomenological event for Level 2 accident scenarios. It is based on Westinghouse PWR analyses. (No specific SAMA identified)
I-2-ISLOCA	1.00E+00	1.225	INTERFACING SYSTEM LOCA INITIATING EVENT FREQUENCY	This initiator identifies all interfacing system LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
2BCC01XXCCS	4.50E-05	1.131	#21 AND #22 CC PUMPS FAIL TO START DUE TO CCF	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. (SAMA 12)
0HRECIRCC2Y	5.30E-02	1.124	OPERATOR FAILS TO INITIATE HH RECIRC COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION.	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Install control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2HPIPERUP	4.00E-03	1.118	CONDITIONAL PROBABILITY OF LP PIPING RUPTURE WHEN EXPOSED TO RCS PRESSURE	This basic event represents a phenomenological event for Level 2 accident scenarios. (No specific SAMA identified)
2HSS2122CCS	2.99E-05	1.083	#21 AND #22 SI PUMPS FAIL TO START DUE TO COMMON CAUSE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure (SAMA 5).
I-2-SLOCAA	1.80E-03	1.078	LOOP A SMALL LOCA INITIATOR	This initiator identifies all Loop A small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
I-2-SLOCAB	1.80E-03	1.078	LOOP B SMALL LOCA INITIATOR	This initiator identifies all Loop B small LOCA initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
2HSS2122CCR	2.76E-05	1.076	#21 AND #22 SI PUMPS FAIL TO RUN DUE TO COMMON CAUSE	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure (SAMA 5).
2BU2TRNBXPM	4.10E-03	1.05	UNIT 2 TRAIN B CC UNAVAILABLE DUE TO PREVENTIVE MAINTENANCE	Consider deferring those PM tasks that require lengthy restoration to outage periods. For all other PM tasks, provide discreet protective barriers and signage for opposite (running) train. Online configuration risk management process most likely already takes this into account. (No specific SAMA identified)
2RVH32192XL	1.31E-04	1.05	MV-32192 (LP A HL TO RHR SUCTION) CATASTROPHIC LEAK (POWER TO VALVE REMOVED)	Consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2RVH32232XL	1.31E-04	1.05	MV-32232 (LP B HL TO RHR SUCTION) CATASTROPHIC LEAK	Consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)
2HPI21SIXXR	1.12E-03	1.048	#21 SI PUMP FAILS TO RUN DURING HIGH HEAD INJECTION	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure (SAMA 5). Unit 2 SGTR frequency is higher than the frequency used for Unit 1. This appears to be driving the importance of this event.
2RVM32193XL	2.63E-03	1.047	MV-32193 (LP A HL TO RHR SUCTION) FAILS TO REMAIN CLOSED	Consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)
2RVM32233XL	2.63E-03	1.047	MV-32233 (LP B HL TO RHR SUCTION) FAILS TO REMAIN CLOSED	Consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is. (SAMA 19)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2HVCSI95XXL	1.31E-03	1.044	CHECK VALVE 2SI-9-5 CATASTROPHIC LEAK	This valve is in series with a second check valve (2SI-9-3), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
2HVCSI96XXL	1.31E-03	1.044	CHECK VALVE 2SI-9-6 CATASTROPHIC INTERNAL LEAK	This valve is in series with a second check valve (2SI-9-4), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
2PISGTRSECB	1.00E+00	1.044	PRESSURE-INDUCED SGTR PROBABILITY FOR MSLB/MFLB EVENTS WITH HIGH/DRY SG	This flag identifies pressure-induced SGTR scenarios due to high differential pressure across the SG tubes. Components related to this event will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. (No specific SAMA identified)
2RCPSL	1.00E+00	1.044	RCP SEAL LOCA FLAG	This flag identifies the importance of all RCP seal LOCA contributors. RCP seal LOCA failures will be addressed elsewhere in this table. (No specific SAMA identified)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2HVCSI93XXL	1.31E-03	1.041	CHECK VALVE 2SI-9-3 CATASTROPHIC LEAK	This valve is in series with a second check valve (2SI-9-5), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
2HVCSI94XXL	1.31E-03	1.041	CHECK VALVE 2SI-9-4 CATASTROPHIC INTERNAL LEAK	This valve is in series with a second check valve (2SI-9-6), both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition. (SAMA 20)
I-LOCL	1.00E+00	1.033	LOSS OF COOLING WATER INITIATING EVENT FREQUENCY	This event identifies all loss of cooling water scenarios that lead to CD. Due to the importance of this event, a SAMA can be developed to make use of alternate cooling water sources. (SAMA 2)
2HTRAINAXPM	1.87E-03	1.032	UNIT 2 SI TRAIN A OUT FOR PREVENTIVE MAINTENANCE	Consider deferring those PM tasks that require lengthy restoration to outage periods. For all other PM tasks, provide discreet protective barriers and signage for opposite train. Online configuration risk management process most likely already takes this into account. (No specific SAMA identified)
2NOCONLOCA	1.00E+00	1.031	NO CONSEQUENTIAL LOCA FLAG	This event is informational and categorizes those small LOCAs that do not involve stuck open relief valves. (No specific SAMA identified)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2BPC21XXXXS	6.90E-04	1.029	#21 CC PUMP FAILS TO START	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. (SAMA 12) Unit 2 SGTR frequency is higher than the frequency used for Unit 1. This appears to be driving the importance of this event.
2PORVLOCA	1.00E+00	1.028	TRANSIENT INDUCED PORV LOCA FLAG	This flag identifies those scenarios whereby the PORV fails to re-seat after opening to provide pressure relief. Due to the importance of this event, a SAMA can be developed to make PORV more reliable thereby reducing failure frequency. (SAMA 21)
0PORVBLOCKY	5.00E-02	1.027	OPERATOR FAILS TO CLOSE BLOCK VALVE TO ISOLATE STUCK OPEN PORV	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
2HPI21SIXXS	6.46E-04	1.027	#21 SI PUMP FAILS TO START DURING HIGH HEAD INJECTION	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of SI pump failure (SAMA 5). Unit 2 SGTR frequency is higher than the frequency used for Unit 1. This appears to be driving the importance of this event.

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
I-2-MSLBB-UP	4.41E-04	1.027	22 SG STEAMLINE BREAK UPSTREAM OF MSIV INITIATOR FREQUENCY	This initiator identifies 22 SG steamline break initiating events and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. (No specific SAMA identified)
0SLOCAXCCDY	6.80E-02	1.026	OPERATOR FAILS TO COOLDOWN AND DEPRESSURIZE RCS COND. ON FAILURE TO ISOLATE PZR PORV	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. (No specific SAMA identified)
0HRECIRCCMY	1.50E-01	1.025	OPERATOR FAILS TO INITIATE HH RECIRC FOR SLOCA COND. ON FAILURE OF RCS COOLDOWN AND DEPRESSURIZATION	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installation of control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST. (SAMA 1)
2LVM32062XN	3.00E-03	1.024	VALVE MV-32062 FAILS TO OPEN	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. However, operator recovery actions may only provide limited benefit due to the high uncertainty involved. Consider installing air operated valve in parallel to provide continuous suction source of water from RWST. (SAMA 3)

Table F.5-2b
Unit 2 Level 2 Importance List Review (Continued)

Event Name	Probability	Risk Reduction Worth	Description	Potential SAMAs
2HTRAINBXPM	1.87E-03	1.022	UNIT 2 TRAIN B SI OUT FOR PREVENTIVE MAINTENANCE	Consider deferring those PM tasks that require lengthy restoration to outage periods. For all other PM tasks, provide discreet protective barriers and signage for opposite train. Online configuration risk management process most likely already takes this into account. (No specific SAMA identified)
0SCLLOOPBPM	1.73E-03	1.021	COOLING WATER LOOP B HEADER OUTAGE MAINTENANCE	Consider deferring those PM tasks that require lengthy restoration to outage periods. For all other PM tasks, provide discreet protective barriers and signage for opposite (running) train. Online configuration risk management process most likely already takes this into account. (No specific SAMA identified)
2RSTSUMPBXF	7.20E-03	1.021	CONTAINMENT SUMP B STRAINER PLUGS DUE TO DEBRIS	Install a redundant strainer of a different design to eliminate single failure event that takes out the RHR, SI and CS systems. (SAMA 24)
2BU2TRNBXCM	1.68E-03	1.02	UNIT 2 TRAIN B CC UNAVAILABLE DUE TO CORRECTIVE MAINTENANCE	Better work control practices may reduce frequency of corrective maintenance activity on the B train of CC. Consider upgrading CC pump and / or train components to a new design. (SAMA 23)

Table F.5-3
PINGP Phase I SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
1	Recirculation automatic swap to RB sump	Install control logic to automatically swap to recirculation mode of ECCS, and drawing suction from RB sump prior to depletion of RWST.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	\$4.25M per unit (\$8.5M total) (S&L 2007) Breakdown: Study: \$278,000 Design:\$1,695,000 Implement:\$1,777,000 Life Cycle:\$500,000	No	Although not retained for Phase II, this SAMA was investigated with respect to uncertainty to gain insight on possible risk benefits at the 95th percentile. See Section F.7.2.
2	Alternate water source to CL system (possible 3rd Diesel CL pump train)	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures.	PI Unit 1/2 Level 1 Importance List / Unit 1 Level 2 Importance List	\$300K per unit (\$600K total) (NMC estimate)	Yes	See Section F.6.1.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
3	Alternate flowpath from RWST	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. However, operator recovery actions may only provide limited benefit due to the high uncertainty involved. Consider installing air operated valve in parallel to provide continuous suction source of water from RWST.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	$250K per unit ($500K total) (NMC estimate)	Yes	See Section F.6.2.
4	N/A	DELETED	N/A	N/A		
5	Diesel driven HPI pump	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP & SGTR by prolonging the time the plant can operate without offsite AC power.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	$1.5M per unit ($3M total) (NMC estimate)	Yes	See Section F.6.3.
6	EQ equipment for flooding	Consider installing waterproof (EQ) equipment (valves / level sensors) capable of automatically isolating the flooding source.	PI Unit 1 Level 1 Importance List	$400K per unit ($800K total) (NMC estimate)	No	See Section F.5.2.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
6a	Segregate flooding zones	Consider segregating this zone into 2 compartments to reduce the impact of a flood on both trains of SI and RHR.	PI Unit 1 Level 1 Importance List	$2M per unit ($4M total) (NMC estimate)	No	See Section F.5.2.
7	Upgrade Diesel Generators D3 and D4	The ability to use non-safety related diesel generators D3 and D4 would provide a backup source of power in addition to the existing four safety related diesels D1, D2, D5, and D6.	PI Unit 1/2 Level 1 Importance List	$1.2M total (NMC estimate)	No	SBO is already a small contributor - <8% of CDF, <1% of LERF, <0.02% of early CF. Top SBO-related release categories involve sequences in which containment and/or vessel does not fail. Also, significant costs would be incurred to upgrade D3 and D4 to safety-related status, which would ultimately cost more than the benefit gained from a 2% improvement in CDF.
8	Swing / SBO diesel for LOOP	Installation of a swing or SBO diesel would provide increased defense in depth and could be considered for LOOP conditions.	PI Unit 1/2 Level 1 Importance List	$8M total (NMC estimate)	No	See Section F.5.2.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
9	Analyze room heatup for natural / forced circulation	Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc.	PI Unit 1/2 Level 1 Importance List	\$62,500 per unit (\$125K total) (S&L 2007) Breakdown(Unit 1&2): Study: \$111,000 Design:none Implement(procedure change):\$14,000 Life Cycle:none	Yes	See Section F.6.4.
10	Alternate means of RWST transfer	Failure of VCT level controller disables the RWST auto transfer feature, rendering the RWST unavailable as an alternate water source to the charging pumps. Alternate means of RWST transfer could be developed, either procedurally or via plant modification. For example, an additional parallel level transmitter signal path that could prevent a spurious failure of any one signal rendering suction unavailable to the charging pumps. A 2 out of 3 level control logic would be required for auto transfer of charging pump suction.	PI Unit 1/2 Level 1 Importance List	\$2.866M per unit (\$5.732M total) (S&L 2007) Breakdown per unit: Study: \$175,000 Design:\$1,526,000 Implement:\$865,000 Life Cycle:\$300,000 Breakdown (Unit 2): Study: \$175,000 Design:\$1,257,000 Implement:\$865,000 Life Cycle:\$300,000	No	Although not retained for Phase II, this SAMA was investigated with respect to uncertainty to gain insight on possible risk benefits at the 95th percentile. See Section F.7.2. Note that addressing SAMAs 9 and/or 12 would provide much, if not most, of the benefit that might be gained from this SAMA.
11	Auto transfer logic improvements	Auto transfer logic improvements, such as improved level controller reliability could also be considered.	PI Unit 2 Level 1 Importance List	\$100K per unit (\$200K total) (NMC estimate)	No	See SAMA 10 above (addresses same group of sequences).

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
12	Alternate RCP thermal barrier cooling	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. A release path will be required since FPS is not a closed system.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	$900K per unit ($1.8M total) (NMC estimate)	Yes	See Section F.6.5. Note that SAMAs 3, 5, and 10 would address most of the CDF risk addressed by this SAMA.
13	Automatic sump pump for Zone 7 AB flooding	This initiator represents an internal flooding scenario that disables various safety-related components. Mitigation of this event can be accomplished via an automatic sump pump system to remove water if the operator fails to isolate Zone 7 of the Aux. Bldg.	PI Unit 1/2 Level 1 Importance List	$300K per unit ($600K total) (NMC estimate)	No	See Section F.5.2.
14	Operator training for PORV failure to re-seat	Reinforce operator training to isolate PORVs when symptoms reveal valves have failed to re-seat. This reduces the amount of radioactivity released to the environment. Consider replacing with more reliable or robust valves to better isolate following lifting.	PI Unit 2 Level 1 Importance List	$600K per unit ($1.2M total) (NMC estimate)	No	Existing model considers that failure to close and failure to open lead to the same accident class, GLH (assuming failure of operator to Cooldown/Depressurize per ECA 3.1/3.2, which leads to SGTR source term). Therefore, quantification of this SAMA modification would produce no difference in the calculated frequency of offsite release or its magnitude.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
15	Portable DC power source	Consider a portable DC power source, such as a rectifier or skid-mounted battery pack that could be used for restoring DC control power to vital components, such as breakers, solenoid valves, etc.	PI Unit 2 Level 1 Importance List	$130K per unit ($260K total) (NMC estimate)	Yes	See Section F.6.6.
16	Replace RHR Loop B return valve	Failure of MV-32169 to open disables RHR Loop B return. Proper operation of this valve is most likely tracked via the MR. Consider replacing this MOV with a FC air-operated valve for improved reliability. This would eliminate CCF for inboard MOVs that currently exist on this flowpath.	PI Unit 2 Level 1 Importance List	$1.2M per unit ($2.4M total) (NMC estimate)	No	Failure of this valve to open results in failure of shutdown cooling initiation (there is no CCF for inboard MOVs that currently exist for the flowpath involved in these sequences). This may not have any positive impact on CDF (FC air-operated valve inside containment may be less reliable than a MOV due to reliance on containment instrument air supply) and would have little, if any, impact on LERF.
17	Bypass around RHR Loop B return valves	Alternatively, a bypass flowpath could be installed around inboard RHR Loop B return valves for improved defense in depth.	PI Unit 2 Level 1 Importance List	$2.362M per unit ($4.724M total) (S&L 2007) Breakdown: Study: $112,000 Design:$870,000 Implement:$1,080,000 Life Cycle:$300,000	No	Although not retained for Phase II, this SAMA was investigated with respect to uncertainty to gain insight on possible risk benefits at the 95th percentile. See Section F.7.2.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
18	Install spare TDAFW for each unit	Operator training can be emphasized to reduce human error probability; however, there is a great deal of uncertainty regarding operator failure probability estimates. Consider installing a spare turbine-driven AFW pump per unit. This would increase reliability of AFW system for each unit. The new pumps would be dedicated to the corresponding unit with no cross-tie capability, thereby eliminating operator error for this action. Note - some operating PWRs have (3) AFW pumps per unit, which provide greater redundancy and defense in depth.	PI Unit 2 Level 1 Importance List	$4M per unit ($8M total) (NMC estimate)	No	TDAFWP makes U2 CDF list only - this is due to Train A DC dependency between Train A AFW and MFW that Unit 1 does not have. Would reduce CDF but would do little for LERF. Implementation of SAMA 15 would reduce the importance of this item and would involve significantly less cost.
19	Upgrade RHR suction piping / install cont. isol. valve	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is.	PI Unit 1/2 Level 2 Importance List	$700K per unit ($1.4M total) (NMC estimate)	Yes	See Section F.6.7.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
19a	Replenish RWST from large water source	This initiator identifies SGTR initiating events for 11 / 12 SG and is based on industry data. Therefore mitigative actions will be addressed elsewhere in this table. Consider upgrading SG to more robust design to lower accident frequency. Consider replenishing the RWST from a large source of water, such as the SFP, if failure to depressurize is part of the scenario	PI Unit 2 Level 1 and Unit 1/2 Level 2 Importance Lists	$1.935M per unit ($3.87M total) (S&L 2007) Breakdown: Study: $225,000 Design:$1,851,000 Implement:$1,294,000 Life Cycle:$500,000	No	Although not retained for Phase II, this SAMA was investigated with respect to uncertainty to gain insight on possible risk benefits at the 95th percentile. See Section F.7.2.
20	Close MOV to prevent RCS backflow to SI system	This check valve is in series with a second check valve, both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition.	PI Unit 1/2 Level 2 Importance List	$313K per unit ($626K total) (S&L 2007) Breakdown: Study: $52,000 Design:$105,000 Implement:$56,000 Life Cycle:$100,000	Yes	See Section F.6.8.
21	Increase reliability of PORV to re-seat	This event identifies the PORV failing to re-seat after opening to provide pressure relief. Due to the importance of this event, a SAMA can be developed to make the PORV more reliable thereby reducing failure frequency.	PI Unit 1/2 Level 2 Importance List	$3M per unit ($6M total) (NMC estimate)	No	Although not retained for Phase II, this SAMA was investigated with respect to uncertainty to gain insight on possible risk benefits at the 95th percentile. See Section F.7.2.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
22	Portable air compressor for containment instrument air supply backup, or tie into (and make available during at power operation) air supply for LTOP used during outages	Consider a portable air compressor to be used in the event of loss of air to RCS PORVs inside containment. Air compressor can be connected to air header inside containment to provide backup supply of air. An alternative would be to tie into nitrogen (or air) bottle source that supplies air to LTOP system during outages.	PI Unit 1 Level 2 Importance List / IPE	$39K per unit ($78K total) (S&L 2007) Breakdown: Study: $39,000 Design: None Implement: None Life Cycle: None	Yes	See Section F.6.9.

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
23	Better work control / upgrade CC pump / train	Better work control practices may reduce frequency of corrective maintenance activity on the B train of CC. Consider upgrading CC pump and / or train components to a new design.	PI Unit 2 Level 2 Importance List	$2.5M per unit ($5M total) (NMC estimate)	No	U2 LERF risk from Tr. B CCW is from SGTR initiating event - SI pump requires CC for continued operation. Not as significant on U1 due to lower SGTR IE frequency from SG replacement. This event is very close to the screening threshold (RRW = 1.02), and would be an expensive modification. SAMA #5 and 19a will address this risk contributor in the interim until planned SG replacement on U2 (2013). Note: Maximum benefit from improved work control practices has probably already been achieved as CCW corrective maintenance impacts MSPI and MR performance indicators (management is highly aware of the need to minimize CM on CCW).

Table F.5-3
PINGP Phase I SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Cost Estimate	Retained	Phase I Baseline Disposition
24	Install redundant RB sump strainer	Install a redundant strainer of a different design to eliminate single failure event that takes out the RHR, SI and CS systems.	PI Unit 2 Level 2 Importance List	$1.2M per unit ($2.4M total) (NMC estimate)	No	This would be an expensive modification to perform directly after current modifications to sump strainers to meet the G.L. Treatment of post accident sump strainer reliability in PRA is currently subject of significant industry/NRC attention and modeling is likely to be changed when consensus is reached on a methodology. Until then, SAMAs 16 or 17, 21, and 22 address part of the LERF risk from sump strainer blockage. See sensitivity study in Section F.2.2.2.

Table F.6-1
PINGP Phase II SAMA List Summary

SAMA Number	SAMA Title	SAMA Description	Source	Phase II Baseline Disposition
2	Alternate water source to CL system	Failure of the cooling water system / pumps may be mitigated via an alternate source of water. The Fire Protection System (FPS) is a standby pressurized water supply that can be connected to the main header of the cooling water system. Multiple connections from FPS to the cooling water system would result in increased defense in depth. The FPS is assumed not to be subject to the same type of failures as the cooling water system, such as screenhouse ventilation failures.	PI Unit 1/2 Level 1 Importance List / Unit 1 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is <u>not</u> cost beneficial.
3	Alternate flowpath from RWST	This valve provides suction source from RWST to charging pumps for seal injection. Local actuation of this valve could mitigate remote operation failures. Since operator recovery actions may only provide limited benefit due to the high uncertainty involved, consider installing air operated valve in parallel to provide continuous suction source of water from RWST.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is <u>not</u> cost beneficial.
5	Diesel driven HPI pump	A diesel driven, HPI pump that could use a large volume, cold suction source would reduce the risk of LOOP & SGTR by prolonging the time the plant can operate without offsite AC power.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is <u>not</u> cost beneficial.
9	Analyze room heatup for natural / forced circulation	Further analysis such as room heatup calculations could be considered to determine to what extent natural or forced circulation can adequately remove heat from the affected areas, for example, portable fans, open doors, etc.	PI Unit 1/2 Level 1 Importance List	The averted cost-risk for this SAMA is **greater** than the cost of implementation and the SAMA is **cost beneficial** (based on 95th percentile results).

Table F.6-1
PINGP Phase II SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Phase II Baseline Disposition
12	Alternate RCP thermal barrier cooling	An alternate source of water could be made available to provide the necessary cooling for RCP thermal barriers. Consider using FPS as a means to provide backup cooling source. This can be accomplished by connecting FPS directly to component cooling system header. A release path will be required since FPS is not a closed system.	PI Unit 1/2 Level 1 Importance List / Unit 1/2 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
15	Portable DC power source	Consider a portable DC power source, such as a rectifier or skid-mounted battery pack that could be used for restoring DC control power to vital components, such as breakers, solenoid valves, etc.	PI Unit 2 Level 1 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
19	Upgrade RHR suction piping / install cont. isol. valve	For Loop A/B HL return to RHR suction, consider upgrading piping downstream of inboard containment isolation valve to handle RCS pressure and install outboard containment isolation valve to prevent possible ISLOCA. RHR piping downstream of newly installed valve can remain as is.	PI Unit 1/2 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.
20	Close MOV to prevent RCS backflow to SI system	This check valve is in series with a second check valve, both prevent backflow from the RCS to the SI system. Both check valves are inside containment with a normally open motor-operated valve upstream (also inside containment). Consider operating with the MOV normally closed, provided that an automatic open signal is sent to the valve for injection from the RWST under a LOCA condition.	PI Unit 1/2 Level 2 Importance List	The averted cost-risk for this SAMA is less than the cost of implementation and the SAMA is not cost beneficial.

Table F.6-1
PINGP Phase II SAMA List Summary (Continued)

SAMA Number	SAMA Title	SAMA Description	Source	Phase II Baseline Disposition
22	Portable air compressor for containment instrument air supply backup, or tie into (and make available during at power operation) air supply for LTOP used during outages	Instead of a plant hardware modification, the low cost option of analyzing the actual capability of the backup air accumulators was chosen to more realistically show that operation of the PORV can successfully provide bleed and feed cooling when secondary side heat removal via the SGs is unavailable. This would involve a review of any overly conservative assumptions found from previous analyses.	PI Unit 1 Level 2 Importance List / IPE	The averted cost-risk for this SAMA is **greater** than the cost of implementation and the SAMA is **cost beneficial** (based on 95th percentile results).

F.10 FIGURES

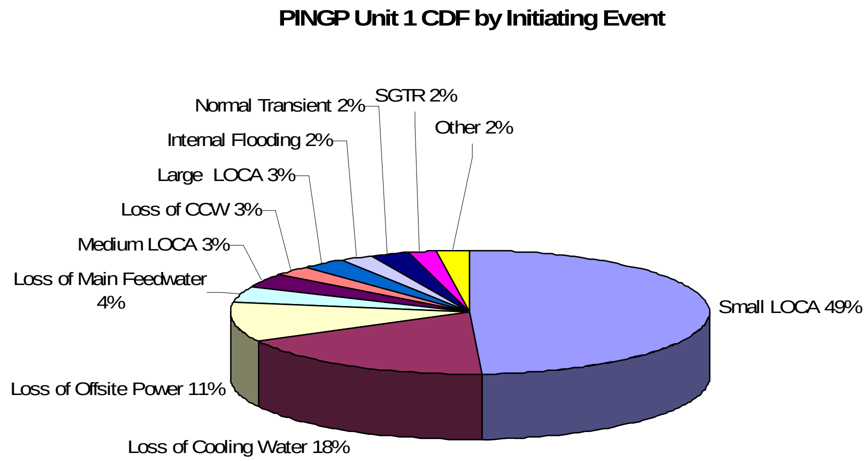


Figure F.2-1
Contribution to Unit 1 CDF by Initiator

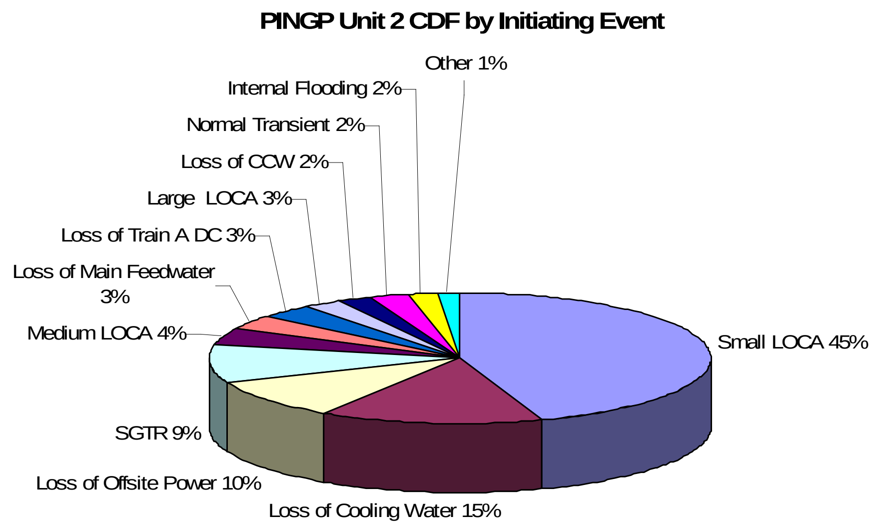


Figure F.2-2
Contribution to Unit 2 CDF by Initiator

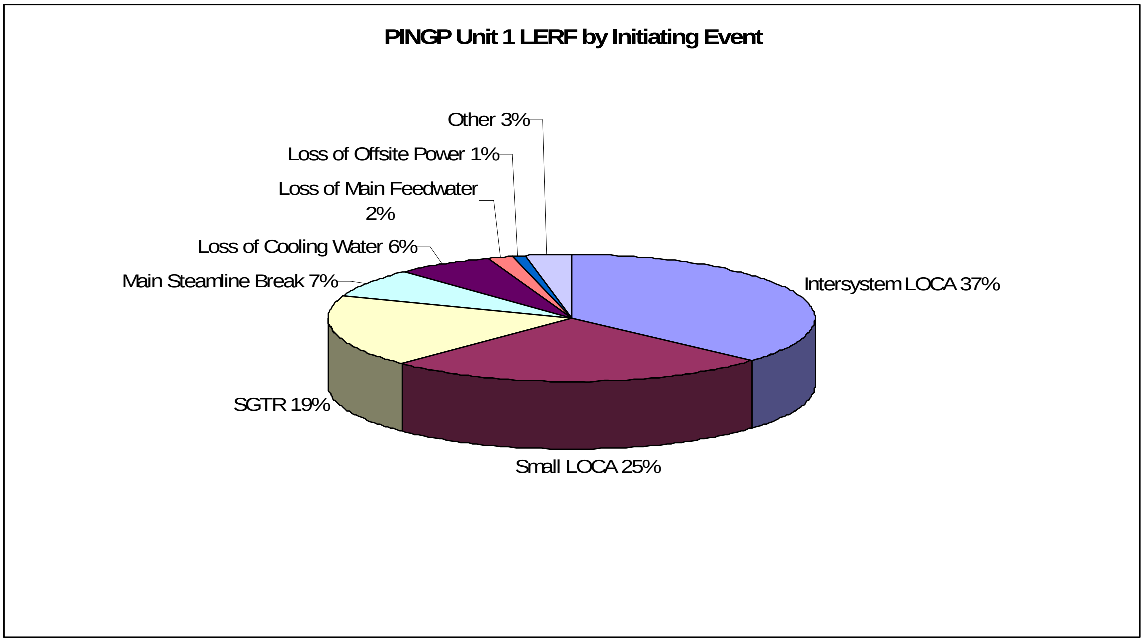


Figure F.2-3
Contribution to Unit 1 LERF by Initiator

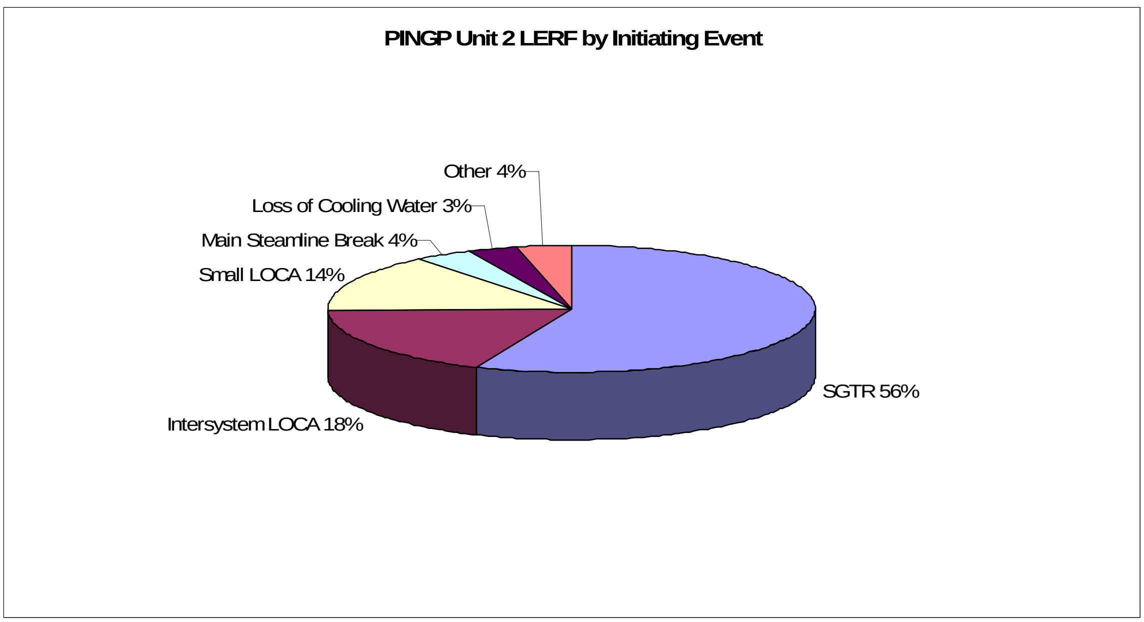


Figure F.2-4
Contribution to Unit 2 LERF by Initiator

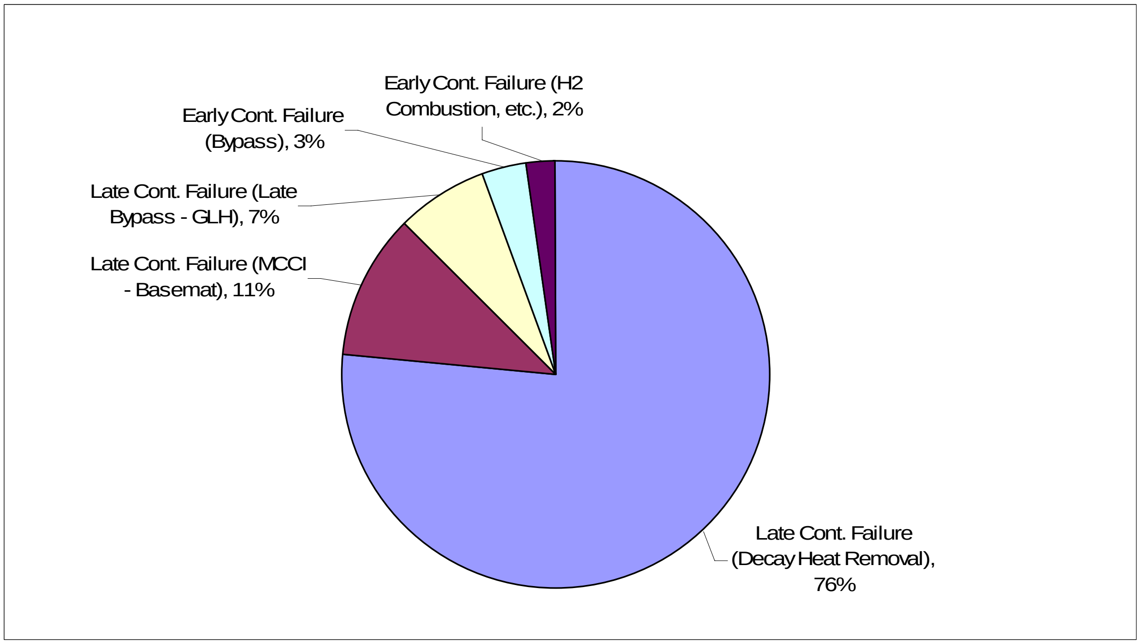


Figure F.2-5
Unit 1 Containment Failure Modes

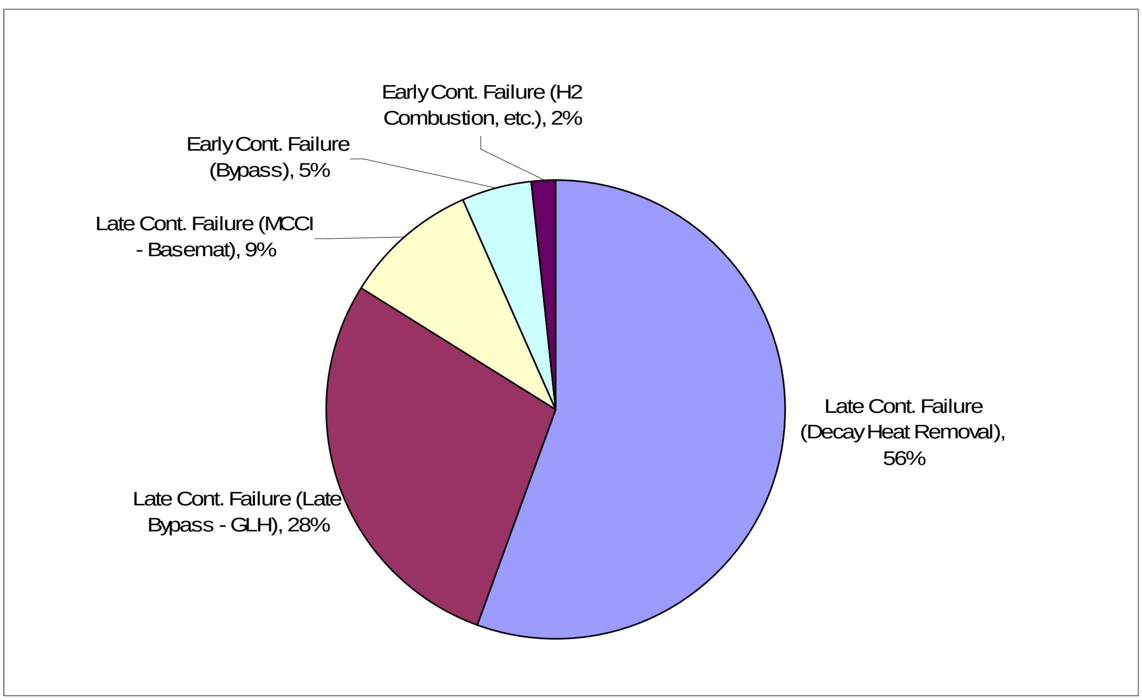


Figure F.2-6
Unit 2 Containment Failure Modes

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Addendum 1 Selected Previous Industry SAMAs

SAMA ID Number	SAMA Title	Result of Potential Enhancement
	Improvements Related to RCP Seal LOCAs (Loss of CC or SW)	
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.
2	Enhance loss of component cooling procedure to facilitate stopping reactor coolant pumps.	SAMA would reduce the potential for reactor coolant pump (RCP) seal damage due to pump bearing failure.
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.
4	Provide additional training on the loss of component cooling.	SAMA would potentially improve the success rate of operator actions after a loss of component cooling (to restore RCP seal damage).
5	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	SAMA would reduce effect of loss of component cooling by providing a means to maintain the centrifugal charging pump seal injection after a loss of component cooling.
6	Procedure changes to allow cross connection of motor cooling for RHRSW pumps.	SAMA would allow continued operation of both RHRSW pumps on a failure of one train of PSW.
7	Proceduralize shedding component cooling water loads to extend component cooling heatup on loss of essential raw cooling water.	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.
8	Increase charging pump lube oil capacity.	SAMA would lengthen the time before centrifugal charging pump failure due to lube oil overheating in loss of CC sequences.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
9	Eliminate the RCP thermal barrier dependence on component cooling such that loss of component cooling does not result directly in core damage.	SAMA would prevent the loss of recirculation pump seal integrity after a loss of component cooling. Watts Bar Nuclear Plant IPE said that they could do this with essential raw cooling water connection to RCP seals.
10	Add redundant DC control power for PSW pumps C & D.	SAMA would increase reliability of PSW and decrease core damage frequency due to a loss of SW.
11	Create an independent RCP seal injection system, with a dedicated diesel.	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.
12	Use existing hydro-test pump for RCP seal injection.	SAMA would provide an independent seal injection source, without the cost of a new system.
13	Replace ECCS pump motor with air-cooled motors.	SAMA would eliminate ECCS dependency on component cooling system (but not on room cooling).
14	Install improved RCS pumps seals.	SAMA would reduce probability of RCP seal LOCA by installing RCP seal O-ring constructed of improved materials
15	Install additional component cooling water pump.	SAMA would reduce probability of loss of component cooling leading to RCP seal LOCA.
16	Prevent centrifugal charging pump flow diversion from the relief valves.	SAMA modification would reduce the frequency of the loss of RCP seal cooling if relief valve opening causes a flow diversion large enough to prevent RCP seal injection.
17	Change procedures to isolate RCP seal letdown flow on loss of component cooling, and guidance on loss of injection during seal LOCA.	SAMA would reduce CDF from loss of seal cooling.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
18	Implement procedures to stagger high pressure safety injection (HPSI) pump use after a loss of service water.	SAMA would allow HPSI to be extended after a loss of service water.
19	Use FP 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.
20	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	SAMA would reduce the frequency of the loss of component cooling water and service water.
21	Procedure enhancements and operator training in support system failure sequences, with emphasis on anticipating problems and coping.	SAMA would potentially improve the success rate of operator actions subsequent to support system failures.
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 FP system or by installing a component cooling water cross-tie.
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.
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.
	Improvements Related to Heating, Ventilation, and Air Conditioning	
25	Provide reliable power to control building fans.	SAMA would increase availability of control room ventilation on a loss of power.
26	Provide a redundant train of ventilation.	SAMA would increase the availability of components dependent on room cooling.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
27	Procedures for actions on loss of HVAC.	SAMA would provide for improved credit to be taken for loss of HVAC sequences (improved affected electrical equipment reliability upon a loss of control building HVAC).
28	Add a diesel building switchgear room high temperature alarm.	SAMA would improve diagnosis of a loss of switchgear room HVAC. Option 1: Install high temp alarm. Option 2: Redundant louver and thermostat
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.
30	Enhance procedure to instruct operators to trip unneeded RHR/CS pumps on loss of room ventilation.	SAMA increases availability of required RHR/CS pumps. Reduction in room heat load allows continued operation of required RHR/CS pumps, when room cooling is lost.
31	Stage backup fans in switchgear (SWGR) rooms	This SAMA would provide alternate ventilation in the event of a loss of SWGR Room ventilation
	Improvements Related to Ex-Vessel Accident Mitigation/Containment Phenomena	
32	Delay containment spray actuation after large LOCA.	SAMA would lengthen time of RWST availability.
33	Install containment spray pump header automatic throttle valves.	SAMA would extend the time over which water remains in the RWST, when full Containment Spray flow is not needed
34	Install an independent method of suppression pool cooling (BWR only).	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.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
35	Develop an enhanced drywell / containment 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.
36	Provide dedicated existing drywell / containment 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.
37	Install an unfiltered hardened containment vent.	SAMA would provide an alternate decay heat removal method for non-ATWS events, with the released fission products not being scrubbed.
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
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.
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 nonsafety-grade portable generator 3) existing station batteries 4) existing AC/DC independent power supplies.
41	Install hydrogen recombiners.	SAMA would provide a means to reduce the chance of hydrogen detonation.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
42	Create a passive design hydrogen ignition system.	SAMA would reduce hydrogen denotation system without requiring electric power.
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.
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.
45	Provide modification for flooding the drywell head (BWR only).	SAMA would help mitigate accidents that result in the leakage through the drywell head seal.
46	Enhance FP system and/or standby gas treatment system (BWR only) hardware and procedures.	SAMA would improve fission product scrubbing in severe accidents.
47	Create a reactor cavity flooding system.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
48	Create other options for reactor cavity flooding.	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
49	Enhance air return fans (ice condenser plants).	SAMA would provide an independent power supply for the air return fans, reducing containment failure in SBO sequences.
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

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
51	Provide a containment inerting capability.	SAMA would prevent combustion of hydrogen and carbon monoxide gases.
52	Use the FP system as a backup source for the containment spray system.	SAMA would provide redundant containment spray function without the cost of installing a new system.
53	Install a secondary containment filtered vent (BWR only).	SAMA would filter fission products released from primary containment.
54	Install a passive containment spray system.	SAMA would provide redundant containment spray method without high cost.
55	Strengthen primary/secondary containment (BWR only).	SAMA would reduce the probability of containment overpressurization to failure.
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.
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.
58	Construct a building to be connected to primary/secondary containment that is maintained at a vacuum (BWR only).	SAMA would provide a method to depressurize containment and reduce fission product release.
59	Refill CST	SAMA would reduce the risk of core damage during events such as extended station blackouts or LOCAs which render the suppression pool unavailable as an injection source due to heat up.
60	Maintain ECCS suction on CST	SAMA would maintain suction on the CST as long as possible to avoid pump failure as a result of high suppression pool temperature

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
61	Modify containment flooding procedure to restrict flooding to below Top of Active Fuel	SAMA would avoid forcing containment venting
62	Enhance containment venting procedures with respect to timing, path selection and technique.	SAMA would improve likelihood of successful venting strategies.
63	1.a. Severe Accident EPGs/Accident Management Guidelines	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
64	1.h. Simulator Training for Severe Accident	SAMA would lead to improved arrest of core melt progress and prevention of containment failure
65	2.g. Dedicated Suppression Pool Cooling (BWR only)	SAMA would decrease the probability of loss of containment heat removal. While PWRs do not have suppression pools, a similar modification may be applied to the sump. Installation of a dedicated sump cooling system would provide an alternate method of cooling injection water.
66	3.a. Larger Volume Containment	SAMA increases time before containment failure and increases time for recovery
67	3.b. Increased Containment Pressure Capability (sufficient pressure to withstand severe accidents)	SAMA minimizes likelihood of large releases
68	3.c. Improved Vacuum Breakers (redundant valves in each line) (BWR only)	SAMA reduces the probability of a stuck open vacuum breaker.
69	3.d. Increased Temperature Margin for Seals (BWR only)	This SAMA would reduce containment failure due to drywell head seal failure caused by elevated temperature and pressure.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
70	3.e. Improved Leak Detection	This SAMA would help prevent LOCA events by identifying pipes which have begun to leak. These pipes can be replaced before they break.
71	3.f. Suppression Pool Scrubbing (BWR only)	Directing releases through the suppression pool will reduce the radionuclides allowed to escape to the environment.
72	3.g. Improved Bottom Penetration Design	SAMA reduces failure likelihood of RPV bottom head penetrations
73	4.a. Larger Volume Suppression Pool (double effective liquid volume) (BWR only)	SAMA would increase the size of the suppression pool so that heatup rate is reduced, allowing more time for recovery of a heat removal system
74	5.a/d. Unfiltered Vent	SAMA would provide an alternate decay heat removal method with the released fission products not being scrubbed.
75	5.b/c. Filtered Vent	SAMA would provide an alternate decay heat removal method with the released fission products being scrubbed.
76	6.a. Post Accident Inerting System	SAMA would reduce likelihood of gas combustion inside containment
77	6.b. Hydrogen Control by Venting	Prevents hydrogen detonation by venting the containment before combustible levels are reached.
78	6.c. Pre-inerting	SAMA would reduce likelihood of gas combustion inside containment
79	6.d. Ignition Systems	Burning combustible gases before they reach a level which could cause a harmful detonation is a method of preventing containment failure.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
80	6.e. Fire Suppression System Inerting (BWR only)	Use of the FP system as a back up containment inerting system would reduce the probability of combustible gas accumulation. This would reduce the containment failure probability for small containments (e.g. BWR MKI).
81	7.a. Drywell Head Flooding (BWR only)	SAMA would provide intentional flooding of the upper drywell head such that if high drywell temperatures occurred, the drywell head seal would not fail.
82	7.b. Containment Spray Augmentation	This SAMA would provide additional means of providing flow to the containment spray system.
83	12.b. Integral Basemat	This SAMA would improve containment and system survivability for seismic events.
84	13.a. Reactor Building Sprays (BWR only)	This SAMA provides the capability to use firewater sprays in the reactor building to mitigate release of fission products into the Rx Bldg following an accident.
85	14.a. Flooded Rubble Bed	SAMA would contain molten core debris dropping on to the pedestal and would allow the debris to be cooled.
86	14.b. Reactor Cavity Flooder	SAMA would enhance debris coolability, reduce core concrete interaction, and provide fission product scrubbing.
87	14.c. Basaltic Cements	SAMA minimizes carbon dioxide production during core concrete interaction.
88	Provide a core debris control system	(Intended for ice condenser plants): This SAMA would prevent the direct core debris attack of the primary containment steel shell by erecting a barrier between the seal table and the containment shell.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
89	Add ribbing to the containment shell	This SAMA would reduce the risk of buckling of containment under reverse pressure loading.
	Improvements Related to Enhanced AC/DC Reliability/Availability	
90	Proceduralize alignment of spare diesel to shutdown board after loss of offsite power and failure of the diesel normally supplying it.	SAMA would reduce the SBO frequency.
91	Provide an additional diesel generator.	SAMA would increase the reliability and availability of onsite emergency AC power sources.
92	Provide additional DC battery capacity.	SAMA would ensure longer battery capability during an SBO, reducing the frequency of long-term SBO sequences.
93	Use fuel cells instead of lead-acid batteries.	SAMA would extend DC power availability in an SBO.
94	Procedure to cross-tie high pressure core spray diesel (BWR only).	SAMA would improve core injection availability by providing a more reliable power supply for the high pressure core spray pumps.
95	Improve 4.16-kV bus cross-tie ability.	SAMA would improve AC power reliability.
96	Incorporate an alternate battery charging capability.	SAMA would improve DC power reliability by either cross-tying the AC busses, or installing a portable diesel-driven battery charger.
97	Increase/improve DC bus load shedding.	SAMA would extend battery life in an SBO event.
98	Replace existing batteries with more reliable ones.	SAMA would improve DC power reliability and thus increase available SBO recovery time.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
99	Mod for DC Bus A reliability (BWR only).	SAMA would increase the reliability of AC power and injection capability. Loss of DC Bus A causes a loss of main condenser prevents transfer from the main transformer to offsite power, and defeats one half of the low vessel pressure permissive for LPCI/CS injection valves.
100	Create AC power cross-tie capability with other unit.	SAMA would improve AC power reliability.
101	Create a cross-tie for diesel fuel oil.	SAMA would increase diesel fuel oil supply and thus diesel generator, reliability.
102	Develop procedures to repair or replace failed 4-kV breakers.	SAMA would offer a recovery path from a failure of the breakers that perform transfer of 4.16-kV non-emergency busses from unit station service transformers, leading to loss of emergency AC power.
103	Emphasize steps in recovery of offsite power after an SBO.	SAMA would reduce human error probability during offsite power recovery.
104	Develop a severe weather conditions procedure.	For plants that do not already have one, this SAMA would reduce the CDF for external weather-related events.
105	Develop procedures for replenishing diesel fuel oil.	SAMA would allow for long-term diesel operation.
106	Install gas turbine generator.	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
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.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
108	Use FP system as a backup source for diesel cooling.	This SAMA would provide a redundant and diverse source of cooling for the diesel generators, which would contribute to enhanced diesel reliability.
109	Provide a connection to an alternate source of offsite power.	SAMA would reduce the probability of a loss of offsite power event.
110	Bury offsite power lines.	SAMA could improve offsite power reliability, particularly during severe weather.
111	Replace anchor bolts on diesel generator oil cooler.	Millstone Nuclear Power Station found a high seismic SBO risk due to failure of the diesel oil cooler anchor bolts. For plants with a similar problem, this would reduce seismic risk. Note that these were Fairbanks Morse DGs.
112	Change undervoltage (UV), auxiliary feedwater actuation signal (AFAS) block and high pressurizer pressure actuation signals to 3-out-of-4, instead of 2-out-of-4 logic.	SAMA would reduce risk of 2/4 inverter failure.
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.
114	Bypass Diesel Generator Trips	SAMA would allow D/Gs to operate for longer.
115	2.i. 16 hour Station Blackout Injection	SAMA includes improved capability to cope with longer station blackout scenarios.
116	9.a. Steam Driven Turbine Generator (BWR only)	This SAMA would provide a steam driven turbine generator which uses reactor steam and exhausts to the suppression pool. If large enough, it could provide power to additional equipment.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
117	9.b. Alternate Pump Power Source	This SAMA would provide a small dedicated power source such as a dedicated diesel or gas turbine for the feedwater or condensate pumps, so that they do not rely on offsite power.
118	9.d. Additional Diesel Generator	SAMA would reduce the SBO frequency.
119	9.e. Increased Electrical Divisions	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
120	9.f. Improved Uninterruptible Power Supplies	SAMA would provide increased reliability of power supplies supporting front-line equipment, thus reducing core damage and release frequencies.
121	9.g. AC Bus Cross-Ties	SAMA would provide increased reliability of AC power system to reduce core damage and release frequencies.
122	9.h. Gas Turbine	SAMA would improve onsite AC power reliability by providing a redundant and diverse emergency power system.
123	9.i. Dedicated RHR (bunkered) Power Supply	SAMA would provide RHR with more reliable AC power.
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., RCIC).
125	10.b. Additional Batteries/Divisions	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., RCIC).
126	10.c. Fuel Cells	SAMA would extend DC power availability in an SBO.
127	10.d. DC Cross-ties	This SAMA would improve DC power reliability.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
128	10.e. Extended Station Blackout Provisions	SAMA would provide reduction in SBO sequence frequencies.
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.
	Improvements in Identifying and Mitigating Containment Bypass	
130	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture (SGTR).	SAMA would enhance depressurization during a SGTR.
131	Improve SGTR coping abilities.	SAMA would improve instrumentation to detect SGTR, or additional system to scrub fission product releases.
132	Add other SGTR coping abilities.	SAMA would decrease the consequences of an SGTR.
133	Increase secondary side pressure capacity such that an SGTR would not cause the relief valves to lift.	SAMA would eliminate direct release pathway for SGTR sequences.
134	Replace steam generators (SG) with a new design.	SAMA would lower the frequency of an SGTR.
135	Revise EOPs to direct that a faulted SG be isolated.	SAMA would reduce the consequences of an SGTR.
136	Direct SG flooding after a SGTR, prior to core damage.	SAMA would provide for improved scrubbing of SGTR releases.
137	Implement a maintenance practice that inspects 100% of the tubes in a SG.	SAMA would reduce the potential for an SGTR.
138	Locate residual heat removal (RHR) inside of containment.	SAMA would prevent intersystem LOCA (ISLOCA) out the RHR pathway.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
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.
140	Increase frequency for valve leak testing.	SAMA could reduce ISLOCA frequency.
141	Improve operator training on ISLOCA coping.	SAMA would decrease ISLOCA effects.
142	Install relief valves in the CC System.	SAMA would relieve pressure buildup from an RCP thermal barrier tube rupture, preventing an ISLOCA.
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.
144	Revise EOPs to improve ISLOCA identification.	SAMA would ensure LOCA outside containment could be identified as such. Salem Nuclear Power Plant had a scenario where an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.
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 be covered with water.
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.
147	Early detection and mitigation of ISLOCA	SAMA would limit the effects of ISLOCA accidents by early detection and isolation
148	8.e. Improved MSIV Design	This SAMA would improve isolation reliability and reduce spurious actuations that could be initiating events.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
149	Proceduralize use of pressurizer vent valves during steam generator tube rupture (SGTR) sequences	Some plants may have procedures to direct the use of pressurizer sprays to reduce RCS pressure after an SGTR. Use of the vent valves would provide a back-up method.
150	Implement a maintenance practice that inspects 100% of the tubes in an SG	This SAMA would reduce the potential for a tube rupture.
151	Locate RHR inside of containment	This SAMA would prevent ISLOCA out the RHR pathway.
152	Install self-actuating containment isolation valves	For plants that do not have this, it would reduce the frequency of isolation failure.
	Improvements in Reducing Internal Flooding Frequency	
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.
154	Improve inspection of rubber expansion joints on main condenser.	SAMA would reduce the frequency of internal flooding, for a plant where internal flooding due to a failure of circulating water system expansion joints is a concern.
155	Implement internal flood prevention and mitigation enhancements.	This SAMA would reduce the consequences of internal flooding.
156	Implement internal flooding improvements such as those implemented at Fort Calhoun.	This SAMA would reduce flooding risk by preventing or mitigating rupture in the RCP seal cooler of the component cooling system and ISLOCA in a shutdown cooling line, an auxiliary feedwater (AFW) flood involving the need to remove a watertight door.
157	Shield electrical equipment from potential water spray	SAMA would decrease risk associated with seismically induced internal flooding

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
158	13.c. Reduction in Reactor Building Flooding (BWR only)	This SAMA reduces the Reactor Building Flood Scenarios contribution to core damage and release.
	Improvements Related to Feedwater/Feed and Bleed Reliability/Availability	
159	Install a digital feedwater upgrade.	This SAMA would reduce the chance of a loss of main feedwater following a plant trip.
160	Perform surveillances on manual valves used for backup AFW pump suction.	This SAMA would improve success probability for providing alternative water supply to the AFW pumps.
161	Install manual isolation valves around AFW turbine-driven steam admission valves.	This SAMA would reduce the dual turbine-driven AFW pump maintenance unavailability.
162	Install accumulators for turbine-driven AFW pump flow control valves (CVs).	This SAMA would provide control air accumulators for the turbine-driven AFW flow CVs, the motor-driven AFW pressure CVs and SG power-operated relief valves (PORVs). This would eliminate the need for local manual action to align nitrogen bottles for control air during a LOOP.
163	Install separate accumulators for the AFW cross-connect and block valves	This SAMA would enhance the operator's ability to operate the AFW cross-connect and block valves following loss of air support.
164	Install a new condensate storage tank (CST)	Either replace the existing tank with a larger one, or install a back-up tank.
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.
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.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
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)
168	Add a motor train of AFW to the Steam trains	For PWRs that do not have any motor trains of AFW, this would increase reliability in non-SBO sequences.
169	Create ability for emergency connections of existing or alternate water sources to feedwater/condensate	This SAMA would be a back-up water supply for the feedwater/condensate systems.
170	Use FP system as a back-up for SG inventory	This SAMA would create a back-up to main and AFW for SG water supply.
171	Procure a portable diesel pump for isolation condenser make-up (BWR only)	This SAMA would provide a back-up to the city water supply and diesel FP system pump for isolation condenser make-up.
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.
173	Change failure position of condenser make-up valve	This SAMA would allow greater inventory for the AFW pumps by preventing CST flow diversion to the condenser if the condenser make-up valve fails open on loss of air or power.
174	Create passive secondary side coolers.	This SAMA would reduce CDF from the loss of Feedwater by providing a passive heat removal loop with a condenser and heat sink.
175	Replace current PORVs with larger ones such that only one is required for successful feed and bleed.	This SAMA would reduce the dependencies required for successful feed and bleed.
176	Install motor-driven feedwater pump.	SAMA would increase the availability of injection subsequent to MSIV closure.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
177	Use Main FW pumps for a Loss of Heat Sink Event	This SAMA involves a procedural change that would allow for a faster response to loss of the secondary heat sink. Use of only the feedwater booster pumps for injection to the SGs requires depressurization to about 350 psig; before the time this pressure is reached, conditions would be met for initiating feed and bleed. Using the available turbine driven feedwater pumps to inject water into the SGs at a high pressure rather than using the feedwater booster alone allows injection without the time consuming depressurization.
	Improvements in Core Cooling Systems	
178	Provide the capability for diesel driven, low pressure vessel make-up	This SAMA would provide an extra water source in sequences in which the reactor is depressurized and all other injection is unavailable (e.g., FP system)
179	Provide an additional HPSI pump with an independent diesel	This SAMA would reduce the frequency of core melt from small LOCA and SBO sequences
180	Install an independent AC HPSI system	This SAMA would allow make-up and feed and bleed capabilities during an SBO.
181	Create the ability to manually align ECCS recirculation	This SAMA would provide a back-up should automatic or remote operation fail.
182	Implement an RWT make-up procedure	This SAMA would decrease CDF from ISLOCA scenarios, some smaller break LOCA scenarios, and SGTR.
183	Stop low pressure safety injection pumps earlier in medium or large LOCAs.	This SAMA would provide more time to perform recirculation swap over.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
184	Emphasize timely swap over in operator training.	This SAMA would reduce human error probability of recirculation failure.
185	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.
186	Install an active HPSI system.	For a plant like the AP600 where an active HPSI system does not exist, this SAMA would add redundancy in HPSI.
187	Change "in-containment" RWT suction from 4 check valves to 2 check and 2 air operated valves.	This SAMA would remove common mode failure of all four injection paths.
188	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.
189	Align low pressure core injection or core spray to the CST on loss of suppression pool cooling (BWR only).	This SAMA would help to ensure low pressure ECCS can be maintained in loss of suppression pool cooling scenarios.
190	Raise high pressure core injection/reactor core isolation cooling backpressure trip setpoints (BWR only)	This SAMA would ensure high pressure core injection/reactor core isolation cooling availability when high suppression pool temperatures exist.
191	Improve the reliability of the automatic depressurization system (BWR only).	This SAMA would reduce the frequency of high pressure core damage sequences.
192	Disallow automatic vessel depressurization in non-ATWS scenarios	This SAMA would improve operator control of the plant.
193	Create automatic swap over to recirculation on RWT depletion	This SAMA would reduce the human error contribution from recirculation failure.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
194	Proceduralize intermittent operation of HPCI (BWR only).	SAMA would allow for extended duration of HPCI availability.
195	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.
196	Modify Reactor Water Cleanup (RWCU) for use as a decay heat removal system and proceduralize use (BWR only).	SAMA would provide an additional source of decay heat removal.
197	CRD Injection (BWR only)	SAMA would supply an additional method of level restoration by using a non-safety system.
198	Condensate Pumps for Injection (BWR only)	SAMA to provide an additional option for coolant injection when other systems are unavailable or inadequate
199	Align EDG to CRD for Injection (BWR only)	SAMA to provide power to an additional injection source during loss of power events
200	Re-open MSIVs (BWR only)	SAMA to regain the main condenser as a heat sink by re-opening the MSIVs.
201	Bypass RCIC Turbine Exhaust Pressure Trip (BWR only)	SAMA would allow RCIC to operate longer.
202	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
203	2.c. Suppression Pool Jockey Pump (BWR only)	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.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
204	2.d. Improved High Pressure Systems	SAMA will improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat.
205	2.e. Additional Active High Pressure System	SAMA will improve reliability of high pressure decay heat removal by adding an additional system.
206	2.f. Improved Low Pressure System (Firepump)	SAMA would provide FP system pump(s) for use in low pressure scenarios.
207	4.b. Clean Up Water Decay Heat Removal (BWR only)	This SAMA provides a means for Alternate Decay Heat Removal.
208	4.c. High Flow Suppression Pool Cooling (BWR only)	SAMA would improve suppression pool cooling.
209	8.c. Diverse Injection System	SAMA will improve prevention of core melt sequences by providing additional injection capabilities.
210	Alternate Charging Pump Cooling	This SAMA will improve the high pressure core flooding capabilities by providing the SI pumps with alternate gear and oil cooling sources. Given a total loss of Chilled Water, abnormal operating procedures would direct alignment of preferred Demineralized Water or the Fire System to the Chilled Water System to provide cooling to the SI pumps' gear and oil box (and the other normal loads).
	Instrument Air/Gas Improvements	
211	Modify EOPs for ability to align diesel power to more air compressors.	For plants that do not have diesel power to all normal and back-up air compressors, this change would increase the reliability of IA after a LOOP.
212	Replace old air compressors with more reliable ones	This SAMA would improve reliability and increase availability of the IA compressors.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
213	Install nitrogen bottles as a back-up gas supply for safety relief valves (BWR only).	This SAMA would extend operation of safety relief valves during an SBO and loss of air events (BWRs).
214	Allow cross connection of uninterruptible compressed air supply to opposite unit.	SAMA would increase the ability to vent containment using the hardened vent.
	ATWS Mitigation	
215	Install MG set trip breakers in control room (BWR only)	This SAMA would provide trip breakers for the MG sets in the control room. In some plants, MG set breaker trip requires action to be taken outside of the control room. Adding control capability to the control room would reduce the trip failure probability in sequences where immediate action is required (e.g., ATWS).
216	Add capability to remove power from the bus powering the control rods	This SAMA would decrease the time to insert the control rods if the reactor trip breakers fail (during a loss of FW ATWS which has a rapid pressure excursion)
217	Create cross-connect ability for standby liquid control trains (BWR only)	This SAMA would improve reliability for boron injection during an ATWS event.
218	Create an alternate boron injection capability (back-up to standby liquid control) (BWR only)	This SAMA would improve reliability for boron injection during an ATWS event.
219	Remove or allow override of low pressure core injection during an ATWS (BWR only)	On failure on high pressure core injection and condensate, some plants direct reactor depressurization followed by 5 minutes of low pressure core injection. This SAMA would allow control of low pressure core injection immediately.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
220	Install a system of relief valves that prevents any equipment damage from a pressure spike during an ATWS	This SAMA would improve equipment availability after an ATWS.
221	Create a boron injection system to back up the mechanical control rods.	This SAMA would provide a redundant means to shut down the reactor.
222	Provide an additional instrument system for ATWS mitigation (e.g., ATWS mitigation scram actuation circuitry).	This SAMA would improve instrument and control redundancy and reduce the ATWS frequency.
223	Increase the safety relief valve (SRV) reseat reliability (BWR only).	SAMA addresses the risk associated with dilution of boron caused by the failure of the SRVs to reseat after standby liquid control (SBLC) injection.
224	Use control rod drive for alternate boron injection (BWR only).	SAMA provides an additional system to address ATWS with SBLC failure or unavailability.
225	Bypass MSIV isolation in Turbine Trip ATWS scenarios (BWR only)	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., SBLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities
226	Enhance operator actions during ATWS	SAMA will reduce human error probabilities during ATWS
227	Guard against SBLC dilution (BWR only)	SAMA to control vessel injection to prevent boron loss or dilution following SBLC injection.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
228	11.a. ATWS Sized Vent	This SAMA would be providing the ability to remove reactor heat from ATWS events.
229	11.b. Improved ATWS Capability	This SAMA includes items which reduce the contribution of ATWS to core damage and release frequencies.
	Other Improvements	
230	Provide capability for remote operation of secondary side relief valves in an SBO	Manual operation of these valves is required in an SBO scenario. High area temperatures may be encountered in this case (no ventilation to main steam areas), and remote operation could improve success probability.
231	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.
232	Make procedural changes only for the RCS depressurization option	This SAMA would reduce RCS pressure without the cost of a new system
233	Defeat 100% load rejection capability.	This SAMA would eliminate the possibility of a stuck open PORV after a LOOP, since PORV opening would not be needed.
234	Change control rod drive flow control valve failure position (BWR only)	Change failure position to the "fail-safest" position.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
235	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.
236	Install digital large break LOCA protection	Upgrade plant instrumentation and logic to improve the capability to identify symptoms/precursors of a large break LOCA (leak before break).
237	Increase seismic capacity of the plant to a high confidence, low pressure failure of twice the Safe Shutdown Earthquake.	This SAMA would reduce seismically -induced CDF.
238	Enhance the reliability of the demineralized water (DW) make-up system through the addition of diesel-backed power to one or both of the DW make-up pumps.	Inventory loss due to normal leakage can result in the failure of the CC and the SRW systems. Loss of CC could challenge the RCP seals. Loss of SRW results in the loss of three EDGs and the containment air coolers (CACs).
239	Increase the reliability of safety relief valves by adding signals to open them automatically (BWR only).	SAMA reduces the probability of a certain type of medium break LOCA. Hatch evaluated medium LOCA initiated by an MSIV closure transient with a failure of SRVs to open. Reducing the likelihood of the failure for SRVs to open, subsequently reduces the occurrence of this medium LOCA.
240	Reduce DC dependency between high pressure injection system and ADS (BWR only).	SAMA would ensure containment depressurization and high pressure injection upon a DC failure.
241	Increase seismic ruggedness of plant components.	SAMA would increase the availability of necessary plant equipment during and after seismic events.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
242	Enhance RPV depressurization capability (BWR only)	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios
243	Enhance RPV depressurization procedures (BWR only)	SAMA would decrease the likelihood of core damage in loss of high pressure coolant injection scenarios
244	Replace mercury switches on FP systems	SAMA would decrease probability of spurious fire suppression system actuation given a seismic event+D114
245	Provide additional restraints for CO_2 tanks	SAMA would increase availability of FP given a seismic event.
246	Enhance control of transient combustibles	SAMA would minimize risk associated with important fire areas.
247	Enhance fire brigade awareness	SAMA would minimize risk associated with important fire areas.
248	Upgrade fire compartment barriers	SAMA would minimize risk associated with important fire areas.
249	Enhance procedures to allow specific operator actions	SAMA would minimize risk associated with important fire areas.
250	Develop procedures for transportation and nearby facility accidents	SAMA would minimize risk associated with transportation and nearby facility accidents.
251	Enhance procedures to mitigate Large LOCA	SAMA would minimize risk associated with Large LOCA
252	1.b. Computer Aided Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.
253	1.c/d. Improved Maintenance Procedures/Manuals	SAMA will improve prevention of core melt sequences by increasing reliability of important equipment
254	1.e. Improved Accident Management Instrumentation	SAMA will improve prevention of core melt sequences by making operator actions more reliable.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
255	1.f. Remote Shutdown Station	This SAMA would provide the capability to control the reactor in the event that evacuation of the main control room is required.
256	1.g. Security System	Improvements in the site's security system would decrease the potential for successful sabotage.
257	2.b. Improved Depressurization	SAMA will improve depressurization system to allow more reliable access to low pressure systems.
258	2.h. Safety Related Condensate Storage Tank	SAMA will improve availability of CST following a Seismic event
259	4.d. Passive Overpressure Relief	This SAMA would prevent vessel overpressurization.
260	8.b. Improved Operating Response	Improved operator reliability would improve accident mitigation and prevention.
261	8.d. Operation Experience Feedback	This SAMA would identify areas requiring increased attention in plant operation through review of equipment performance.
262	8.e. Improved SRV Design	This SAMA would improve SRV reliability, thus increasing the likelihood that sequences could be mitigated using low pressure heat removal.
263	12.a. Increased Seismic Margins	This SAMA would reduce the risk of core damage and release during seismic events.
264	13.b. System Simplification	This SAMA is intended to address system simplification by the elimination of unnecessary interlocks, automatic initiation of manual actions or redundancy as a means to reduce overall plant risk.

Addendum 1 Selected Previous Industry SAMAs (Continued)

SAMA ID Number	SAMA Title	Result of Potential Enhancement
265	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.
266	Install tornado protection on gas turbine generators	This SAMA would improve onsite AC power reliability.