Enclosure 1
WBN Unit 2
Severe Accident Management Alternatives Analysis

Westinghouse

To:	File	Date:	January 21, 2009
cc:			
From:	Robert Lutz	Your ref:	N/A
Ext:	412-374-4946	Our ref:	LTR-RAM-I-08-062
Fax:	412-374-5099		Rev 3

Subject: Watts Bar Unit 2 Severe Accident Mitigation Alternatives

The attached is the transmittal to Tennessee Valley Authority (TVA) of the following deliverable: Final Watts Bar Unit 2 Severe Accident Mitigation Alternatives (SAMA) analysis. The SAMA report is Attachment 1 to this letter, which is Westinghouse Proprietary Class 3. This letter report was revised to incorporate TVA comments.

Questions may be referred to the undersigned.

Author: Stephen A. Nass
Risk Applications & Methods I
Electronically Approved*

Author: Mitch Waller

Author: Robert J. Lutz, Jr.
Risk Applications & Methods I
Electronically Approved*

Manager: Melissa A. Lucci
Risk Applications & Methods I
Electronically Approved*

***** Electronically Approved Records are Authenticated in the Electronic Document Management System***

1 INTRODUCTION

The Watts Bar Unit 2 Final Supplemental Environmental Impact statement for the Completion and Operation of WBN Unit 2 (June 2007) was submitted to the NRC on February 15, 2008. NRC requested additional information by letter dated June 3, 2008. By letter dated July 2, 2008, TVA committed to provide a WBN Unit 2 Severe Accident Mitigation Alternatives (SAMA) analysis consistent in scope and content with the SAMA analyses provided in support of recent license renewal applications. This report documents the development of a risk model to evaluate Unit 2 severe accidents, the identification of SAMA candidates, and a cost benefit analysis of those candidates. The results of this evaluation identify potentially cost effective hardware and procedure changes that will be considered for implementation.

2 LIST OF ACRONYMS

ABGTS	Auxiliary Building Gas Treatment System
ABSCE	Auxiliary Building Secondary Containment Enclosure
AFW	Auxiliary Feedwater
AOI	Abnormal Operating Instruction
AOT	Allowed Outage Time
ATWS	Anticipated Transient Without Scram
CCF	Common Cause Failure
CCS	Component Cooling Water System (WBN System Designation)
CCW	Component Cooling Water
CDF	Core Damage Frequency
CT	Combustion Turbine
CVCS	Chemical and Volume Control System
DG	Diesel Generator
DWST	Demineralized Water Storage Tank
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EGTS	Emergency Gas Treatment System
EOP	Emergency Operating Procedure
EPSIL	Emergency Preparedness Section Instruction Letter
ERCW	Emergency Raw Cooling Water (WBN System Designation)
ERG	Emergency Response Guideline
FPS	Fire Protection System
GOI	General Operating Instruction
HEP	Human Error Probability
HPCI	High Pressure Injection System
HRA	Human Reliability Analysis
HVAC	Heating, Ventilation and Air Conditioning
IPE	Individual Plant Examination

IPEEE	IPE for External Events
ISLOCA	Inter-System Loss of Coolant Accident
LOCA	Loss of Coolant Accident
LOSP	Loss of Offsite Power
MCR	Main Control Room
MD	Motor Driven
MI	Maintenance Instruction
MSPI	Mitigating System Performance Indicator
NCP	Normal Charging Pump
PER	Problem Evaluation Report
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PWST	Primary Water Storage Tank
RCIC	Reactor Core Isolation Cooling
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RRW	Risk Reduction Worth
RWST	Refueling Water Storage Tank
SAMA	Severe Accident Mitigation Alternative
SBO	Station Blackout
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SI	Safety Injection
SQUG	Seismic Qualification Users Group
SW	Service Water
TD	Turbine Driven
UHI	Upper Head Injection

3 METHODOLOGY

The methodology selected for the SAMA assessment of Watts Bar Unit 2 (WBN2) is based on the Nuclear Energy Institute's (NEI) SAMA Analysis Guidance Document [NEI 2005] and involves identifying SAMA candidates that have the highest 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 economic cost-risk. These values provide a measure of both the likelihood and consequences of a core damage event. The SAMA assessment consisted of the following steps:

- Update the Watts Bar Nuclear Unit 1 (WBN1) Probabilistic Risk Assessment (PRA) Model to address peer review facts and observations (F&O), and to account for Unit 2 operation. The model developed (WBN4SAMA) includes a Level 1 and Level 2 analyses of internal events including internal floods. The results of the combined Level 1 and Level 2 analysis are expressed as Release Category frequencies for input to the Level 3 analysis. The contributions of external events are incorporated as described in Section 4.3.

- Perform a Level 3 PRA analysis using the WBN4SAMA Level 2 internal events PRA output and site specific meteorology, demographic, land use, and emergency response data as input. The Level 3 analysis is performed using the MELCOR Accident Consequences Code System (WinMACCS) (Section 4.6).

- Calculate the monetary value of the unmitigated WBN Unit 2 severe accident risk using U.S. Nuclear Regulatory Commission (NRC) regulatory analysis techniques [NRC 1997]. This becomes the maximum averted cost-risk (MACR) that is possible (Section 5).

- Identify potential SAMA candidates based on the WBN4SAMA PRA, the WBN1 Individual Plant Examination (IPE) [TVA 1992], the WBN1 Individual Plant Examination for External Events (IPEEE) [TVA 1998], and documentation from the industry and NRC (Section 6).

- Perform a Phase I SAMA Analysis by screening out SAMA candidates that are not applicable to the WBN2 design, are of low benefit in pressurized water reactors (PWRs) such as WBN2, candidates that have already been implemented at WBN2 or whose benefits have been achieved at WBN2 using other means, and candidates whose roughly-estimated cost exceeds the possible MACR (Section 7).

- Calculate the risk reduction attributable to each remaining SAMA candidate and perform a Phase II SAMA Analysis by comparing the averted cost-risk 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 8).

- Evaluate how changes in the SAMA analysis assumptions might affect the cost-benefit evaluation (Section 9).

- Summarize results and identify conclusions (Section 10).

4 SEVERE ACCIDENT RISK

4.1 WBN Unit 2 Level 1 SAMA Model

The Watts Bar Unit 2 SAMA model was developed based on the latest Watts Bar Unit 1 model (WBN-REV4). Facts and Observations (F&O) from the WOG peer review performed on the Watts Bar Unit 1 PRA model were reviewed and the A and B level F&Os which may affect SAMA evaluation were identified. PRA model changes were incorporated to resolve those F&Os. The resolution and status of all the A and B level F&Os are described in Section 4.4

Individual F&Os which were resolved as part of this effort include:

- Core damage arrest modeling in the Level 2 model was made consistent with the Level 1 model.
- Thermal-hydraulic evaluation of bleed and feed cooling success criteria requirements was revised to reflect updated bleed and feed cooling requirements (2 PORVs to support bleed and feed cooling with one SI pump).
- Added loss of plant compressed air initiating event LOPA.
- A sensitivity analysis of human actions was performed by setting all operator actions to failure. Numerous minor risk model changes were identified through this review.
- Detailed sequence evaluation of the top 100 model scenarios. This review was required for F&O AS-02. This review also provided the response to F&O QU-03, to verify logic for Auxiliary Feedwater (AFW) decay heat removal recovery. This specific issue was resolved during the Watts Bar Unit 1 Rev 4 model update. While numerous model observations were made, only ventilation system recovery was identified as a potential model change for the SAMA model.

Interviews were conducted with Sequoyah personnel to identify potential model changes required for dual unit operation. The use of Sequoyah personnel was appropriate because of their experience with dual unit operation and the similarity of the Sequoyah and Watts Bar designs. These interviews were used to establish the need for specific modeling of dual unit initiating events, beyond those modeled for Unit 1 alone, as well as the potential need to modify common systems to reflect dual unit operation. A review of Sequoyah's PRA model was also performed to identify differences in success criteria and initiating event logic for support systems. As a result of the interviews and the Sequoyah PRA model review, the following changes were incorporated into the Watts Bar SAMA Model:

- Changes to CCS to remove credit for the Unit 2 pumps from the Unit 1 model to reflect dual unit operation.
- Change to ERCW success criteria based on dual unit operation.

Following review of the various shared systems with the Sequoyah model (i.e., compressed air, ERCW, CCS, HVAC and AC and DC electric power), no further plant model changes to shared systems were identified as necessary for the WBN Unit 2 SAMA model.

4.2 WBN Unit 2 Level 2 SAMA Model

The containment event tree used for the IPE was developed as a stand alone module. This event tree structure was reproduced and linked to the level 1 SAMA model. This migration to the SAMA containment event tree (CET) model included:

- Migrating split fraction rules to the new model. This included adjustment of split fraction designations for conflicting top event designations.
- Migrating interim variable (macro) assignments to the new model. This included designation of new macros for all previous CET initiating events.
- Migrating release category binning logic to the new model. Again, this included adjustment of top event designations to prevent conflict with the level 1 model top event designations.
- Translating the new model from plant damage state (PDS) initiator basis to establish level 1 model conditions for each PDS. In general, this was done by translating the previous initiators to using new macros to establish the model conditions.
- Incorporating the resulting CET module into the level 1 logic and resolving conflicting top event naming designations.

Release categories were retained from the IPE level 2 model and the binning of release categories into the four categories; Early Containment Failure, Containment Bypass, Late Containment Failure, and Intact Containment shown in Table 1, was also retained from the IPE model.

4.3 Quantitative Strategy for External Events

The SAMA PRA model is an internal events including internal flooding, at power model. External events were evaluated in the IPEEE using seismic margins and the EPRI Fire Induced Vulnerability Evaluation (FIVE) methodologies. No vulnerabilities to external events were identified.

A multiplication factor of 2 is applied to the internal event results to account for the contribution to core damage from fire and other external events. The factor of two is based on a review of the SAMA submittals for a number of 4-loop Westinghouse plants including Wolf Creek [WCNOC 2006], Vogtle [SNC 2007], Catawba [DUKE 2001], McGuire [2001a] and D. C. Cook [AEP 2003]. The first two were chosen because they represent recent applications while the latter three, while older applications, were chosen because they represent ice condenser plants.

Additionally, while the dominant core damage sequences will be different for seismic, fire and other external events, overall the contributions to release categories should be bounded by the internal events PRA sequences. For example, it is not expected that containment bypass sequences (SG tube ruptures and interfacing system LOCAs) will be dominant release sequences for fire and seismic initiators since these tend to result in loss of power to operate and control plant equipment. Also, RCP seal LOCAs are a significant contributor to fire risk and SAMAs directed at maintaining RCP seal cooling are already considered for internal initiating events.

4.4 PRA Model Quality

The A and B level F&Os from the WOG peer review performed on the Watts Bar Unit 1 PRA model are shown in Table 2. All A and B level F&Os were reviewed for impact on the SAMA analysis. The Watts Bar Unit 2 SAMA model incorporates the resolution of the A and B level F&Os described in Table 2.

4.5 WBN Unit 2 SAMA Model Results

The core damage frequency result for the base case SAMA model is 1.537×10^{-5}, and the base case release category results are shown in Table 3.

4.6 WBN Unit 2 Level 3 SAMA Model

4.6.1 Analysis

The WinMACCS computer code, Version 3.4 [NRC 2007] was used to perform probabilistic analyses of radiological impacts. The WinMACCS code is the current version of the MACCS2 code. A detailed description of the MACCS model is provided in NUREG/CR-4691 [NRC 1990]. The enhancements incorporated in MACCS2 are described in the MACCS2 User's Guide [NRC 1998].

Site-specific input parameters formed the basis for the analysis, including population distribution, economic parameters, and agricultural product. Plant-specific release data included nuclide release quantities, release timing and duration, release energy (thermal content), release frequency, and release category (i.e., early release, late release). The behavior of the population during a release (evacuation parameters) was based on declaration of a general emergency and the WBN Plant emergency planning zone (EPZ) evacuation time.

Generic input parameters given with the MACCS2 Sample Problem A, which includes the data used in NUREG 1150 [NRC 1989], supplemented the site-specific data.

This data, in combination with site-specific meteorology, were used to simulate the probability distribution of impact risks (exposure and economic cost) to the surrounding 80-kilometer (within 50 miles) population.

4.6.2 Population Distribution

The population surrounding the WBN Plant site was estimated for the year 2040. The distribution was given in terms of the population at 10 distances, ranging from 0 miles to 50 miles from the plant, in the direction of each of the 16 compass points (north, north-northeast, northeast, etc.), a total of 160 segments. The population projections were determined using 2000 census population data. A map was prepared displaying county and census tract boundaries for all counties partly or totally within the 50 mile boundary. County population data for 2000 were allocated to the appropriate sectors, using census tracts to the extent feasible. For segments near the plant site, especially within 5 miles, aerial photos and TVA staff knowledge of the area were also used. The segments populations were projected for the year 2040 using growth rates from county population projections. The total projected population within 50 miles of the site was estimated to be 1,523,390 (see Table 4).

4.6.3 Economy and Agriculture Data

Agriculture production information was generated using SECPOP 2000. SECPOP provides the WinMACCS model with required information on the crops season and shares (fraction of land devoted to the crop).

WinMACCS also requires spatial distribution of certain economic data (fraction of land devoted to farming, annual farm sales, fraction of farm sales resulting from diary production, property values of farm and non-farm land). SECPOP also produces this data for the site.

4.6.4 Radionuclide Release

Core damage sequences that lead to containment failure (failure mode defined as bypass, early, and late) and release of radioactive materials to the environment are considered in this section. The core damage sequences from the Level 1 PRA are binned into plant damage states based on similar characteristics that control the accident progression following core damage and the timing and magnitude of fission product releases to the environment. The possible fission product releases are then binned into release categories that represent similar release magnitudes and timing. The Level 2 release categories are defined as conditional probabilities that, when combined with the plant damage state frequencies, yield release frequencies. The determination of the release characteristics for each release category is based on representative accident scenarios that reflect the post core damage behavior for the dominant sequence or sequences within a plant damage state. These core damage accident scenarios then become the major contributors to the release level categories associated with each of the containment failure modes.

The WBN2 Level 2 model is represented by a large containment event tree that is based on the NUREG-1150 Level 2 assessment for Sequoyah. The event tree nodes and split fractions were reviewed to assure that the consequences, in terms of release frequencies, would be larger than would be expected with an updated Level 2 model. This will maximize the consequences, which in turn would maximize the economic benefits of the candidate SAMAs.

The release categories that are used in the SAMA assessment and examples of various accident scenarios leading to containment failure and/or bypass are presented below.

These release categories represent a consolidation of release categories from the WBN2 Level 2 PRA. The consolidation was performed to simplify the SAMA assessment by choosing the most severe release characteristics from the WBN2 Level 2 PRA for each of the three SAMA release categories. This provides the largest potential benefit in terms of fission product release prevention or mitigation for the alternatives in the Phase 1 assessment.

- Release Category I results from a reactor vessel breach with early containment failure.
- Release Category II results from a reactor vessel breach with containment bypass.
- Release Category III results from a reactor vessel breach with late containment failure.
- The remaining core damage sequences do not challenge the containment and result in an intact containment.

Table 5 shows the equilibrium reactor core radionuclide inventory at the time of a reactor trip. Table 6 provides important information on time to core damage, containment failure, and release duration.

Table 7 shows the fission product release fractions associated with each of the release categories. Table 3 provides a representation of the dominant accident scenarios that lead to each release category and the likelihood of their occurrence.

4.6.5 Evacuation

Evacuation data, including delay time before evacuation, area evacuated, average evacuation speed, and travel distance, was obtained from the *Tennessee Multi-Jurisdictional Radiological Emergency Response Plan for the Watts Bar Nuclear Plant*, Annex H [TVA 2006]. For this analysis, the evacuation and sheltering region was defined as a 10-mile radial distance (the EPZ) centered on the plant. A sheltering period was defined as the phase occurring before initiation of evacuation procedures. During the sheltering period, shielding factors appropriate for sheltered activity were used to calculate doses to individuals in contaminated areas.

At the end of the sheltering period, residents would begin traveling out of the region. Travel speeds and delay times were based on the evacuation data also found in the *Tennessee Multi-Jurisdictional Radiological Emergency Response Plan for the Watts Bar Nuclear Plant*, Annex H [TVA 2006]. General population evacuation times for the various areas within the 10-mile radius were averaged to determine an overall evacuation delay time and evacuation speed. Average evacuation speeds based on the most conservative general population evacuation times in an adverse weather condition were considered (see Table 8).

Based on the data cited above, an average evacuation speed of 1 meter per second following a sheltering and evacuation delay time of 45 minutes and 2.50 hours were used. These delay values are provided in the *Tennessee Multi-Jurisdictional Radiological Emergency Response Plan for the Watts Bar Nuclear Plant,* Annex H, [TVA 2006] and NUREG/CR-4551, Vol. 2 [NRC 1990]. In addition, consistent with the analysis in the NUREG-1150 evaluation of the Sequoyah Nuclear Plant, it was assumed that 99.5 percent of the population in the 10-mile EPZ would be evacuated.

For this analysis, it was conservatively assumed that persons residing farther than 10 miles away from the plant would continue their normal activities unless the following predicted radiation dose levels were exceeded. At locations where a 50-rem whole body effective dose equivalent in 1 week was predicted, it was assumed that relocation would take place after half a day. If a 25-rem whole body dose equivalent in 1 week were predicted, relocation of individuals in those sectors was assumed to take place after 1 day.

4.6.6 Meteorology

Annual onsite meteorology data sets from 2001 through 2005 were used to prepare the sequential hourly data (8760 hours) required for use in WinMACCS. The 2002 sequential hourly meteorology data was found to result in the largest risk based on sampling the population dose consequence for each year with a reference set of fission product releases and was used for all of the analyses presented below. The conditional dose from each of the other years was found to be within 20 percent of the chosen year. The 2003 weather data set was found to result in the lowest population doses.

4.7 Severe Accident Risk Results

Table 9 summarizes the risks of a severe accident (without any SAMAs implemented), with mean meteorological conditions, within an 80-kilometer (50-mile) radius of the reactor site. The analysis assumes that a site emergency would have been declared early in the core damage accident sequence and that all nonessential site personnel would have evacuated the site in accordance with site emergency procedures before any radiological releases to the environment occurred. In addition, emergency action guidelines would be implemented to initiate evacuation of the public within 16.1 kilometers (10 miles) of the plant. The WinMACCS computer code models the evacuation sequence to estimate the dose to the general population within 80 kilometers (50 miles) of the accident. The frequency of each release category is given in Table 3. Table 10 shows the population dose risks (accident consequence multiplied by the release frequency) for each accident release category. These frequencies are based on WBN4SAMA PRA model.

Overall, the dose risk results are small. Completion and operation of WBN Unit 2 would not significantly change the risks evaluated for WBN Unit 1 because the principal change to Unit 1 accident mitigation capabilities is the loss of the Unit 2 CCS pumps as backup to the Unit 1 B Train CCS pumps, which is not risk significant. Changes to other systems, including shared systems, were found to have no significant impact on the

Unit 1 risks. This is consistent with the conclusions of NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) [NRC 1996]. Accidents that could affect multiunit sites are typically initiated by external events. Severe accidents initiated by external events such as tornadoes, floods, earthquakes, and fires traditionally have not been discussed in quantitative terms in final environmental statements and were not considered in the GEIS [NRC 1996]. In the GEIS, however, NRC staff did evaluate existing impact assessments performed by NRC and the industry at 44 nuclear plants in the United States and concluded that the risk from beyond-design-basis earthquakes at existing nuclear power plants is small. Additionally, the staff concluded that the risks from other external events are adequately addressed by a generic consideration of internally initiated severe accidents. To account for the possible contribution of fires and other external events to the core damage frequency at Watts Bar, the internal events core damage frequency was doubled. Thus, all candidate SAMAs are evaluated using the averted costs based on doubling the core damage frequency from the internal events PRA analysis.

5 COST OF SEVERE ACCIDENT RISK / MAXIMUM BENEFIT

This section explains how to monetize the severe accident consequences based on the formulas in the Nuclear Energy Institute's SAMA Analysis Guidance Document [NEI 2005]. This analysis is also used to establish the maximum benefit that could be achieved if all risk for reactor operation were eliminated (i.e., accident consequences without SAMA implementation).

5.1 Off-Site Exposure Cost

The annual off-site exposure risk was converted to dollars using the conversion factor of $2,000 per person-rem, and discounted to present value using the following standard formula:

$$W_{pha} = C * Z_{pha} \quad (1)$$

Where:

W_{pha} = monetary value of public health risk after discounting ($)

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

t_f = years remaining until end of facility life = 40 years

r = real discount rate (as fraction) = 0.07 per year

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

The Level 3 analysis showed a baseline annual off-site population dose risk of about 3.30 person-rem. The calculated value for C using 40 years and a 7 percent discount rate is approximately 13.42 years. 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 (13.42). In this calculation, the delay until the initial time of operation is conservatively assumed to be zero. The calculated off-site exposure cost is estimated to be $88,541.

5.2 Off-Site Economic Cost

The annual off-site economic risk was discounted to present value using the following standard formula:

$$W_{ca} = C * Z_{ca} \qquad (2)$$

Where:

W_{ca} = monetary value of economic risk after discounting

C = $[1\text{-}\exp(-rt_f)]/r$ (years)

t_f = years remaining until end of facility life = 40 years

r = real discount rate (as fraction) = 0.07 per year

Z_{ca} = monetary value of economic (accident) risk per year before discounting ($ per year)

The Level 3 analysis showed a baseline annual off-site economic risk of $5,692. Calculated values for off-site economic costs caused by severe accidents must be discounted to present value. This is performed in the same manner as for public health risks and uses the same C value. The resulting value is $76,365.

5.3 On-Site Exposure Cost

The values for on-site (occupational) exposure consist of "immediate dose" and "long-term dose." The best estimate value provided in NUREG/BR-0184 [NRC 1997] for immediate occupational dose is 3,300 person-rem/event, and long-term occupational dose is 20,000 person-rem (over a 10-year clean-up period). The following equations are used to calculate monetary equivalents.

5.3.1 Immediate Dose

$W_{IO} = R * F * D_{IO} * C$ (3)

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 (1.54×10^{-5} events per year)

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

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

r = real discount rate (0.07 per year)

t_f = years remaining until end of facility life (40 years).

The best estimate of the immediate dose cost for WBN Unit 2 is:

W_{IO} = $2{,}000 * 1.54 \times 10^{-5} * 3{,}300 * \{[1 - exp(-0.07 * 40)]/0.07\}$

= $1,361

5.3.2 Long-Term Dose

$W_{LTO} = R * F * D_{LTO} * C * \{[1 - exp(-rm)]/rm\}$ (4)

Where:

W_{LTO} = monetary value of accident risk for long-term on-site doses, after discounting, ($)

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

F = accident frequency (1.54×10^{-5} events per year)

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

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

r = real discount rate (0.07 per year)

t_f = years remaining until end of facility life (40 years).

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

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

$$W_{LTO} = 2{,}000 * 1.54 \times 10^{-5} * 20{,}000 * \{[1 - \exp(-0.07 \times 40)]/0.07\} * \{[1 - \exp(-0.07 * 10)]/0.07 * 10\}$$

$$= \$5{,}931$$

5.3.3 Total On-Site Exposure

The total occupational exposure is then calculated by combining equations 3 and 4 above. The total accident related on-site (occupational) exposure risk (W_O) is:

$$W_O = W_{IO} + W_{LTO} = (\$1{,}361 + \$5{,}931) = \$7{,}292$$

5.4 On-Site Economic Cost

On-site economic cost includes cleanup and decontamination cost, and either replacement power cost or repair and refurbishment cost.

5.4.1 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:

$$PV_{CD} = [C_{CD}/m] * \{[1-\exp(-rm)]/r\} \quad (5)$$

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 (0.07)

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

The resulting net present value of a single event is:

$$PV_{CD} = [\$1.5 \times 10^9 / 10 \text{ years}] * \{[1-\exp(-0.07*10)]/0.07\}$$

$$= \$1.08 \times 10^9.$$

The NEI 05-01 uses the following equation to integrate the net present value over the average number of remaining service years:

$$U_{CD} = PV_{CD} * C \quad (6)$$

Where:

U_{CD} = total cost of cleanup and decontamination over the analysis period ($-years)

PV_{CD} = net present value of a single event ($\$1.08 \times 10^9$)

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

r = real discount rate (0.07 per year)

t_f = years remaining until end of facility life (40 years).

The resulting net present value of cleanup integrated over the license term is

$$U_{CD} = \$1.08 \times 10^9 * \{[1-\exp(-0.07*40)]/0.07\}$$

$$= 1.45 \times 10^{10} \text{ \$-years}$$

5.4.2 Replacement Power Cost

Long-term replacement power costs were determined following NRC methodology in NUREG/BR-0184 (NRC 1997). The net present value of replacement power for a single event, PV_{RP}, was determined using the following equation:

$$PV_{RP} = [B/r] * [1 - \exp(-rt_f)]^2 \quad (7)$$

Where:

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

r = real discount rate (0.07)

t_f = 40 years (license period)

B = a constant representing a string of replacement power costs that occur over the lifetime of a reactor after an event (for a 910MWe "generic" reactor, NUREG/BR-0184 uses a value of $1.2E+8) ($/yr)

= $\$1.2 \times 10^8 * 1160/910 = \$1.53 \times 10^8$ for WBN Power level of 1160 MWe.

The resulting net present value of a single event is:

$$PV_{RP} = [\$1.53 \times 10^8/0.07] * [1 - \exp(-0.07*40)]^2$$

$$= \$1.93 \times 10^9.$$

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

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

Where:

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

r = real discount rate (0.07)

t_f = 40 years (license period)

The resulting net present value of replacement power integrated over the license term is

$$U_{RP} = [\$1.93 \times 10^9/0.07] * [1-\exp(-0.07*40)]^2$$

$$= 2.43 \times 10^{10} \text{ \$-years}$$

5.4.3 Total On-Site Economic Cost

The total on-site economic costs are calculated by summing cleanup/decontamination costs and replacement power costs, and multiplying this value by the internal events CDF.

On-site economic cost = $(1.45 \times 10^{10}$ $-years + 2.43×10^{10} $-years) * 1.54×10^{-5}/year

= $595,708

5.5 Total Cost of Severe Accident Risk / Maximum Benefit

The sum of the baseline costs is as follows:

Off-site exposure cost	=	$88,541
Off-site economic cost	=	$76,365
On-site exposure cost	=	$7,292
On-site economic cost	=	$595,708
Total cost	=	$767,906

The total cost risk represents the maximum averted cost risk if all risk were eliminated. The MACR ($767,906) is based on at-power internal events contributions.

The internal events MACR is doubled to account for external events contributions. The resulting modified MACR (MMACR) is $1,535,812 and was used in the Phase I screening process.

6 SAMA Identification

The list of SAMA items evaluated for WBN is given in Table 16. The process used to identify these SAMA items is described below.

The first source used to identify SAMA items is NEI 05-01 "Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document [NEI 2005]. Generic industry SAMAs that are to be considered are the 153 items that are identified in Table 14 of NEI 05-01. Next, the license renewal applications for several recent submittals were reviewed and any SAMA items identified were added to the list of items to be evaluated. The plants reviewed were Cook [APS 2003], Catawba [DUKE 2001], McGuire [DUKE 2001a], Wolf Creek [WCNOC 2006], and Vogtle [SNC 2007]. The review of these plant license renewal submittals resulted in the addition of 105 SAMA items (items 154 through 258) for consideration.

Identification of WBN-specific items began with a review of the original WBN Individual Plant Examination (IPE) [TVA 1992] and the WBN Individual Plant Examination for External Events (IPEEE) [TVA 1998]. The list of potential plant improvements from Section 6 of the IPE was reviewed and 12 additional SAMA items (items 259 through 270) were added. No potential improvements were identified from the IPEEE analyses.

Additional WBN-specific items included a review of the important systems and basic events. Each system and basic event with a risk reduction worth greater than 1.02 was reviewed to identify any potential SAMAs. In total, 13 new SAMA items (items 271 through 283) were generated from the importance review. Further review of the top 100 dominant sequences did not identify any additional candidate SAMAs.

As a result of the reviews described above, 283 potential SAMA candidates were identified. A complete listing is contained in Table 16.

6.1 Industry SAMA Analysis Review

The SAMA identification process for WBN Unit 2 included review of the standard list of PWR SAMA candidates from NEI's Severe Accident Mitigation Alternatives (SAMA) Analysis – Guidance Document [NEI 2005] as well as selected industry SAMA submittals. Submittals from Ice Condenser plants as well as recent 4-loop PWRs were included in the review. While many of these SAMAs are ultimately shown not to be applicable to WBN or not to be cost beneficial, they capture potentially important changes not identified for WBN due to PRA modeling differences or SAMAs that represent alternate methods of addressing risk.

Phase I SAMAs were included from the following U. S. nuclear power sites:

- Cook [APS 2003]
- Catawba [DUKE 2001]
- McGuire [DUKE 2001a]
- Wolf Creek [WCNOC 2006]
- Vogtle [SNC 2007]

6.2 WBN IPE

The WBN1 IPE did not identify any plant vulnerabilities. However a PRA screening was performed to examine major contributors to either the total core damage frequency or the early release frequency.

For individual initiators, single component failures, or single operator actions, potential enhancements were evaluated if they contributed more than 5×10^{-5} per reactor-year to the core damage frequency. Potential enhancements of a single system train were evaluated further if they contributed more than 1×10^{-4} per reactor-year to the total core damage frequency.

The results for Watts Bar lead to the conclusion that there were three contributors to the total core damage frequency that exceed the PRA screening criteria for consideration of potential enhancements. Loss of offsite power and the total loss of CCS initiating event categories each contribute greater than 5×10^{-5} to the total core damage frequency. Additionally, failure of operator action to trip the RCPs in the event of a loss of CCS train A contributes greater than 5×10^{-5} to the total core damage frequency.

The options for potential enhancements were organized in terms of changes to procedural and plant hardware features.

6.2.1 ENHANCED PROCEDURES/OPERATOR ACTIONS

The following procedure enhancements were suggested in the Watts Bar IPE

1. For addressing a loss of CCS train A, consideration should be given to revising AOI-15, "Loss of Component Cooling Water," to facilitate stopping the RCPs on loss of CCS train A to minimize the potential for RCP seal damage due to pump bearing failure.

2. Also, in the event of a total loss of CCS, clearer guidance on the desirability of cooling down the RCS prior to a seal LOCA developing to minimize the potential for seal damage should be considered. In general, additional training on the loss of CCS initiator is suggested[1].

3. In the event of a loss of offsite power followed by the failure of both shutdown boards on one unit, the procedures would be enhanced by adding the guidance to align the C-S diesel generator (i.e., the fifth diesel generator) to one of the shutdown buses not powered in the accident sequence due to the loss of a normally aligned diesel generator[2]. This alignment could be accommodated by including a reference to the spare diesel generator in AOI-35, "Loss of Offsite Power."

6.2.2 ENHANCED PLANT HARDWARE

The following plant hardware enhancement was suggested in the Watts Bar IPE.

1. A potential improvement that could be evaluated is a plant change to provide connections for both centrifugal charging pumps, on both units, to the ERCW system for lube oil cooling in the event of a loss of CCS cooling to the associated pump. Currently, this capability is only available for centrifugal charging pump A on Unit 1. A sensitivity study shows that this could result in a decrease of about 4% in the total CDF.

6.2.3 ADDITIONAL INSIGHTS AND RECOMMENDATIONS

Additional insights were presented in the IPE based on sensitivities to various scenarios. The recommendations offered were not associated with significant plant vulnerabilities and were below the PRA enhancement criteria for further evaluation. The insights and recommendations listed below were viewed as additional considerations.

1. Enhancements to the operator training and procedures for responding to failures of support systems could potentially be beneficial, with emphasis on anticipating problems and coping.

2. Ventilation has been conservatively modeled in this study. Area ventilation is provided to the motor-driven AFW pumps and the CCS pumps from multiple systems serving the plant elevation where these pumps are located. Beyond design basis concurrent failures of the available WBN1 ventilation is assumed

---

[1] Later assessments of RCP seal behavior following a loss of all seal cooling shows that this time is too short to support operator actions.

[2] Following completion of the IPE, it was determined that the 5th diesel was not cost-beneficial and completion of this feature was not pursued by TVA.

to impact the long-term availability of the AFW and CCS. An evaluation of the CCS/AFW area cooling requirements could be performed which could reduce this interdependence by crediting natural convection and availability of other coolers at this plant elevation.

3. In the event of a loss of ERCW, which would eventually lead to a loss of CCS cooling, additional guidance on the relationship of CCS to ERCW and the desirability of eliminating CCS loads to extend the time of suitable CCS temperatures is a potential consideration for evaluation. This could be accomplished by revising AOI-13, "Loss of ERCW," to alert the operators to shed CCS loads prior to CCS heatup.

4. During a loss of all AC, the steam generator power-operated relief valves (PORV) are to be locally operated to depressurize the steam generators, thereby cooling down the RCS. The addition of provisions for remote operation of these valves could potentially be beneficial due to the high area temperatures that may be encountered.

5. In the event of a loss of CCS cooling to the charging pumps, the time available for operation of the pumps would be limited by the loss of lube oil heat exchanger cooling. To extend the time available to protect the pumps, consideration could be given to increasing the oil capacity.

6. Losses of RCP seal cooling could potentially be reduced if the RCP thermal barrier cooling dependence on component cooling water, which is required for the charging pumps that provide RCP seal injection, could be eliminated.

7. Ventilation for the 480V board room that contains the unit vital inverters is provided by one train of ventilation. The PRA model relies substantially on recovery actions by the operators. Consideration could be given to providing two trains[3].

8. From a severe accident point of view, one potential change, for consideration, would be the delaying of containment spray operations relative to the Phase B condition. Currently, containment sprays actuate immediately in response to a Phase B condition, and air return fans (ARF) actuate after a 10-minute delay. This is currently a requirement of the design basis LOCA where switchover to containment spray recirculation occurs prior to ice melt; thereby limiting pressure increases below containment design pressure. Modular Accident Analysis Program analyses of representative core damage sequences indicate

[3] SAMA 269 describes the changes implemented for this issue.

that actuation of the containment sprays while ice remains in the ice condenser has little impact on severe accident containment performance and may be detrimental in that operation of the sprays rapidly depletes the inventory of the RWST, making its contents unavailable for vessel injection. Since many scenarios have successful injection for core cooling but failure at recirculation, the rapid depletion of the RWST due to spray operation accelerates the time to core damage. Therefore, an evaluation balancing the severe accident versus design basis requirements could be made.

6.3 WBN IPEEE

The Watts Bar IPEEE evaluated seismic events, internal fire events, and other external events. The only vulnerability identified by the IPEEE has already been corrected as described in 6.3.3. The results of the IPEEE in the three areas is shown below.

6.3.1 SEISMIC EVENTS

During the performance of the IPEEE Seismic Margins Assessment the Seismic Review Team (SRT) did not identify any significant concerns with the plant configuration control. Various minor maintenance and housekeeping issues were identified and were dispositioned and work requests (WR's) were written as needed.

No changes in maintenance, operating and emergency procedures, surveillance, staffing, or training programs were identified due to the evaluation performed for the seismic event.

6.3.2 INTERNAL FIRE EVENT

No significant plant improvements were identified during the systematic evaluation of the internal fire event. The existing plant configuration and procedures adequately provide sufficient margins for the internal fire event. No changes to the physical configuration, maintenance, operating and emergency procedures, surveillance, staffing, or training programs were identified due to the evaluations performed for the internal fire event.

SAMAs 142, 143,144, 145, 146, and 256 are included in the Phase 1 analysis to specifically address potential fire risks.

6.3.3 OTHER EXTERNAL EVENTS

During the systematic evaluation of the other external events, one configuration related condition was identified by the walkdown team as needing further attention:

> During the walkdown, it was confirmed that Category I building entrances and exterior openings in walls and slabs are protected against tornado generated missiles which could penetrate and hit safety related equipment. The only exception was an opening in the concrete canopy on the Unit 2

side of the Auxiliary Building. This opening had the potential to allow tornado missiles to penetrate the Auxiliary Building from the Unit 2 area.

Thus, Problem Evaluation Report (PER) WBPER970050 was initiated to evaluate and provide necessary corrective action. The resolution was to design and install a steel shield plate over the opening to provide the required protection. That modification is complete.

No other plant improvements were identified during the evaluation as needed. The existing plant configuration and procedures adequately provide sufficient margins for the other potential severe accident external events. No other changes to the physical configuration, maintenance, operating and emergency procedures, surveillance, staffing, or training programs were identified due to the evaluations performed for the other external events.

6.4 WBN Unit 2 PRA Importance List Review

The systems and basic events that have a risk reduction worth greater than 1.02 were reviewed to identify potential SAMAs. Table 11 lists the systems that have a RRW greater than 1.02 relative to CDF.

Table 12 lists the systems that have a RRW greater than 1.02 relative to LERF. Table 13 lists the basic events that have a RRW greater than 1.02 relative to CDF. And Table 14 lists the basic events that have a RRW greater than 1.02 relative to LERF.

The SAMA candidates identified through this review are identified in Table 15.

6.5 List of Phase I SAMA Candidates

The initial list of SAMA candidates to be evaluated is presented in Table 16.

7 PHASE I SAMA ANALYSIS

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:

- Not Applicable: If a proposed SAMA does not apply to the WBN design, it is not retained.
- Already Implemented: If the SAMA or equivalent was previously implemented and is accounted for in the PRA model, it is not retained.
- Combined With Another SAMA: If a SAMA is similar in nature and can be combined with another SAMA to develop a more comprehensive or plant specific SAMA, only the combined SAMA is further evaluated.

- Excessive Implementation Cost: If the estimated cost of implementation is greater than the modified Maximum Averted Cost-Risk, the SAMA cannot be cost beneficial and is screened from further analysis.
- Very Low Benefit: If the SAMA is related to a non-risk significant system which is known to have negligible impact on the risk profile, it is not retained

Table 16 provides a description of how each SAMA was dispositioned in Phase 1. Those SAMAs that required a more detailed cost-benefit analysis are evaluated in Section 8.

8 PHASE II SAMA ANALYSIS

The purpose of the Phase II analysis is to perform a cost-benefit analysis on the SAMAs that were not screened out in Phase I. The Phase I screening resulted in 18 SAMAs retained for further analysis. The risk benefit for each of these was analyzed using the PRA model described in Section 4. The cost of implementation of the SAMAs was estimated to identify those SAMAs that are potentially cost beneficial. The results of the Phase II analysis are shown in Table 17 and are described below.

SAMA 4: Improve DC bus load shedding.

Description: The SBO procedure includes shedding DC loads to extend battery availability. This SAMA evaluates the potential for enhancement to shed additional loads to extend battery life until AC power is recovered.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming AC power is always recovered prior to battery failure. The risk model was revised to set the offsite power recovery top event (OGR1) to guaranteed success. The resulting CDF is 1.493×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $83,399.

Cost: The TVA estimated cost of this SAMA is $31,675.

SAMA 8: Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.

Description: Training is conducted on inadvertent Safety Injection, and loss of a single AC bus, however not on the loss of two 120V buses. This SAMA evaluates potential improvements in this operator training for loss of a second 120V bus.

Risk Benefit: The risk benefit was bounded by eliminating the contribution of the loss of 120V bus initiators. The risk benefit was calculated by removing the consequences of a loss of each of the single bus initiator events from the base case consequences. The resulting CDF is 1.516×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $21,469.

Cost: The TVA estimated cost of this SAMA is $26,773.

SAMA 32: Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.

Description: Low pressure ECCS automatically aligns for recirculation from the containment sump, however the high head recirculation is manual. This SAMA evaluates potential design improvements to automatically align high head recirculation.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming that swapover to high pressure recirculation was always successful. The risk model was revised to set the top event for transfer to high pressure recirculation (RRH) to guaranteed success. The resulting CDF is 9.329×10^{-6}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $530,264.

Cost: The TVA estimated cost of this SAMA is $2,100,000.

SAMA 45: Enhance procedural guidance for use of cross-tied component cooling or service water pumps.

Description: Watts Bar has the capability to cross-tie CCS trains and ERCW trains, and a flood mode procedure exists to supply CCS from ERCW by installing a spool piece. This SAMA will review procedural guidance in AOI-15 for potential upgrades.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming that ERCW alignment to charging pump cooling was always successful. The risk model was revised by setting the top event for charging pump cooling recovery (CCPR) to guaranteed success. The resulting CDF is 1.432×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $89,003.

Cost: The TVA estimated cost of this SAMA is $31,675.

SAMA 46: Add a service water pump.

Description: An alternate pump exists that can be temporarily connected to the ERCW system to provide ERCW capability, however a permanent diesel driven 10,000 gpm pump could be installed at the IPS flush connection to provide increased ERCW availability.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming that ERCW pump 1A-A was always successful. The risk model was revised to set pump 1A-A to guaranteed success in alignments for top events AEBEI, AEBEX, and AEX. The resulting CDF is 1.429×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $102,000.

Cost: The TVA estimated cost of this SAMA is $1,042,511.

SAMA 56: Install an independent reactor coolant pump seal injection system, without dedicated diesel.

Description: There is potential to install a small RCP seal injection pump in the PD pump room. This would be useful for loss of ERCW and loss of CCS which contributes 35% of the core damage. Suction piping, discharge piping, and power are available in the PD pump room. The current PD pump would be dismantled and a new low capacity high pressure pump would be installed. Room cooling requirements will also need to be evaluated.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming RCP seal injection is always successful when AC power is available. The risk model was revised by setting top event SE to guaranteed success when offsite power or a diesel generator is successful. Normal conditions are applied otherwise. The resulting CDF is 7.902×10^{-6}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $675,053.

Cost: The TVA estimated cost of this SAMA is $2,400,000.

SAMA 70: Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.

Description: The WBN turbine driven AFW pump flow control valves have a nitrogen supply that can be manually aligned. The nitrogen backup is not credited in SBO risk model. Installing accumulators would eliminate this manual action.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming the turbine-driven AFW pump level control valves (LCV) will not fail closed. The risk model was revised to set the LCV fails closed failure mode to guaranteed success in the Auxiliary Feedwater top events (AFC, AFX, and AF100). The resulting CDF is 1.538×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $1,945.

Cost: The TVA estimated cost of this SAMA is $256,204.

SAMA 71: Install a new condensate storage tank (auxiliary feedwater storage tank).

Description: The two unit CSTs are cross-tied so that they can supply either unit. Installation of a new third CST would require a new pad, and piping to tie it in to the AFW supply.

Risk Benefit: There is no risk benefit for this modification. The same operator actions and procedures would be required to cross-tie the third CST as are presently available for the cross-tie of the two existing CSTs.

Cost: The TVA estimated cost of this SAMA is $1,706,586.

SAMA 87: Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.

Description: Watts Bar is evaluating the status of the construction air compressors. Permanent installation of this air compressor could improve the reliability of the station air system. Installation would need to consider HVAC requirements for the self-cooled compressor.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming the normal plant air system is always successful. The risk model was revised by setting top event for plant air (PD) to guaranteed success. The resulting CDF is $1.486\text{x}10^{-5}$. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $121,460.

Cost: The TVA estimated cost of this SAMA is $886,205.

SAMA 112: Add redundant and diverse limit switches to each containment isolation valve.

Description: Most of the containment isolation valves are air operated valves, however the ECCS valves are mostly motor operated. There is redundant valve status indication in control room. This SAMA will evaluate the number of CIVs where installation of limit switches may provide a benefit.

Risk Benefit: The risk benefit was bounded by calculating the change due to eliminating interfacing system LOCA initiating events. Interfacing LOCA due to failures other than containment isolation failure such as failure of valve disk integrity are unaffected by this change, however a maximum potential risk reduction was generated by requantifying the risk model without the ISLOCA initiating events. The resulting CDF is $1.535\text{x}10^{-5}$. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $4,565.

Cost: The TVA estimated cost of this SAMA is $691,524.

SAMA 136: Install motor generator set trip breakers in control room.

Description: Installing a low cost means for tripping the motor generator sets from the control room may reduce the risk from ATWS.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming the operator action to trip the reactor is always successful. In the WBN risk model, this operator action is modeled as part of operator action OEB. The risk model was therefore quantified with operator action OEB set to guaranteed success. The resulting CDF is 1.529×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $7,397.

Cost: The TVA estimated cost of this SAMA is $241,795.

SAMA 156: Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.

Description: Procedure AOI-7.07 provides direction to connect ERCW to CCS to supply the thermal barrier coolers. AOI-15 for loss of CCS should be revised to refer to AOI-7.07

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming RCP seal injection is always successful when AC power is available. A bounding evaluation for this case was generated by revising the risk model by setting top event SE to guaranteed success when offsite power or a diesel generator is successful. Normal conditions are applied otherwise. The resulting CDF is 7.902×10^{-6}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $675,053.

Cost: The TVA estimated cost of this SAMA is $31,675.

SAMA 176: Provide a connection to alternate offsite power source.

Description: Two 161kV lines come into the Watts Bar switchyard from the nearby hydro plant switchyard. There are 5 redundant lines into the hydro switchyard. This SAMA would implement a design change to install an additional transmission line from the hydro plant.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming removal of grid-related failures from the frequency of loss of offsite power. From NUREG/CR-6890 (Table ES-2), grid related causes result in 1.86E-2 LOSP events per critical reactor year, compared with 3.59E-2 total LOSP frequency per critical reactor year. The risk model was revised by reducing LOSP frequency by 51.8%. The resulting

CDF is 1.5128×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $42,254.

Cost: The TVA estimated cost of this SAMA is $9,126,460.

SAMA 256: Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.

Description: The Appendix R program rerouted permanent cables and conduits as necessary, however procedure enhancements for control of temporary cable impacts on fire protection will be reviewed. This SAMA only includes potential procedure enhancements, since hardware modifications were previously completed.

Risk Benefit: Although fire risk is not directly quantified in the risk model the benefit of enhancing the procedure controlling temporary alterations was estimated by conservatively reducing the consequences of all release categories except SGTR by 25%. The resulting CDF is 1.144×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $426,340.

Cost: The TVA estimated cost of this SAMA is $19,608.

SAMA 273: Provide a redundant path for ECCS suction from the RWST around check valve 62-504.

Description: Check valve 62-504 is a single failure point for ECCS injection and contributes 7% to CDF. This SAMA would implement a design change to install a parallel check valve with 62-504.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming check valve 62-504 is always successful. The risk model was revised to set check valve 62-504 to guaranteed success in common CVCS supply top event VS. The resulting CDF is 1.438×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $87,379.

Cost: The TVA estimated cost of this SAMA is $439,945.

SAMA 276: Provide an auto start signal for AFW on loss of Standby Feedwater pump.

Description: Incorporation of an AFW auto start signal on loss of the Standby Feedwater pump is under review. This SAMA would improve reliability of AFW for low power events (<18%) before Main Feedwater pumps are started. This SAMA is to implement a design change to install logic to start AFW on loss of flow from Standby Feedwater pump.

Risk Benefit: The risk benefit is only applicable to startup where a loss of SG heat sink could occur if the startup feed pump fails. The maximum benefit would be the elimination of all startup risk. This is modeled as reducing the risk for all initiators except SGTR by 1/365 assuming that startup is only performed for the equivalent of one day per year and that the startup risk is approximately equal to the at-power risk. Therefore the averted risk cost is $5,926.

Cost: The TVA estimated cost of this SAMA is $615,605.

SAMA 279: Provide a permanent tie-in to the construction air compressor.

Description: The final disposition of the construction air compressor is under evaluation. This SAMA is to implement a design change to use the construction air compressor in addition to the A, B, C and D compressors.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming the normal plant air system is always successful. The risk model was revised by setting top event for plant air (PD) to guaranteed success. The resulting CDF is 1.486×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $121,460.

Cost: The TVA estimated cost of this SAMA is $909,893.

SAMA 280: Add new Unit 2 air compressor similar to the Unit 1 D compressor.

Description: The final disposition of installing a compressor similar to the Unit 1 D compressor is under evaluation. This SAMA is to implement a design change to install a new compressor similar to the Unit 1 D compressor in place of current Unit 2 D compressor.

Risk Benefit: The risk benefit was bounded by calculating the change due to assuming the normal plant air system is always successful. The risk model was revised by setting top event for plant air (PD) to guaranteed success. The resulting CDF is 1.486×10^{-5}. Calculating the averted risk cost relative to the base case using the method described in Section 5 results in a net benefit of $121,460.

Cost: The TVA estimated cost of this SAMA is $814,546.

9 UNCERTAINTY ANALYSIS

Sensitivity cases were run for the following conditions to assess their impact on the overall SAMA evaluation:

- Use a real discount rate of 7 percent, instead of the 3 percent value used in the base case analysis.

- Use the 95th percentile PRA results in place of the mean PRA results.
- Use alternate MACCS2 input variables for selected cases.

9.1 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 7 percent has been changed to 3 percent, which could be viewed as conservative, and the MMACR was recalculated using the methodology outlined previously.

Implementation of the 3 percent RDR increased the MMACR by 81 percent compared with the case where a 7 percent RDR was used. This corresponds to an increase in the MMACR from $1,535,812 to $2,775,610.

The Phase 1 SAMA list was reviewed to determine if such a decrease in the MMACR would impact the disposition of any SAMAs. It was determined that no additional SAMAs could have been screened in the Phase 1 if an RDR of 3 percent were used in place of the 7 percent value.

The Phase 2 SAMAs are dispositioned based on detailed analysis. As shown in Table 18, the determination of cost effectiveness changed for one Phase 2 SAMA when the 3 percent RDR was used in lieu of 7 percent. However, the margin by which the SAMA becomes "cost beneficial" is small and it does not mean that this SAMA would be screened from consideration if a 3 percent real discount rate were applied in the SAMA analysis as other factors influence the decision making process, such as the 95th percentile sensitivity analysis.

9.2 95th Percentile PRA Results

The results of the SAMA analysis can be impacted by implementing conservative values from the PRA's uncertainty distribution. If the best estimate failure probability values were consistently lower than the "actual" failure probabilities, the PRA model would underestimate plant risk and yield lower than "actual" averted cost-risk values for potential SAMAs. Re-assessing the cost benefit calculations using the high end of the failure probability distributions is a means of identifying the impact of having consistently underestimated failure probabilities for plant equipment and operator actions included in the PRA model. This sensitivity uses the 95th percentile results to examine the impact of uncertainty in the PRA model.

For WBN2, the results of the RISKMAN analysis of the Level 1 internal events model uncertainty analysis are provided below:

PARAMETER	CDF per reactor-yr
Mean	1.59E-05
5 percent	3.86E-06
50 percent	9.19E-06
95 percent	4.28E-05

The PRA uncertainty calculation identifies the 95th percentile CDF as 4.28E-05 per year. This is a factor of 2.78 greater than the CDF point estimate produced by the WNB2 PRA.

For WBN2, RISKMAN model also includes an integral Level 2 model so that the impact of the Level 1 parameter uncertainty can be measured in terms of early releases. The results show:

PARAMETER	LERF per reactor-yr
Mean	3.80E-07
5 percent	1.05E-07
50 percent	2.37E-07
95 percent	9.83E-07

The PRA uncertainty calculation identifies the 95th percentile LERF as 9.83E-07 per year. This is a factor of 2.5 greater than the LERF point estimate produced by the WBN2 PRA.

As shown in Table 19, the determination of cost effectiveness changed for two Phase 2 SAMAs when the 95^{th} percentile parameter uncertainty was used in lieu of the mean values. However, the margin by which the SAMA becomes "cost beneficial" is small and it does not mean that this SAMA would be screened from consideration if a 95th percentile LERF were applied in the SAMA analysis as other factors influence the decision making process.

9.3 WinMACCS Input Variations

The MACCS2 model was developed using the best information available for the WBN 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, sensitivity assessments were performed on a group of parameters that has previously been shown to impact the Level 3 results. These parameters include:

- Meteorological data
- Population estimates
- Evacuation effectiveness
- Radionuclide release height

Meteorological data and radionuclide release height have been studied extensively (e.g., the Vogtle and Wolf Creek SAMA Uncertainty analyses) and have been shown to result in relatively small changes in overall risk.

On the other hand, population density and evacuation speed have been show to have the greatest effect on risk. Population density increases have been accounted for in the WBN SAMA assessments by using the projected 2040 population densities in the 50 mile radius of the WBN site. Smaller population increases would serve to reduce the cost effectiveness of various SAMA alternatives.

The impact of evacuation speed was investigated by performing a sensitivity analysis with MACCS2 where the evacuation speed was reduced from 2.2 mph (1 meter/sec) to 1.6 mph and another where the evacuation speed was increased to 3.4 mph. The results, in terms of impact on the baseline SAMA cost benefit are provided in Table 20. As shown in Table 20, the cost effectiveness of all SAMAs does not change with changes in evacuation speed. This is due to the relatively low contribution of offsite exposure cost to the overall cost as shown in Section 4.5.

10 CONCLUSIONS

The benefits of revising the operational strategies in place at Watts Bar and/or implementing hardware modifications can be evaluated without the insight from a risk-based analysis. However, use of the PRA in conjunction with cost-benefit analysis methodologies provides an enhanced understanding of the effects of the proposed changes relative to the cost of implementation and projected impact on offsite dose and economic impacts.

The results of this study indicate that of the identified potential improvements that can be made at WBN, several are cost beneficial based on the methodology applied in this analysis:

- SAMA 4: Review station blackout procedures for improvements in DC load shedding.

- SAMA 45: Enhance procedural guidance for use of cross-tied component cooling or service water pumps.

- SAMA 156: Enhance procedural guidance for use of ERCW for RCP thermal barrier cooling..

- SAMA 256: Enhance procedure for controlling temporary alterations to reduce fire risk from temporary cables.

These SAMAs could be considered to be cost beneficial alone, but given the risk reduction provided by each SAMA, implementation of any one of them could make the averted cost risk of implementation of the remaining SAMAs not cost beneficial as the relevant risk factors would be addressed. However, TVA commits to implementation of the identified procedure enhancements (SAMAs 4, 45, 156, and 256).

The results of the uncertainty analysis for this study indicate that one additional SAMA is cost beneficial:

• SAMA 8: Increase training on response to loss of two 120V AC buses.

TVA also commits to implementation procedure enhancements identified in SAMA 8.

Table 1 Definition and Causes of Containment Failure Mode Classes

Failure mode	*Definition and Causes*
Early Containment Failure	Involves structure failure of the containment before, during, or slightly after (within a few hours of) reactor vessel failure. A variety of mechanisms can cause structure failure, including direct contact of core debris with containment, rapid pressure and temperature loads, hydrogen combustion, and fuel coolant interaction (ex-vessel steam explosion). Failure to isolate containment or to provide early venting of containment after core damage also is classified as early containment failures.
Containment Bypass	Involves failure of the pressure boundary between the high-pressure reactor coolant and low-pressure auxiliary system. For pressurized water reactors, steam generator tube rupture, either as an initiating event or as a result of severe accident conditions, will lead to containment bypass. In this scenario, if core damage occurs, a direct path to the environment can exist.
Late Containment Failure	Involves structural failure of the containment several hours after reactor vessel failure. A variety of mechanisms can cause late structure failure, including gradual pressure and temperature increase, hydrogen combustion, and basemat melt-through by core debris. Venting containment late in the accident also is classified as a late containment failure.
Intact Containment	Involves no structural failure or bypass of the containment. If core damage occurs, fission products are retained in the containment and there is no release to the environment.

Table 2 Level A and B F&O Resolution

F&O	Description	Resolution Status	Model Impact
IE-01	The IE database Notebook document does not completely identify all methodologies used in the frequency estimates or the basis for using the various methodologies. For example, the IE Data notebook only mentions performing frequency estimates based on plant specific and generic data, where as in the WBN IPE report Section 3.3.1 several initiator frequencies were estimated using fault tree solution. IE guidance should explain the process used to develop the initiating event frequencies and the basis for using industry accepted methodologies. The data, calculations, and results should be presented in the PSA report. The notebook does not contain enough detail to sufficiently reproduce all the results (i.e., the IPE report states certain frequencies were estimated using fault tree solution; however, in the notebook and the IPE report some of the frequencies appear to have been possibly obtained from using generic data). Detailed guidance that describes the process used and criteria for using the different methodologies should be provided such that the results can be reproduced. The data, calculations, and results should be part of the PSA report or a stand-alone calculation file. IE-06 has been combined into IE-01 - An explanation of the process used to identify and apply systematic techniques as plant specific fault tree models or FMEAs to quantify initiating event frequencies and recovery was not found in the IE documentation. Guidance should be provided that describes the process for developing initiating event frequencies and the basis for using the different methodologies. The guidance and documentation should provide sufficient detail to reproduce all results.	Closed - A new initiating event notebook was created showing the basis and process used to calculate each initiating event frequency such that the results are reproducible. Initiating events created via system fault trees are documented in their respective system notebooks.	None
IE-02	PLG-1351, Initiating Event Database Notebook, Table 1-3 documents "Prior" Means that are updated with Plant Specific Data. There is no basis shown for the majority of the Prior Means. There is no match with either the PLG Data shown on Table 1-1 for PLG or NUREG/CR-5750. Some of the IE frequencies used are significantly higher than the NUREG values (SGTR, inadvertent closure of all MSIVs). Some IE frequencies are significantly lower than the NUREG values (LLOCA, steam line breaks) but no numerical basis is shown. The bases for the calculations should be provided. Document basis of Prior Means. Detailed discussion and calculation should be developed for deviation from NUREG/CR-5750 (or other referenced data sources).	Closed - A new initiating event notebook was created showing the basis and process used to calculate each initiating event frequency such that the results are reproducible. Initiating events created via system fault trees are documented in their respective system notebooks. NUREG-5750 was used as the basis for many of the prior means.	None

F&O	Description	Resolution Status	Model Impact
IE-03	The initiating event analysis does not appear to have considered loss of HVAC as a potential initiator. Loss of HVAC was not included in the support system FMEA. Loss of HVAC was considered and dismissed in a summary analysis, after the support system initiator analyses were done (per Stillwell memo 1992). The current system notebook for AC power states that room cooling is necessary for success of 6.9-kv boards, 480V AC busses and 115V AC busses. If this is true, then it would seem that the loss of HVAC should be incorporated into (or at least further addressed in) the initiating event analysis. Clarify whether or not Loss of HVAC is an initiator for AC power rooms, CCS rooms, and ERCW rooms. Either add to the model if needed, or provide discussion in the documentation if not needed.	Closed - TVA calculation WBNOSG4-242 shows that 6.9kV rooms remain less than 103.5F for at least 24 hours following loss of ventilation. Also, shutdown boards only supply mitigative plant features, not loads that would cause unit trip.	An ORT success term was used to show that operators would have tripped the reactor prior to room heatup. This prevents a very short term action from being dependent on a very long term heatup impact.
IE-05	The frequency for Loss of Offsite Power is updated with a Bayesian process. The plant specific data is listed as 0 failures in 20 years, i.e., the exposure time for the switchyard is considered to be 20 years (since 1980). The claim is made, but not adequately substantiated, that the switchyard experience since 1980 is applicable to the current switchyard operation, thus allowing 20 years accumulated experience. There is no evidence provided that a) records for switchyard failures over the past 20 years were kept and are accurate (including partial failure), b) switchyard configuration is the same now as it was during construction, c) electrical transients are the same now as in construction. Reducing the exposure time from 20 to 2.89 years (to reflect length of plant operation considered for PSA Rev 3) would increase the mean LOSP frequency about a factor of 3-4 depending on the assumptions of the Bayesian analysis. Use 2.89 years for plant specific time for switchyard experience or provide stronger justification for use of an exposure time of 20 years for the switchyard.	Closed - The initiating event LOSP, Loss of Offsite Power, is based on NUREG/CR 5750, was performed for the Revision 4 PSA model. The Revision 4 initiating event analysis documents that the distribution was Bayesian updated using RISKMAN with 0 events in 20 years. Note that the use of 20 years of data includes non operational time and time from before commercial operation. This distribution was Bayesian updated using RISKMAN with 1 event in 6.25 years. The resulting mean of 4.85E-02/reactor year was used in the Revision 4 model. This analysis was compared to a generic total loss of offsite power frequency from NUREG/CR-6928. The NUREG provides a frequency of 3.59E-02/reactor year. If the Bayesian update was to be performed with the updated prior generic frequency and only a 6 year plant specific data window, the resultant frequency would be lower than the Revision 4 LOSP frequency. Therefore the Revision 4 frequency is maintained.	None

F&O	Description	Resolution Status	Model Impact
IE-07	The Loss of Instrument Air initiator is not treated explicitly. It should capture the dependency of Instrument Air and AFW flow control. Some failures of instrument air could cause an initiator and fail AFW flow control. These do not appear to have been evaluated. Instrument Air to essential PSA loads is supplied by essential air and control air. The FMEA for support systems initiating events states that if control air is lost, essential air will supply loads. Loss of Instrument Air is dismissed as a special initiating event, but included as a cause of a MSIV closure. However, a loss of all air fails AFW flow control whereas the MSIV closure event modeling assumes AFW flow control is operable. Quantify Loss of Instrument Air as an initiator. (This is needed to complete the dependency analysis).	Closed - A Loss of Plant Air initiating event was incorporated into the model.	The Loss of Plant Air (LOPA) initiating event was added to the model with a generic initiating event frequency of 9.81E-3. The guaranteed failure term for plant compressed air top event PD in event tree module MECH was changed to include an "INIT=LOPA" term. The initiating event LOPA was added to the initiating event group ALL and requantified at a quantification cutoff of 1E-12.

F&O	Description	Resolution Status	Model Impact
AS-01	Accident Scenario Evaluation (Event Tree Structure): Since several specific modeling issues have been identified, a comprehensive review of the entire logic structure is recommended. The success criteria associated with the RCP Seal LOCA model is overly conservative. As currently modeled, only failure of Thermal Barrier cooling to all four RCPs combined with failure of RCP Seal Injection to any one of the four RCPs results in a RCP Seal LOCA. With the logic modeled in this manner, individual pump RCP Seal failures due to loss of Thermal Barrier cooling to one pump combined with a loss of seal cooling to the same pump does not appear to be captured. This modeling technique is not representative of techniques currently used across industry to model RCP Seal LOCAs. This conservatism may result in a mis-representation of the importances of non-RCP Seal LOCA related components. Additional modeling practices associated with the handling of Common Causes Failures appear to be incorrect (see DE-01 for CCF concerns). This model currently contains logic that has the potential to skew the RCP Seal LOCA results and to also skew the importances of other plant systems. This may result in masking the true importances of some systems and components. Revise the RCP Seal LOCA model to ensure that all valid combinations of failures associated with Thermal Barrier Cooling and Seal Injection Cooling to the same RCP result in a RCP Seal LOCA. Suggest converting the RCP Seal LOCA model to the Westinghouse Owners Group (WOG 2000) methodology once it is approved by the NRC.	Closed - The WOG 2000 Model for RCP seal behavior following a loss of all seal cooling has been implemented into Rev. 4 of the WBN PRA model (Reference the RCP Seal Injection and Thermal barrier Cooler System Notebook). It appears that the failure to supply either seal injection or thermal barrier cooling to one RCP is modeled to result in failure of all RCP seals, even if only seal injection to only one pump is failed. This is obviously conservative modeling. However, this conservatism should only impact risk applications that use relative risk measures such as RAW and Fussell-Vesely and should not impact risk applications that use delta risk measures such as SAMA. The only masking that could potentially occur would be the identification of insights from the WBN PRA that might suggest a SAMA feature. However, the evaluation of the SAMA feature would not be impacted. The 21 gpm per pump leak is not a dominant contributor to core damage; the dominant seal failure leading to core damage is the 181 gpm leak with non-recovery of RCS make-up prior to battery depletion. In this case, the number of pumps experiencing the 182 gpm leak does not impact the results. Therefore this F&O can be considered closed for the SAMA assessment.	None

F&O	Description	Resolution Status	Model Impact
AS-02	There is no specific guidance document. The event sequences in the original IPE which are referenced in the current revision are based upon the EOPs and AOPs in effect at the time of the original IPE. Guidance; Accident Scenario Evaluation (Event Tree Structure): The documentation of the plant model RISKMAN rule development was not sufficient for the majority of the plant model to allow determination of the rationale behind the development of each top events rule. The lack of documentation made it difficult to confirm the fidelity of the model rules. Since these rules define the accident sequences and their dependencies, it is critical in this type of model to carefully document and verify the operation of the rules. Document the basis for the event tree rules and binning for all top events and macros; perform independent review of each to confirm the basis. Perform a detailed evaluation that analyzes the sequence of events that lead to core damage (50 top sequences minimum)	Closed - A detailed evaluation of the top 100 sequences was completed including review of the event sequence logic and top events The top 100 sequences represents 79% of the core damage frequency and no issues were identified. A specific, rigorous evaluation of the event tree rule structure was not performed. No specific errors were identified through the closure of this or other F&Os. The large fraction of CDF represented by the scenarios reviewed provides a level of confidence in the reasonableness of the model results.	None - The detailed evaluation of scenarios required for F&O AS-02 has been completed. This review provides the response to F&O QU-03 (Verify logic for sequence 9 – operator recovers AFW decay heat removal at AFD11 when AFC is guaranteed failure). This issue was resolved during the Rev 4 model update. This is shown in that previous scenario 9 or similar items no longer appear in the model results. The top 100 scenarios account for 79% of CDF and 28% of LERF and more than the first two decades (2.5E-6 to 8.8E-9 CDF) of ranked scenarios by CDF. Review of this scenario list has shown that the dominant excessive LOCA scenario (RPV catastrophic failure – scenario number 5) is assigned to a NOLERF endstate. Subsequent review confirms that this is appropriate, given industry PTS work.
AS-03	Success Criteria and Bases: The Accident Sequence Notebook (PLG-1339) does not completely describe the process used to 1) develop the accident sequences or 2) determine the success criteria associated with the accident sequences. The notebook contains the statement that the success criteria is based primarily on the FSAR Chapter 15 Analyses;	Closed- The Rev 4 WBN PRA Success Criteria were reviewed for reasonableness against other Westinghouse 4-loop PWRs, including the McGuire, Catawba and Cook ice	None

F&O	Description	Resolution Status	Model Impact
	however, specific details identifying which Chapter 15 scenario each success criteria is based on are generally not provided. The rationale behind the individual success criteria is not provided, and references to specific supporting calculations (MAAP runs associated with success criteria, FSAR assumptions, etc.) are not provided. A number of specific criteria in Table C-1 of PLG-1339 refer generally to NUREG-4550, but not to particular assumptions or analyses in the study. A significant number of references are simply left blank. This makes it difficult to check that appropriate assumptions have been made in establishing the criteria. There is no guidance associated with how the rules were structured to reflect the defined success criteria. Guidance should be provided that describes in sufficient detail the process used and identifies criteria for defining the accident sequences to be modeled. The bases for the success criteria should be clear and traceable to supporting analyses or assumptions. Information should be included on what the associated rules are and what they are designed to do.	condenser containment plants. This is considered to be a valid comparison basis. The key success criteria were compared based on information in the PWROG PRA Database R6. It was found that all of the WBN2 success criteria, except the Bleed and Feed Issue raised in F&O TH-02, are similar to those used in the other PRAs. The Bleed and Feed success criteria are being assessed independently and the SAMA assessment will use the new success criteria basis. A more detailed comparison was completed against the Comanche Peak (CPSES) PRA Success Criteria and several instances of conservatism were found in the WBN Success Criteria: - The very small LOCA required HP recirc for success whereas CPSES uses normal RHR or HP recirc as the success endstate, and - The medium LOCA required 2 of 4 HP injection pumps whereas CPSES only requires 1 of 4 as a success state, Removing the conservatisms in the WBN success criteria would reduce the overall probabilities of the release category bins in the Level 2 assessment and therefore reduce the overall offsite consequences. The impact of removing the conservatisms in the WBN2 model used to assess SAMA would be to reduce the maximum possible benefit attainable for any alternative. Thus, using conservative success criteria in the Level 2 model maximizes the possible benefit which could potentially result in additional	

F&O	Description	Resolution Status	Model Impact
		features being classified as cost-effective. Therefore, it is concluded that the success criteria in the WBN2 PRA, except for the bleed and feed success which is being re-assessed for the SAMA assessment, are acceptable for use in the SAMA assessment without the completion of additional analyses to justify the WBN2 success criteria. Therefore this F&O can be considered closed for the SAMA analysis.	
AS-04	Accident Scenario Evaluation (Event Tree Structure): The guaranteed success split fractions for turbine trip and reactor trip should be used only when the occurrence of the IE ensures that these top events can be by-passed. Even though the rods have fallen and the turbine has tripped on previous trips categorized as RT or TT events, this does not ensure that these will occur on future trips. If plant conditions require a reactor trip, the likelihood that the rods are inserted must be questioned. As the frequencies for these IE are fairly large, this could lead to underestimation in the CDF contribution from ATWS and turbine trip failures. Remove RT and TT cases from these split fractions and assess the appropriateness of the remaining beneficial failures.	Closed - The applicable event trees were modified to correct this model deficiency.	None
AS-09	Accident Scenario Evaluation (Event Tree Structure): Top Event CM (Core Melt) - allows success when top event OB (operators align bleed and feed) and one train of either safety injection or charging is successful. It does not require success of top event BF (hardware for bleed and feed - PORVs). Top event BF should be questioned - revise top event BF rules to require at lease one charging pump and one safety injection pump. Require top event BF success when taking credit for Top OB (operators align bleed and feed) success. [See F&O TH-10 for discussion on number of pumps required]	Closed - Logic rules were modified to questioning of BF with OB and an injection pump for bleed and feed success. Top event BF is anded with OB=S in CMS term. In ET module GTRAN1, top event OB is questioned before BF, but BF is set to guaranteed failure on OB failure. Macro BFSUPP in event tree module GTRAN1 is necessary for BF success and requires one train of charging OR one SI pump. See resolution of TH-10. This F&O can be considered closed.	Success criteria changes were made to reflect the requirement for two PORVs when performing bleed and feed cooling using SI pumps.

F&O	Description	Resolution Status	Model Impact
AS-11	Accident Sequence Evaluation (Event Tree Structure): The loss of multiple 120VAC panels can cause spurious actuation of key plant safety equipment. The failure of panels 1-1 and 1-3 may have consequences such as the spurious actuation of RHR pumps and automatic swap over without water in the sump (which leads to pump failure). This could also lead to the automatic closure of the MSIV or other negative impacts associated with a spurious safety systems actuation. The failure of multiple 120VAC buses has occurred in the industry-especially due to the failure of the automatic transfer feature. This is not modeled as an initiator and is not in the current set of rules for the failure of multiple inverters, post trip. If this is a valid issue, model loss of multiple 120VAC panels as an IE; model the consequences of the loss of both 120VAC panels in the rules, post trip. If this issue can occur, then this might be a Level A significance depending on its impact to the baseline PRA and current applications. If this is not an issue, research which proves this is not a problem should be documented. If it is determined that this issue cannot occur, this is effectively a Level D significance (i.e., documentation of the resolution).	Closed - There is currently no dependency identified in the dependency matrix that would require a multiple 120 VAC failure be modeled as an initiating event. Also, no common mode failures have been identified that would necessitate the modeling of loss of multiple 120 VAC failures as separate initiating events. The potential for secondary failure of more than one 120 VAC buses is reflected in the model structure and results.	None

F&O	Description	Resolution Status	Model Impact
AS-12	Success Criteria and Bases - The RISKMAN rules are coded in such a way that it is difficult for a reviewer to determine how the rules function, or verify the success criteria, the recoveries modeled, and the general accuracy of the rules. This is particularly important for the WBN model that uses "branch-everywhere" logic, in which RISKMAN rules provide the only basis for checking the model. Correct rules are critical to ensure that the risk model reflects the as-built as-operated plant. Improve the documentation of the rules and associated information. Consider implementing improvements such as the following: 1) Define all Macros used in plain English; 2) Eliminate the use of doubly-defined split fractions; 3) Code the rules in the SAME order as the top event list; 4) Perform and document detailed checking of the split fraction rules; 5) Document all bypasses as comments within the rules or use a TRUE branch everywhere tree. A detailed evaluation is recommended of the top sequences (at least the top 50) that analyzes each for the sequence of events that lead to core damage. This evaluation should document the basis for each important systems failure. For example: On a loss of ERCW all air compressors are lost. The evaluation should note these dependent failures. The sequences should then be evaluated for validity. Invalid and unrealistic sequences will require model changes to prevent invalid sequences.	Closed - Detailed review of top 100 scenarios from the Rev 4 model output have been performed and identified (and otherwise noted) errors have been corrected. No further changes required for the SAMA model.	None
SY-03	System Model Structure (Fault Tree): The system notebooks reviewed (Safety Injection, Chemical and Volume Control, and Main Steam) do not provide guidance for performance of the systems analysis and do not reference any external methodology documents. Guidance is important due to the complexity of identifying top events and split fractions in a consistent manner. As a minimum, the original IPE guidance for systems analysis should be referenced. An updated systems analysis methodology document could be more useful in the longer term. Consider creating a system guidance document that covers all aspects of systems modeling, specifies system designations, the failure mode identifiers and basic event coding.	Closed - Documentation of a systems analysis guidance document is not necessary for the SAMA evaluation.	None

F&O	Description	Resolution Status	Model Impact
SY-07	Guidance: The basis for the model assumptions are not directly referenced in the notebooks and are difficult to trace. There is some inconsistency in the description of model assumptions and their impact to specific top events. For example, in the PORV system notebook Assumption 4 from Section 3.1, "Failure of PORV or safety valve to reseat following pressure relief will result in an isolable small LOCA." This assumption has no direct reference to justify its use, in particular the part about safety valve failure to reseat being isolable. In the condensate and feedwater system analysis the following statement is made: "the bypass valve (FCV-2-35A) receives from a flow device." Although the references located at the end of the document probably provide this information, it would make review easier if the references are listed directly with the statements of fact. The assumptions in Section 1.2 of the Success Criteria Notebook are not traceable back to Appendix A of the IPE where they are referenced. Include more specific references in the system notebooks assumptions to facilitate traceability of information.	Closed - Documentation of the sources of assumptions is not necessary for the SAMA evaluation.	None

F&O	Description	Resolution Status	Model Impact
SY-08	Systems Modeled: There is no documentation of a plant specific analysis for the EDG repair analysis or for AFW turbine-driven pump repair. The Onsite AC Recovery Notebook provides a table entitled "Time to Recover a Failed Diesel Generator." The test states that this is based on a review of diesel generator failure and maintenance records collected from several plants, with an assessment of the severity of the observed failures and the experience of operations and maintenance experts. The WBN PRA staff was not able to provide the bases for the values within this table. It was stated that this may be from the Zion analysis. The AFW System Notebook uses Top Event TRP to represent the recovery of the AFW turbine-driven pump. The system notebook states that failure due to start failures is approximately 60% of all AFW turbine-driven pump failures, and the fraction of non-recoverable failures is approximately 40%. Reference 59 is shown as the source in the text but it is not listed in the reference list. The probability values used for EDG repair (time to recover a failed diesel) cannot be demonstrated as being applicable to WBN. There is a potential that the recovery probabilities are not applicable which could result in an increase in the contribution of the LOOP initiator. Perform a plant specific analysis for EDG repair or document an evaluation to show that an available analysis for another plant is directly applicable to WBN. Improve documentation for AFW turbine-driven pump recovery (reference 59 in text is not on reference list).	Closed - Documentation of the basis for recovery actions is not necessary for the SAMA analysis.	None
DA-01	Guidance/Documentation: There is no written documentation to identify which data notebook (Erin or PLG) is used for each analysis. Erin and PLG used similar but not identical methods. For common cause Erin primarily used the INEEL data while PLG primarily used data from PLG-0500. The results presented in Appendix B in the Erin notebook are not cross-referenced to their basis. For example, distributional parameters were provided but the source of parameters was not provided or referenced. Both documents contain a brief discussion of what was done and some of the theoretical bases for the process. However, there is insufficient data or guidance to allow someone other than the author to reproduce the results. Each data notebook should have sufficient documentation and guidance to reproduce and update the data values. Consideration should be given to establishing a single data notebook, following a single methodology, and using common data sources.	Closed - A single data notebook was created to identify all the data used. The source and plant specific data used to create each data variable was documented such that the results are reproducible.	None

F&O	Description	Resolution Status	Model Impact
DA-02	Unique Unavailabilities or Data Modeling Issues: Plant operation with a SG PORV blocked was assumed to be not allowed because of the Maintenance Rule unavailability criterion. Thus, this configuration is not modeled in the PRA. However, operation with a SG PORV blocked had occurred at WBN in order to permit repair of the SG PORV. Although the impact on baseline CDF/LERF is probably minimal, the condition has existed and should be included in the model. This configuration (operation with SG PORV blocked) should be incorporated into the PRA model. Alternatively, provide a more detailed assessment to demonstrate why the condition need not be included.	Closed - Maintenance alignments are included in the model to discuss the block valves being closed. The closure of one and two valves are modeled.	None

F&O	Description	Resolution Status	Model Impact
DA-04	Plant Specific Component Data: Table 2-2 of the ERIN data notebook lists the raw component failure data considered for the data update. This table shows a total of 7 failures of PRA related components, including 3 pump failures, 1 valve failure treated as a pump (see F&O DA-03), 1 valve failure, and a controller wiring error that resulted in a CCF of 2 compressors. *The only values that were updated were PORV block valves* and no update was performed for instrumentation. As indicated in Table 2-2 only 5 of the 7 components would have been used in the update; however, a review of the events and demand data used for the update, as presented in table 2-3, shows a total of 9 component failures used in the update. These included 1 AFW turbine pump failure, 1ACA dryer failure, 2 MFW pump failures, 1RHR pump failure (see F&)DA-03), 1 ERCW pump failure and 3 CCW pump failures. The ERCW pump failure and the 3 CCW pump failures in Table 2-3 had no corresponding events in Table 2-2. No additional information is presented to permit tracing these failures. Additional review of the raw data sent to Erin indicated that there were additional failures that had not been listed in Table 2-2 which had been included in Table 2-3. The ACCESS data base list of the raw events by ERIN was reviewed and the 3 CCW pump events were there - as was an ERCW pump event. However, this list also had one additional ERCW pump failure that was not included in the failure count in Table 2-3. Further review revealed that the second ERCW pump failure was a duplicate of the first so that the data in Table 2-3 was appropriate. The reviewer concerns include the treatment of the maintenance frequency and duration data where there is a greater degree *of manipulation of the raw data. The discrepancies between the raw data* and the values used as input to the Bayesian update are more difficult to discern. The data error for the ERCW pumps needs to be resolved. The report should be expanded to include the raw data for maintenance frequency and duration and to show (at least example) any mathematical manipulations of the raw data needed to derive the data in Table 2-3. The data should be explicitly described to the extent that an independent reviewer can reproduce the values in Table 2-3 from the raw data. If necessary to reproduce the calculations, critical intermediate results should be included in the report.	Closed - A single data notebook was created to identify all the data used. The source and plant specific data used to create each data variable was documented such that the results are reproducible. *The plant specific failures are referenced.*	None

F&O	Description	Resolution Status	Model Impact
DE-01	Common Cause Treatment: There is an inconsistency in the logic for RCP seal LOCA for top event SE in the RCP seal and thermal barrier system notebook. An assumption for top event TB states that a single event consisting of common cause failure of all eight seal injection inlet check valves to re-open after loss of offsite power is used to represent all contribution from loss of seal injection. A failure to reopen any one of the eight seal injection inlet check valves will result in a loss of all seal injection for one RCP. A simultaneous loss of thermal barrier cooling for the same pump will result in a seal LOCA for that RCP. The single common cause element as modeled is not appropriate for this scenario. A review of the logic indicates that the single induced RCP seal LOCA would not be identified in this model. [See F&O AS-01 for discussion about overall induced seal LOCA model logic.] RCP Seal LOCA represents a significant fraction of the WBN CDF. The modeling of the check valve common cause failure is non-conservative and could have an impact on the CDF. The Induced RCP Seal LOCA model should be revised to correct the common cause failure logic.	Closed - Model was revised in Rev 4 to address failure of flow to a single RCP. Also, for top event TB thermal barrier booster pumps were added to the model.	Thermal barrier booster pumps were added to the TB fault tree.
DE-02	Spatial Dependencies: The treatment of spatial dependencies is inconsistent and not thoroughly documented. The IPE internal flooding analysis used a simplified approach which relied heavily on engineering judgment. The documentation of the IPE Internal Flooding Analysis provides only a simplified summary of the analyses performed. The IPE summary did not address evaluation of flooding impacts from various pipe breaks in various locations on a room by room basis, but instead focused on impacts from a Building/Elevation standpoint. For elevations that had stairwells that propagated downwards, the internal flooding approach appears to have been to assume the impact to be negligible for that elevation, but consider potential floods originating on that elevation when evaluating lower elevations. For the lowest elevation, where a flood was modeled as occurring, it was not readily evident that the frequency used included the potential for pipe breaks at the higher elevations. In addition, the expected elevation of the flood was not specified in the IPE summary, and operator actions that may have been credited to isolate pipe breaks, and therefore limit the expected flood depths were not identified. For example, in the discussion of Auxiliary Building postulated flood, a statement is made that the passive sump is assumed to be completely	Closed - A conservative flooding analysis can be used for the SAMA analysis. Documentation of the internal flooding analysis would not affect SAMA evaluation.	None

F&O	Description	Resolution Status	Model Impact
	overfilled and that enough water is assumed to accumulate such that the RHR and Containment Spray pumps are assumed to be failed. There is no discussion of what the maximum volume of water, and resulting maximum flood depth, was calculated to be. In addition, there was no justification as to why effects of other flood initiators on equipment at higher elevations in the Building were not modeled. The internal flooding analysis does not discuss potential spray related impacts, submergence effects on cables, equipment that would be impacted via cables/termination boxes, etc. A more detailed summary of the internal flooding analysis performed for the IPE should be maintained as part of the PRA, as the IPE summary documentation does not provide adequate information to explain the bases for the analysis. Based on the information available, the reviewers felt that there is a strong possibility that the initiating event frequencies and maximum flood depths (and therefore the impacted equipment) currently modeled may be overly conservative. Recommendations: Review the RI-ISI analysis and the HELB/MELB analysis to check that important underlying assumptions associated with the internal flooding analysis remain valid. This should include 1) review of credited operator actions (which are not identified in the current internal flooding analysis), 2) check to see if the internal flooding initiating event frequencies associated with the modeled scenarios should be updated, 3) verification that the equipment assumed failed in the internal flooding is consistent with impacts identified in the other analyses, and 4) a discussion on potential spray effects and submergence effects and why they are/are not included in the analysis.		
DE-07	The ERCW system analysis does not postulate the common cause failure of the strainers. The strainers have a motorized back wash function and are postulated to fail without the backwash function. However, the strainer failure is modeled as a "plug" failure mode. Because plugging is a passive mode, as opposed to the active failure of the motorized equipment, CCF was not included. CCF of both strainers will fail all ERCW. This mechanism may be significant to loss of ERCW initiating event frequency, and therefore important to CDF. Include CCF of ERCW strainers in the ERCW system unavailability and loss of ERCW fault trees.	Closed - Plugging of ERCW traveling screens and failure of the operator to initiate manual backwash is addressed under total loss of ERCW initiating event ERCWTL. Strainer plugging is a slowly evolving event with adequate time for corrective and compensatory measures (manual strainer rotation, etc.), relative to 24 hour mission time for plant model.	None

F&O	Description	Resolution Status	Model Impact
HR-01	A human action sensitivity study to identify sequences that, except for a low human error rate, would have been dominant contributors to core damage frequency has not been performed. The PRA provides no indication of the impact on core damage frequency as a result of truncation of sequences with multiple human errors which when taken as a whole result in unrealistically low human error probabilities. Perform a human action sensitivity analysis to identify potentially dependent actions within sequences and to identify the amount of credit taken for very low combined human action failure probabilities in the sequences. Consider establishing a lower limit for human action failure in any given sequence (e.g., no less than 1E-06 or other defensible cutoff)	Closed - A sensitivity study was performed setting operator actions to guaranteed failure and reviewing the top 50 resulting sequences. Model changes were made based on this review. A separate sensitivity evaluation was performed to ensure that portions of the event model were not shielded by being quantified at 0.0. No additional scenarios of interest were identified through this sensitivity evaluation.	1 Top event ORT was set to guaranteed success to remove room ventilation top event (i.e. very long term) impact on a very short term action when ESFAS is (eventually assumed) failed due to loss of room ventilation 2 Top event OMU was set to guaranteed failure with OSE and RRH failed. 3 Top event RRH was set to guaranteed failure with OCD failed. 4 Top event RRH was set to guaranteed failure with OSE and OT failed. 5 Top event RRH was set to guaranteed failure with OSE and OT failed. 6 The emergency boration function and top event RRH were set to guaranteed failure with OS and ORT failed.

F&O	Description	Resolution Status	Model Impact
HR-03	Calibration errors do not appear to be considered within top event RL, Initiation of RHR Containment Sump Swapover. The containment swapover requires indication of low RWST level and high sump water level. The system analysis considers the possibility of frozen RWST instrumentation lines but does not include common cause failure of either set of water level sensors. For the frozen lines, the system analyst assumes the operator would respond correctly and swapover the sump (I.e., no impact on HEP due to failed instrumentation). Typically, a pre-initiator error across multiple channels would be considered. Although common cause failure of multiple channels, based on collected data, is considered, pre-initiator errors are not well represented in the PRA data. Thus, it may not be appropriate to ignore the potential for common sensor failure. Calibration errors are found to be addressed by top event TOT within the AFW system notebook. Recommendation: 1) A systematic search should be done for pre-initiator errors guided by a process and rules developed by the HRA task; 2) Human interactions identified by this search should be quantified by the HRA task not the system analyst. [A possible way to address the noted pre-initiator would be to incorporate the impact of calibration error failing 3/4 channels into Top Event RL and other multi-channel instrumentation tops. Then requantify the HEP for manual swapover with failed instrumentation.]	Closed - Common cause failures are addressed in common cause group RWSTMSC This has been incorporated into the model	None
HR-04	Repair is modeled for some components. However, no operator action is included for the start of the repaired component. It is unclear as to whether this action is included in the data for the fraction of start failures that are recoverable. Operator action HTPR1, Start the Turbine-Driven Pump Given it Failed to Start due to Control or Signal Failures, (LOSP) is used in top event TPR. TPR is used to represent the recovery of the turbine-driven pump from a control or signal failure or the repair of the pump. HTPR1 is under an AND Gate with the fraction of start failures that are unrecoverable. This implies that the repair includes the operator action. The lack of consideration of specific scenario timing, confusion, and resource loading could result in an optimistic treatment of the repair. Clarify the treatment of the operator action for the repair. Ensure that it is consistent with the scenarios for which it is credited.	Closed - Repair and recovery that is modeled in the PRA was reviewed and found to be appropriate. Additional treatment of important component recovery was evaluated as potential SAMAs (e.g., SAMA 20, 158, 160). While explicit treatment of pump restart would be more rigorous, the current treatment is judged adequate for the SAMA model for restart of the turbine driven AFW pump.	None

F&O	Description	Resolution Status	Model Impact
HR-08	Post-Initiator Human Actions: The HRA and operator interviews were performed in 1992 when the plant was under construction. The input information for the HRA is therefore representative of construction era procedures, training, and operators. An update should be performed to reflect current operator training and procedures, and this should be reviewed with plant Operations/Training staff. Recommendations: Update the HRA to reflect current procedures and practices. Use a single approach if possible (i.e., either an updated FLIM or alternative methodology such as the cause-based decision tree (CBDT) method per EPRI TR-100259.	Closed - The HRA was updated to use the EPRI HRA calculator in Revision 4 to the PRA	None
HR-09	Pre-Initiator Human Actions: Ice condenser plants have an important pre-initiator human error for failure to restore the operating floor plugs after refueling. The failure probability for this human action is quantified at 2.7E-7 (a very low number). This is calculated as the product of an initial human error for failure to restore of 3E-3, and two independent recovery actions of 0.025 and 1E-3. The analysis was done with simplified THERP. The second recovery is credited as a completely independent action, with a failure probability lower than the original action. It is unusual for a recovery action to be more reliable than the original action. The calculation was performed in 1992; it should be updated to reflect the procedures currently in place. The failure to remove drain plugs is a single point failure for LOCA; thus this operator error could be risk significant. Assess the HEP against the current operating procedures using realistic recovery probabilities.	Closed - The HRA was updated to use the EPRI HRA calculator in Revision 4 to the PRA	None
HR-10	Guidance: The WBN PRA uses 3 HRA methods: R0, R1 - FLIM; R2, R3 - THERP & EPRI-CBDT. Comparison of HEPs indicate a reduction of human error probabilities with each new revision. The use of three different methods in the same PRA will produce inconsistent HEPs which could affect risk ranking and prioritization. The HRA should be performed with a consistent method.	Closed - The HRA was updated to use the EPRI HRA calculator in Revision 4 to the PRA	None

F&O	Description	Resolution Status	Model Impact
HR-11	The original HRA (1992) uses 60 minutes for available timing for several HEPs related to loss of secondary side cooling. Available time for several other related HEPs was defined as 40 and 45 minutes. The one hour time is based on a deterministic calculation of heat loads. The most recent MAAP analysis (R3) provides a 33 minute time to start feed and bleed. The HRA should use consistent times, presumably based on the recent analysis. Timing of events to restore RCP seal cooling to prevent seal LOCA are based on 60 minutes. The Brookhaven model allows a seal LOCA to occur at times less than 60 minutes. The assumed timing in the seal LOCA model should be consistent with the assumptions in the HRA. The HRA methods are time sensitive. Use of correct timing consistent with available analyses and models is essential. The HRA should used consistent times based on the most recent analysis. Develop consistent timing for important sequences and re-quantify HEPs based on these times	Closed - The HRA was updated to use the EPRI HRA calculator in Revision 4 to the PRA. This is a symptomatic F&O about consistency of timing of actions in the HRA and the relationship to the success criteria. Two specific examples are mentioned in the F&O whose resolution is documented here. Based on engineering judgment, these are the two most time sensitive operator actions in the PRA. - The new time window for operator actions for bleed and feed from the WBN2 PRA Success Criteria analyses of 25 minutes with at least one charging pump available and 10 minutes if only an SI pump is available was substituted into the HEP assessment for HAOB1 and HAOB2. The resulting HEP did not change substantially in either case. Based on the HRA methodology for operator actions to establish bleed and feed cooling in the HRA Calculator for Revision 4 of the PRA, shortening the time window available for operator action form 30 minutes does not change the resulting HEPs. - The implementation of the WOG2000 model for RCP seal behavior should include a limitation of 13 minutes for restoration of RCP seal cooling. If seal cooling is restored at a time after 13 minutes, a large seal LOCA should be assumed. Therefore, this F&O can be considered closed for the SAMA assessment if the operator action time window for Bleed and Feed and Restoration of RCP seal cooling are consistent with the values provided above.	None

F&O	Description	Resolution Status	Model Impact
HR-13	The HRA uses times of 3,4,12 hours for restoration of ventilation to shutdown board rooms. This information is taken from TI-ECS-95 (Sequoyah study). Reference TI-ECS-96 is a Watts Bar study but the assumptions may not be applicable to the PRA. The assumptions in these studies should be reviewed and made appropriate for the WBN PRA. The recovery of HVAC for the shutdown board rooms can have a significant impact on the CDF results. Assess room cooling consistently for a 24 hour analysis with the appropriate analysis. Quantify room cooling recovery actions with the recovery times from the appropriate analysis.	Closed - As evaluated by TVA calculation WBNOSG4-242, 6.9kV and 480V Board Room Transient Temperature Analysis (RIMS T71 010416 804), 6.9kV board room temperature only reaches 103.5F by the end of the 24 hour period analyzed, such that loss of board room cooling would not result in component failure or unreliable operation during the PRA model mission time, such that the room ventilation top events can effectively be removed from the model.	An ORT success term was used to show that operators would have tripped the reactor prior to room heatup. This prevents a very short term action from being dependent on a very long term heatup impact.

F&O	Description	Resolution Status	Model Impact
HR-15	Treatment of Dependencies: It appears each HEP is quantified independently. Although each action considers failures and successes directly relevant to the HI in question, there is no process in the HRA to perform a systematic examination of all human actions in an individual sequence. An example of potential human action dependencies is HAOF1, HAOF2. HAOF1, *restore MFW, states that there is 45 minutes* to restore MFW. This action could be asked after failure of repairing or recovering AFW (actions HAOS3, HAOS4, HTPR1)). These human action failures may significantly reduce the time available to recover MFW or add to operator confusion. If the actions to restore MFW are performed concurrently with that of the actions to recover AFW then the adequacy of resources would need to be determined. Establishing bleed & feed operation following failure of actions to establish AFW or MFW is another potential dependency, but this is explicitly addressed by features of the WOG Emergency Response Guidelines such that most PRAs for Westinghouse PWRs define a low-dependency or no-dependency situation for these actions. It is still good practice to identify the potential relationship and explain the rationale for establishing type of dependency. To be consistent with accepted HRA methodology, there must be a systematic process to identify, assess and adjust dependencies between multiple human errors in the same sequence, including those in the initiating events. When addressing needed enhancements to the HRA methodology, include the following steps to address dependent human actions: 1) Perform a systematic evaluation of all risk significant sequences, *in which two or more post initiator actions are credited on the* same sequences, including any recoveries; 2) Evaluate the potential for dependence among the actions in each sequence, document the basis for classifying the actions as dependent or independent; 3) Quantify the effects of dependencies using an accepted methodology; 4) Modify the split fractions for HRA values as appropriate to reflect dependencies.	Closed - A sensitivity study was performed setting operator actions to guaranteed failure and reviewing the top 50 resulting sequences. Model changes were made based on this review.	1 Top event ORT was set to guaranteed success to remove room ventilation top event (i.e. very long term) impact from very short term action when ESFAS is eventually assumed to fail following loss of room cooling 2 Top event OMU was set to guaranteed failure with OSE and RRH failed. 3 Top event RRH was set to guaranteed failure with OCD failed. 4 Top event RRH was set to guaranteed failure with OSE and OT failed. 5 Top event RRH was set to guaranteed failure with OSE and OT failed. 6 The emergency boration function and top event RRH were set to guaranteed failure with OS and ORT failed.

F&O	Description	Resolution Status	Model Impact
QU-01	The success of Top Event PI recovers the failures of both PR and SE in Top Event CM. As Top Event PI only includes the PORV block valves, this is not an appropriate recovery for stuck open Primary Safety Relief Valves and RCP Seal LOCAs. This may significantly masks any contribution from primary safety relief valve failures and independent RCP seal failures. Break top event PR into the 4 desired functions: 1) PORV opens when required; 2) PORVs reclose when required; 3) SRVs open when required; 4) SRVs close when required. Since this was identified through a limited review of the rules; a comprehensive review of the rules is recommended to ensure that similar errors do not exist.	Closed - Top event PI recovery of both PR and SE in top event CM was corrected. It is not appropriate that this recovers stuck open primary relief and RCP seal failure. The relevant CM success term has been rewritten to require PR and SE success and PI either successful or bypassed, such that PI does NOT recover either stuck open primary relief or RCP seal failure	None
QU-03	Sequence #9 questions the AFW decay heat removal split fraction AFD11 when top event AFC is guaranteed failed. [This overestimates the worth of this sequence]. This is not the appropriate split fraction for this condition; the AFD split fraction where AFC is not questioned should be used. As modeled, the worth of this sequence is overestimated. Develop the not questioned split fractions.	Closed - The detailed evaluation of scenarios required for F&O AS-02 has been completed. This review also provided the response to F&O QU-03 (Verify logic for sequence 9 (recovers AFW decay heat removal at AFD11 when AFC is guaranteed failure). This specific issue was resolved during Rev 4 model update. This is shown in that previous scenario 9 or similar items no longer appear in the model results.	None
QU-04	The DG top events are noted as having a dependency on the 125 VDC Battery Board (top event DA & DB). The fault tree GAIV shows this dependency; however, in the event tree rules success of the respective top events DA or DB does not fail the DG (top event GA or GB). Although the DG local batteries are sufficient for at least three starts, the 6.9kv buses still require breaker control power from the station batteries. Thus, this dependency should be modeled or the basis for screening documented. The 125 VDC dependency should be modeled in the event tree. Fix the event tree and rules.	Closed - Diesel generators are questioned in the SHARED event tree module before DC power is questioned in the ELECT1 and ELECT2 modules, respectively. Also, DG failure is much higher than battery failure, such that this would not be a material contributor relative to DG failure.	None

F&O	Description	Resolution Status	Model Impact
QU-05	An evaluation of sources of uncertainty and their effects on the analyses have not been performed for the current PRA model. Characterization of the effects of uncertainties is an important attribute of the complete PRA, particularly for usage of the PRA for risk informed applications. Perform and document an evaluation of sources of uncertainty and their effects on the analysis for the current PRA and for subsequent PRA updates.	Closed - Documentation of the sources of uncertainty are not required for SAMA. Evaluation of how changes in analysis assumptions may affect the cost-benefit results will be performed as part of the SAMA analysis.	None
QU-06	TVA provided a truncation sensitivity evaluation for the review. Based on the results of this evaluation , it appears that the current truncation level of 1E-10 does not achieve a sufficiently stable risk result, i.e., there seemed to be a significant CDF contribution remaining in the truncated residual. This can lead to errors when evaluating against absolute risk thresholds such as 1E-3 in the maintenance rule and 1E-6 in Reg. Guide 1.174. It is important that the truncation level used produce a set of results that capture a sufficient portion of the total. In absolute threshold evaluations use an acceptable truncation limit such that any unaccounted-for contribution is sufficiently small for the application. An example of an approach that may be used is to check that an order of magnitude drop in truncation causes a CDF/LERF change of less than 1%. It is also prudent to store at a minimum the end state and unaccounted file for each node used in the truncation sensitivity study.	Closed - Reference model is now quantified at 1E-12	None

F&O	Description	Resolution Status	Model Impact
L2-01	On page 2-13 of the Level 2/LERF notebook it is stated that the survivability of the air return fans is based on their design basis to function in LOCA containment conditions. There is no information provided regarding their ability to operate in conditions beyond the DBA LOCA conditions which are of concern in the PRA. The air return fans, along with the igniters, are an integral part of the hydrogen control strategy for the ice condenser containments. This is especially crucial since the ultimate capacity of the Watts Bar containment is stated to be 105 psig. Many large dry containments that employ fan coolers as a post-LOCA heat removal feature rely on reducing fan speed to increase torque to prevent overheating the motor in the dense mixtures that occur during high containment pressures. Some large dry containment plants have predicted that the fan motors are not capable of sustained operation at pressure significantly above their design pressure (which is on the order of 45 to 60 psig, i.e., substantially below the Watts Bar containment ultimate capacity). When severe accident dense aerosols are also considered, the issue may be more pronounced. Assess the capability of the air return fans to operate under the post core damage conditions (containment pressure and aerosol loadings) predicted in MAAP analysis that are used to determine post core damage containment performance and fission product release characteristics.	Closed – The LERF / Level 2 PRA Analysis Notebook, Revision 1 (2000) identifies two functions for the air return fans (ARFs): enhancing heat removal by the ice condenser and the containment sprays and to limit hydrogen concentrations in potentially stagnant regions of the ice condenser containment. With respect to hydrogen, the LERF / Level 2 Notebook documents assessments of hydrogen mixing with and without the ARFs operating and concludes that there is no impact on containment integrity. The ARFs are not modeled in the 2000 LERF/ Level 2 analyses as an assist to heat removal from the ice condenser or the containment spray and therefore it is concluded that the ARFs are not required for effective heat removal (note that the ARFs have no heat removal capability themselves). Also, it is noted that the air return fans were not part of the resolution of GSI-189 (i.e., there was no recommendation to provide an alternate source of power for the ARFs to reduce challenges to containment integrity base don the NRC study in "Technical Assessment Summary for GSI-189: Susceptibility of Ice Condenser and Mark III Containments to Early Failure From Hydrogen Combustion During a Severe Accident," (2003). Because the air return fans are not required following a station blackout, it is concluded that they are not required for containment protection for any event. Thus, this F&O is closed with no changes to the WBN Level 2 PRA model for either the SAMA assessment or the WBN2 model update.	None

F&O	Description	Resolution Status	Model Impact
L2-02	Level 1/Level2 Interface (page 2-43): The accident sequences from Level 1 analysis that were determined to be core damage sequences (based on success criteria used in Level 1 assessment) were binned into the various plant damage states which were then assessed in the Level 2 analysis. However, in some cases the subsequent MAAP analyses performed in the Level 2 assessment determined that the accident sequence did not result in core damage. This resulted in the definition of a containment event tree top node (top event 3 - CV) which is used to consider both core damage arrested in-vessel and sequences that were determined not to result in core damage. This implies that at least some of the success criteria in Level 1 analysis were not realistic. It is recommended that top event 3 - CV deal only with real core damage sequences that are arrested in-vessel. Those accident sequences that are determined not to result in core damage should be reconciled by updating the appropriate portions of the Level 1 PRA. The calculated core damage frequency is conservative. Update the appropriate portions of the Level 1 analysis so that all accident sequences assigned to a core damage state are true core damage sequences.	Closed - This was addressed in the Rev 4 update by changing the binning rules in the LERF model. Previously, for feed and bleed endstate, there was 77% recovery of CDF (PDS LCI). Endstates BCI (MLOCA with no recirc) = 0.23 recovery, FCI (SLOCA with no recirc) = 0.32 recovery, LNIYA and LNIYC = 0.0, whereas current LERF model has LER7 for BCI and FCI (=0.008), LER5 for LCI (=0.155), LER1 for LNIYA (=0.993, versus 0.0 for CV) and LER4 for LNIYC (=0.166, versus 0.0 for CV). If some of the core damage sequences do not really result in core damage when analyzed with the Level 2 model, then the core damage frequency is conservative. This is not unexpected since some of the success criteria are bounding a number of accident sequences and the representative accident sequence for Level 2 may not be bounding for Level 1. The SAMA assessment depends only on the consequence analysis. As long as the frequency of the release category bins from the Level 2 assessment are accurate, then this F&O will not impact the SAMA assessment. A review of the treatment of the top event CV indicates that the release category bins are accurate in this respect. Therefore, this F&O is considered closed for the SAMA assessment.	None

F&O	Description	Resolution Status	Model Impact
L2-03	The Level +2 PRA does not include operator actions. O particular importance to LERF is the proceduralized action to depressurize the RCS after the core damage has occurred per the EOPs (FR-C.1) The only RCS depressurization considerations in the Level 2 analysis are induced events such as creep failure of the hot leg. Another human action potentially important to LERF is to manually open AFW discharge valves after loss of all instrument air. This action is included in the SBO sequences, but not in the LERF analysis. Both of these actions have significant impact on reducing HPME which is a large contributor to LERF. No SAMG activities have been included in the Level 2 analysis. The SAMG included both written guidance and training and their impact on the Level 2 scenarios, particularly those that are LERF contributors, should be considered to make the analysis more realistic. Appropriate integration of the WBNP EOPs and the SAMG would change the LERF considerably and would likely result in a LERF value less than 10-7. This is important in PRA applications as none of the LERF measures are above the 10-7 cutoff criteria. Update the appropriate portions of the Level 1 analysis to include pre-core damage operator actions per EOPs that can impact Level 2 results. Update Level 2 analyses to reflect the impact of post core damage EOP and SAMG activities.	Closed - An assessment of the possible operator actions that can be considered in the Level 2 PRA are described in WCAP-16657-P (Reference 8). All of the operator actions reduce the overall probabilities of the release category bins in the Level 2 assessment and therefore reduce the overall offsite consequences. The impact of including these operator actions in the WBN2 model used to assess SAMA would be to reduce the maximum possible benefit attainable for any alternative. Thus, not including operator actions in the Level 2 model maximizes the possible benefit which could potentially result in additional features being classified as cost-effective. Therefore, this F&O is considered closed for the SAMA assessment.	None

F&O	Description	Resolution Status	Model Impact
L2-04	Phenomena CETs/HEPs/System Considered/Success Criteria: The hydrogen generation used in the analyses is based almost entirely on the MAAP 3b version 17 results for the various accident sequences considered. The LERF quantification is sensitive to the hydrogen detonations. MAAP 4.03 predicts considerably more hydrogen production for some accident sequences than does version 3B based on the later version's more detailed modeling of core degradation. The most pronounced differences are those in which the water is added to the core after the onset of core degradation and relocation. This would occur due to accumulator injection due to RCS depressurization. In addition, the differences in MAAP code models related to RCS cooldown and depressurization can influence MAAP prediction of core recovery/core damage for SGTR and events with SG cooldown of the RCS. The potential for increased hydrogen generation for some accident sequences may impact the Level 2/LERF results. The SGTR differences are not expected to significantly change the overall results. Verify that MAAP results used in the current Level 2/LERF analysis reflect appropriate prediction of hydrogen generation and response for SGTR and sequences involving SG cooldown and depressurization of RCS. For future analyses and Level 2 updates, transition to MAAP 4.0	Closed - The WBN Level 2 model is not sensitive to differences in hydrogen generation for various core damage accident scenarios that can be predicted between the various computer code versions (e.g., MAAP3.0 vs. MAAP4.0). The availability of the hydrogen igniters is the determining factor for all core damage sequences. Increases or decreases in hydrogen generation are within the capability of the igniters and the overall uncertainties in hydrogen generation for a given core damage scenario. Differences in modeling SGTR and RCS cooldown and depressurization sequences between the various versions of the MAAP code are not expected to have an impact on the SAMA assessments. Comparisons have shown that the only impact is on the time available for operator actions and that these times are only changed by less that a few minutes out of 20 to 30 minutes. These small changes should have insignificant changes on the subsequent HEPs for the actions. Therefore, this F&O can be considered closed for the SAMA assessment.	None

F&O	Description	Resolution Status	Model Impact
L2-05	Phenomena CETs/HEPs/System Considered/Success Criteria: The current Level 2 assessment relies heavily on NUREG-1150 analyses. Significant additional information is available which could have an impact on the result of the current NUREG-1150 based analysis. References include: 1) In-vessel steam explosions (NUREG-1524, August 1996); 2) Thermally induced SG tube failure (EPRI); 3) Direct Containment Heating (NUREG/CR-6427). Review recent information and consider updating Level 2 assessment to be consistent with current published research findings.	Closed - All of new assessments of the likelihood or magnitude of the phenomena reduces the overall probabilities of the release category bins in the Level 2 assessment and therefore reduce the overall offsite consequences. The impact of including these new phenomena considerations on the WBN2 model used to assess SAMA would be to reduce the maximum possible benefit attainable for any alternative. Thus, not including the new phenomena considerations in the Level 2 model maximizes the possible benefit which could potentially result in additional features being classified as cost-effective. Therefore, this F&O is considered closed for the SAMA assessment.	None
L2-09	LERF Definition: The WOG LERF definition was chosen because it contained a more detailed description that is easily applied to Level 1 PRA. The WBN LERF definition encompasses other commonly-used LERF definitions with one exception - the classification of SGTR with high pressure SI success and SG isolation failure. The sequence is binned as non-LERF. The WBN LERF does not address Emergency Action Levels (EAL). The definition of early in LERF is related to releases within 4 hours after notification of evacuation. Without assigning EAL's to the SGTR sequence progression, it is not possible to justify the binning of the sequence as non-LERF. Although most other plants bin this similar sequence as non-LERF, the EAL's must be included in the Level 2 to justify it for WBN. The Level 2 as it stands does not support the binning of the SGTR with HPI as a non-LERF event. For SGTR with HPI, the initiation of offsite emergency actions may not occur until quite late in the accident sequence; close to the time of core damage. Justify the exclusion of the SGTR with HPI available based on timing of core damage in relation to the EALs.	Closed - An assessment of the EALs for WBN concludes that a General Emergency would be declared more than 4 hours before core damage occurs for a SGTR with SI available but an inability to stop the loss of RCS inventory through the tube rupture. The SGTR event itself would cause an Alert declaration based on the loss of one fission product barrier. The inability to equalize RCS and SG secondary side pressure to stop the loss of RCS inventory would result in SG overfill and the initiation of some fission product releases (based on normal RCS fission product inventories) which would escalate the declaration to at least a Site Emergency. The potential loss of a second fission product barrier (the fuel rod cladding) would be diagnosed as the	None

F&O	Description	Resolution Status	Model Impact
		RWST is drained and the inability to switch to ECC recirculation due to the lack of containment sump water. This would trigger a General Emergency and the potential for initiation of offsite protective actions. The remaining water in the RWST would permit several hours of continued injection prior to failure of ECCS, followed by another period of several hours before core uncovery occurred. Thus, at least 4 hours are available between the declaration of a General Emergency and the onset of core uncovery overheating. This neglects the obvious operator action to refill the RWST (per the EOPs on loss of ECCS recirculation) which could prevent core damage altogether. Therefore the SGTR with HPI available is properly binned as a non-LERF sequence and this F&O can be considered closed for the SAMA assessment.	
MU-01	The WBNP Configuration Control and Maintenance Desk Top Procedure does not provide the necessary details to guide the maintenance of an as-built, as-operated PRA. The procedure does not provide adequate detail for 1) the monitoring and collecting of specific types of PRA inputs; and 2) the process for identifying and processing open PRA issues. Changes in plant performance, operation, or design that affect the PRA models, assumptions, or inputs, could result in significant changes in PRA results, but the procedure does not define specific requirements for monitoring, evaluation, and incorporating changes into the PRA.	Closed - Maintenance and Update procedures are not needed for the SAMA analysis. This item is considered closed because TVA procedures SPP-9.11 and NEDP-26 have been issued to address the issues in the finding.	None

F&O	Description	Resolution Status	Model Impact
MU-06	Application Re-evaluation: There is no specific guidance on how to perform the impact assessment or ensure that impacted PSA Applications are updated in a timely manner. Revise procedural requirements to include a listing of potentially impacted PSA applications that require a qualitative review to ensure that the conclusions remain valid. The procedure should also require an update of past PSA Applications that are affected by the latest PSA update, and should provide guidance on how to document that an impact evaluation has been performed.	Closed - Maintenance and Update procedures are not needed for the SAMA analysis. This item is considered closed because TVA procedures SPP-9.11 and NEDP-26 have been issued to address the issues in the finding. In particular NEDP-26 contains requirements to review model applications after a PRA update.	None
MU-07	There is no means to determine the effectiveness of the current process to identify potential changes to the PRA as a result of plant modifications. Document the process to evaluate plant modifications with respect to the impact on the PSA.	Closed - Maintenance and Update procedures are not needed for the SAMA analysis. this item is considered closed because a revision to TVA procedures SPP-9.3 has been issued to require that DCN's be reviewed for PRA impact.	None

F&O	Description	Resolution Status	Model Impact
TH-01	Success criteria analysis are primarily based on FSAR and NUREG-4550 analyses. This likely results in a somewhat conservative analysis that might be made less so through additional plant-specific analyses for selected scenarios. It may be prudent to review the NUREG 4550 bases to verify their continued applicability in light of plant changes over time and changes in generally accepted state of the art methodology. Conservatisms should be included with care in a PRA intended for use in risk-informed plant applications, since it is easy to compound conservatisms within accident sequences resulting in unrealistic representation of plant risk and risk contributors. Check the PRA for significant sources of conservatisms that may skew the PRA results.	Closed - The use of more realistic success criteria in place of conservative success criteria from NUREG/CR 4550 and the WBN FSAR would reduce the overall core damage frequency which, in turn, would reduce the overall probabilities of the release category bins in the Level 2 assessment. Therefore, the overall offsite consequences would be reduced. The impact of including more realistic success criteria considerations on the WBN2 model used to assess SAMA would be to reduce the maximum possible benefit attainable for any alternative. Thus, using conservative success criteria in the PRA model would maximize the possible benefit which could potentially result in additional features being classified as cost-effective. The potential for conservative success criteria to mask the importance of some SAMA alternatives was also assessed by comparing the success criteria to other Westinghouse 4-loop plants. As described in the response to AS-03, the success criteria used in the WBN PRA are reasonable compared to other 4-loop Westinghouse plants. Therefore, this F&O is considered closed for the SAMA assessment.	None

F&O	Description	Resolution Status	Model Impact
TH-03	The source of success criteria for ATWS as referenced in the documentation in Event Tree Notebook Appendix C is WCAP-11993. The success criteria for ATWS pressure relief (per PRA Rev 2 documentation) is from NUREG/CR-4550 which uses the moderator temperature coefficients (MTC) for critical regimes of -7pcm/F and -20pcm/F. These MTCs, and their implied impact on pressure relief capacity, are not consistent with the approach defined in WCAP-11993. If it is intended that the PSA should be based on WCAP-11993, the model should instead use the UET approach, and split fractions reflective of the current core loading, per the WCAP. Review the ATWS modeling and reconcile the documentation with what is actually modeled. Consider implementing the WOG model per WCAP-11993. Follow progress of the current WOG ATWS program and consider implementing the revised approach when available.	Closed - Incorporated in WBN Rev 4 update. See Pressurizer PORV and Safety Valves Systems Analysis Sections 1.2.3 and 3.2.3.2 and RPS Systems Analysis Section 3.1.2.	None
TH-06	The success criteria allow 1 of 4 HHSI/CVCS pumps for response to a small LOCA. The SI pumps have a shutoff head of ~1500 psi. There is no supporting analysis to show that 1 SI pump can provide adequate make-up flow for breaks at the low end of the SLOCA size range (e.g., 3/8 inch or 1/2 inch break) without additional action for primary pressure reduction. Provide the basis for assuming that 1 SI pump will provide adequate injection capability for the full range of small LOCAs	Closed - Success Criteria analyses for the WBN2 PRA show that one HHSI pump can provide adequate flow to maintain RCS inventory for a 3/8 inch LOCA IF AFW is operable. In this case, the RCS pressure falls to just above the secondary side pressure (at the atmospheric dump setpoint) before significant RCS inventory is lost. At this lower RCS pressure, the HHSI pump can easily keep up with break flow. Therefore, this F&O is considered closed.	None

F&O	Description	Resolution Status	Model Impact
TH-10	The success criteria for the ECCS pumps and PORVs for bleed and feed appear to either be incorrectly stated or incorrectly incorporated into the model. This might significantly affect the contribution of failure of bleed and feed to the CDF results. Top event BF is modeled in the top event rules so that success of one charging pump OR one SI pump will allow success of top BF. However, MAAP runs for Bleed and Feed appear to justify success with one train of ECCS injection pumps (one charging and one SI pump) plus one PORV. Peer reviewer inspection of the MAAP cases provided for feed & bleed cooling in the notebook indicated that the MAAP-predicted ECCS flowrates at several sampled times shown in the results plots are higher than would be expected based on the pump head curve data and the predicted RCS pressure at these time steps if only one pump were credited. (These were "back of the envelope" calculations, performed as ballpark estimates; however, they appeared to indicate that the ECCS flowrates shown in the MAAP results were higher than would be provided by a single pump). Thus, the model rules are allowing success on bleed and feed with one high head pump and one PORV, when the MAAP runs only justify two pumps and one PORV. It was also noted that some of the previous revision PRA documentation indicated that feed & bleed success requires 2 PORVs. The success criteria for feed and bleed was stated in PLG-1339 as 2 PORV and 1/4 HHSI/CVCS pumps. If this is true, then feed and bleed should be guaranteed failure for transient initiators Loss of 6.9 kV board and Loss of 125 Vdc battery board because one PORV would be unavailable. A check of the event trees, however, shows that feed and bleed is allowed for these events. The success criteria for feed and bleed as implemented in the model appears to allow a 1/2 PORV success criterion for certain events. Either revise top event BF rules to require at least one charging and one SI pump (to match available analyses) or perform MAAP runs to show that the modeled criterion is acceptable. It is unclear whether credit could be taken for two SI pumps, but there is the potential for a basis to be developed. Review the basis for the PORV bleed and feed success criterion and the implementation of the proper success criterion in the model. Ensure that, if 2 PORVs are required, the model properly accounts for event-specific dependencies.	Closed - Success Criteria analyses for the WBN2 PRA for Bleed and Feed were compared against the WBN PRA Rev. 4 model (see Section 3.1 of this report) and HR-011 resolution status. The WBN PRA model used in the SAMA assessment was modified if necessary to be consistent with the WBN2 Success Criteria analyses for the number of pumps and PORV required for success. However, the HRA was not revised based on the assessment described in the resolution of F&O HR-11.	Success criteria changes were made to reflect the requirement for two PORVs when performing bleed and feed cooling using SI pumps.

F&O	Description	Resolution Status	Model Impact
TVA-001	WBN-ENG-01-005 Self Assessment Effectiveness Review enhancement E1. A pending standard for PSA is in the review cycle by ASME and the NRC. Enhancements to the WBN model and documentation will be required to meet the provisions of the standard if it remains as currently proposed.	Closed - Not needed for SAMA analysis. The SAMA analysis is not a risk informed application and is not required to meet the PRA standard.	None
TVA-002	WBN-ENG-01-005 Self Assessment Effectiveness Review enhancement E2. The thermal hydraulic analyses and core melt success criteria were developed using the Modular Accident Analysis Program (MAAP) version 3B and have not been updated since the original analysis. The MAAP version 4 computer code is now available within Engineering and incorporates later research on core melt phenomena. A MAAP4 model for WBN has been developed as a task in the current PSA revision.	Closed - Not needed for SAMA analysis. Updating to a newer version of MAAP may provide more realistic success criteria. However basing the SAMA analysis on a conservative model will result in conservative calculation of the SAMA benefit, and therefore SAMAs may be included which actually could be excluded.	None
TVA-11	Add cooling to the thermal barriers via the thermal barrier booster pumps to the CCS system notebook. The thermal barrier booster pumps were deleted in Revision 4 to the PSA. The reference that was the basis for this deletion is not valid and the thermal barrier booster pumps need to be added back into the model.	Closed - See resolution to DE-01	Thermal barrier booster pumps were added to the TB fault tree.

Table 3 Release Category Frequencies and Related Accident Sequences

Release Category	*Base Case Frequency*	*Example Scenario*
I	2.638×10^{-7}	The major accident contributors to this release event are initiated by loss of offsite power and the essential raw cooling water system; failure of the emergency diesels to start and/or failures in the 125-volt direct current distribution system, together with loss of secondary cooling; and no recovery before core melt.
II	1.192×10^{-7}	The main contributor to this release event is initiated by a steam generator tube rupture in conjunction with either an operator error or a random failure of electrical distribution systems, leading to failure of the coolant system and failure to control the affected steam generator before core melt occurs.
III	1.995×10^{-6}	The major accident contributors to this release event are initiated by loss of offsite power and various failures in the alternating current distribution systems; no recovery of power before core melts; a reactor coolant system loss-of-coolant accident (large- and medium-sized loss-of-coolant accident); and failure to establish long-term core cooling.
IV	1.299×10^{-5}	Contributors to this category are core damage sequences which lead to benign releases (intact containment)

Table 4 Projected 2040 Population Distribution within 80 Kilometers (50 miles)

Direction	*Miles*										
	0-1	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	*0-50*
N	0	18	0	0	135	2,465	1,885	2,778	4,768	6,172	18,222
NNE	0	0	18	411	185	1,536	11,762	18,766	14,502	2,547	49,727
NE	0	0	18	308	287	827	3,783	16,734	29,838	78,334	130,130
ENE	0	0	18	308	287	497	3,553	29,539	63,798	25,3831	351,832
E	0	8	431	308	616	552	11,352	18,647	30,063	44,013	105,990
ESE	0	0	0	27	41	68	6,230	20,120	5,068	3,280	34,833
SE	8	0	0	29	39	135	19,852	15,185	3,950	4,822	44,020
SSE	21	0	0	246	413	103	8,951	12,907	2,918	48,593	74,151
S	16	0	0	0	1,983	3,824	4,586	42,883	56,430	17985	127,707
SSW	0	0	21	0	0	546	5,725	42,517	46,281	106,392	201,482
SW	0	0	0	0	0	1,051	12,978	14,499	62,307	111,795	202,630
WSW	0	6	36	59	126	711	12,791	2,837	2,840	3,372	22,778
W	0	14	22	101	90	710	3,406	5,555	2,944	5,474	18,316
WNW	0	0	22	126	79	490	2,091	4,372	5,654	20,511	33,345
NW	0	108	332	376	526	2,655	2,889	18,634	10,462	15,956	51,940
NNW	0	0	0	173	123	3,116	1,536	33,843	11,609	5,890	56,290
Total	45	154	918	2,472	4,930	19,286	11,3370	299,816	353,432	728,967	1,523,390

Note: To convert from mile to kilometer multiply the value by 1.609.
Source [SAIC 2007]

Table 5 Watts Bar Core Inventory

Nuclide	Isotope	Group[a]	Curies
Cobalt	Co-58	6	1.11E+06
	Co-60	6	8.67E+05
Krypton	Kr-83m	1	1.15E+07
	Kr-85m	1	2.39E+07
	Kr-85	1	1.03E+06
	Kr-87	1	4.81E+07
	Kr-88	1	6.66E+07
Xenon	Xe-131m	1	1.05E+06
	Xe-133m	1	6.16E+06
	Xe-133	1	1.91E+08
	Xe-135m	1	4.05E+07
	Xe-135	1	6.43E+07
	Xe-138	1	1.67E+08
Iodine	I-130	2	1.93E+06
	I-131	2	9.46E+07
	I-132	2	1.39E+08
	I-133	2	1.95E+08
	I-134	2	2.16E+08
	I-135	2	1.86E+08
Bromine	Br-83	2	1.15E+07
	Br-84	2	2.14E+07
Cesium	Cs-134	3	1.66E+07
	Cs-135	3	0.00E+00
	Cs-136	3	5.89E+06
	Cs-137	3	1.17E+07
	Cs-138	3	1.81E+08
Rubidium	Rb-86	3	1.87E+05
	Rb-88	3	6.83E+07
	Rb-89	3	8.92E+07
Strontium	Sr-89	4	9.34E+07
	Sr-90	5	8.94E+06
	Sr-91	5	1.16E+08
	Sr-92	5	1.24E+08
Yttrium	Y-90	7	9.48E+06
	Y-91m	7	6.76E+07
	Y-91	7	1.21E+08
	Y-92	7	1.25E+08
	Y-93	7	9.48E+07
	Y-94	7	1.51E+08
	Y-95	7	1.57E+08
Zirconium	Zr-95	7	1.67E+08
	Zr-97	7	1.61E+08
Niobium	Nb-95	7	1.69E+08
	Nb-97m	7	1.53E+08
	Nb-97	7	1.62E+08
Molybdenum	Mo-99	6	1.78E+08
Technetium	Tc-99m	6	1.57E+08

Nuclide	Isotope	Group[a]	Curies
	Tc-99	6	0.00E+00
	Tc-101	6	1.61E+08
Ruthenium	Ru-103	6	1.48E+08
	Ru-105	6	1.00E+08
	Ru-106	6	5.00E+07
Rhodium	Rh-103m	6	1.48E+08
	Rh-105	6	9.55E+07
	Rh-106	6	5.33E+07
	Rh-107	6	5.77E+07
Antimony	Sb-127	4	8.05E+06
	Sb-129	4	3.03E+07
	Sb-130	4	1.00E+07
Tellurium	Te-125m	4	1.93E+04
	Te-127m	4	1.33E+06
	Te-127	4	7.93E+06
	Te-129m	4	5.81E+06
	Te-129	4	2.88E+07
	Te-131m	4	1.86E+07
	Te-131	4	7.99E+07
	Te-132	4	1.36E+08
	Te-133	4	1.06E+08
	Te-134	4	1.73E+08
Barium	Ba-137m	5	1.11E+07
	Ba-139	5	1.73E+08
	Ba-140	5	1.73E+08
	Ba-141	5	1.56E+08
	Ba-142	5	1.49E+08
Lanthanum	La-140	7	1.79E+08
	La-141	7	1.58E+08
	La-142	7	1.54E+08
	La-143	7	1.46E+08
Cerium	Ce-141	8	1.59E+08
	Ce-143	8	1.48E+08
	Ce-144	8	1.29E+08
Praseodymium	Pr-143	7	1.44E+08
	Pr-144	7	1.30E+08
	Pr-145	7	1.01E+08
Neodymium	Nd-147	7	6.39E+07
Neptunium	Np-239	8	1.87E+09
Plutonium	Pu-238	8	3.15E+05
	Pu-239	8	3.48E+04
	Pu-240	8	4.38E+04
	Pu-241	8	1.49E+07
	Pu-243	8	2.86E+07
Americium	Am-241	7	9.80E+03
	Am-242	7	7.93E+06

Nuclide	*Isotope*	*Group* [a]	*Curies*
Curium	Cm-242	7	3.98E+06
	Cm-244	7	1.61E+05

[a] The grouping is based on NUREG-1465.
Source [SAIC 2007]

Table 6 Release Times, Heights, and Energies for Release Categories

Release Category	*Release Height (meters)*	*Warning Time (hours)*	*Release Time (hours)*	*Release Duration (hours)*	*Release Energy* [a] *(megawatts)*
I	10.00	8	10	2	28
II	10.00	20	24	4	1
III	10.00	20	30	10	3.5

[a] These values were taken from similar accident scenarios given in NUREG/CR-4551.
Source [SAIC 2007]

Table 7 Fission Product Source Terms

Release Category	*NG*	*I*	*Cs*	*Te*	*Sr*	*Ru*	*La*	*Ce*	*Ba*	*Mo*
I	0.90	0.042	0.043	0.044	0.0027	0.0065	0.00048	0.004	0.0046	0.0065
II	0.91	0.21	0.19	0.0004	0.0023	0.07	0.00028	0.00055	0.025	0.07
III	0.94	0.0071	0.011	0.0052	0.00036	0.00051	4.2×10^{-6}	4.0×10^{-6}	0.0013	0.00051

NG = Noble gases.
Source [SAIC 2007]

Table 8 Evacuation Times 0-to-16-kilometer (0-to-10-mile) Area

Evacuation Paths	*Permanent Population, Adverse Condition (hrs-min)*	*Special Population, Adverse Condition (hrs-min)*	*General Population, Adverse Condition (hrs-min)*
1	6 - 40	3 - 40	5 - 12
2	4 - 23	2 - 41	3 - 47
3	4 - 21	2 - 43	5 - 0
4	4 - 10	2 - 36	3 - 41
5	4 - 37	2 - 53	4 - 05
6	4 - 25	2 - 45	3 - 54
7	4 - 21	2 - 43	3 - 51
8	4 - 25	2 - 45	3 - 54
9	3 - 26	2 - 15	3 - 30
10	3 - 26	2 - 15	3 - 30
11	3 - 26	2 - 30	3 - 50
12	3 - 26	2 - 30	3 - 54
13	3 - 26	2 - 0	3 - 30
14	3 - 26	1 - 35	3 - 30
15	3 - 20	1 - 30	3 - 25
Total	61 - 20	37 - 21	58 - 33
Average hours	4 - 5	2 - 29	3 - 54
Average speed over 10 miles (miles per hour)	2.45	4.02	2.56
(meters per second)	1.1	1.8	1.15

Source [SAIC 2007]

Table 9 Severe Reactor Accident Annual Risks

Release Category	*Offsite Population Dose within 80 kilometers (50 miles) (Person-Rem)*	*Offsite Economic Cost within 80 Kilometers (50 miles) (dollars)*
I - Early Containment Failure	2.19×10^{6}	4.45×10^{9}
II - Containment Bypass	3.42×10^{6}	8.11×10^{9}
III - Late Containment Failure	1.16×10^{6}	1.78×10^{9}

Table 10 Annual 80-Kilometer (50-mile) Population Dose and Economic Cost Risk

Release Category	*Population Dose Risk (person-rem/year)*	*Economic Cost Risk (dollars/year)*
I - Early Containment Failure	5.78×10^{-1}	1.17×10^{3}
II - Containment Bypass	4.08×10^{-1}	9.67×10^{2}
III - Late Containment Failure	2.31×10^{0}	3.55×10^{3}

Table 11 System Importance (RRW > 1.02) for CDF (Model Name: WBN4SAM2)

Rank	System	System Description	Reduction Worth
1	ERCW	ESSENTIAL RAW WATER COOLING SYSTEM	1.6398E+000
2	RHR	WBN RESIDUAL HEAT REMOVAL SYSTEM	1.6386E+000
3	CVCS	WBN CHEMICAL AND VOLUME CONTROL SYSTEM	1.1321E+000
4	EPS-AC	AC ELECTRIC POWER SYSTEMS	1.0827E+000
5	CCS	COMPONENT COOLING SYSTEM	1.0672E+000
6	EPS-DC	DC ELECTRIC POWER SYSTEMS	1.0470E+000
7	RCS	RCS SYSTEMS AND MISC. FUNCTIONS	1.0445E+000
8	AFW	AUXILIARY FEEDWATER SYSTEM	1.0414E+000
9	VENT	VENTILATION SYSTEMS	1.0246E+000

Table 12 System Importance (RRW > 1.02) for LERF (Model Name: WBN4SAM2)

Rank	System	System Description	Reduction Worth
1	ERCW	ESSENTIAL RAW WATER COOLING SYSTEM	1.7756E+000
2	AFW	AUXILIARY FEEDWATER SYSTEM	1.6258E+000
3	EPS-AC	AC ELECTRIC POWER SYSTEMS	1.1740E+000
4	RHR	WBN RESIDUAL HEAT REMOVAL SYSTEM	1.1636E+000
5	AIR	WBN - PLANT COMPRESSED AIR SYSTEMS	1.0876E+000
6	RCS	RCS SYSTEMS AND MISC. FUNCTIONS	1.0741E+000
7	CIS	CONTAINMENT SYSTEMS	1.0616E+000
8	VENT	VENTILATION SYSTEMS	1.0567E+000
9	CVCS	WBN CHEMICAL AND VOLUME CONTROL SYSTEM	1.0448E+000
10	VSEQ	V SEQUENCE EVENTS	1.0421E+000
11	EPS-DC	DC ELECTRIC POWER SYSTEMS	1.0334E+000
12	CCS	COMPONENT COOLING SYSTEM	1.0242E+000
13	SEC	SECONDARY SYSTEMS AND FUCNTIONS	1.0221E+000

Table 13 Basic Event Importance (RRW > 1.02) for CDF (Model Name: WBN4SAM2)

Rank	Basic Event	Basic Event Description	BE Risk Reduction
1	DHARR1	Operators fail to perform alignment for high head recirculation	1.3228E+000
2	ERCWGLOBAL	Global Failure of ERCW Pumps	1.2337E+000
3	COVFO1___0620504	Check valve 62-504 fails to open on demand	1.0734E+000
4	[PMOFR0___07000CS PMOFR1___07001AA PMOFR1___07001BB PMOFR2___07002BB]	Common cause failure to run of CCS pumps CS, 1AA, 1BB, 2BB	1.0246E+000

Table 14 Basic Event Importance (RRW > 1.02) for LERF (Model Name: WBN4SAM2)

Rank	Basic Event	Basic Event Description	BE Risk Reduction
1	ERCWGLOBAL	Global Failure of ERCW Pumps	1.2926E+000
2	FRACT_1AS_NONREC	Fraction 1-AS failures not recoverable	1.1431E+000
3	DHARR1	Operators fail to perform alignment for high head recirculation	1.1011E+000
4	PDMOD23	Relief valve 0-32-512,513, 514,4906,540, or 541 opens prematurely	1.0717E+000
5	DHADS2	SGTR with isolation. Steam dumps avail. For cooldown	1.0626E+000
6	FDHADS2	Control flag	1.0626E+000
7	CNTLK1_PREEXISTL	Isolation failure due to large pre-existing leaks	1.0532E+000
8	DHAMU1	Operator failure to open valves 59-737, 738, 511 & 742 and start	1.0406E+000
9	[PTSFS1___00301AS]	Turbine pump 1A-S fails to start on demand	1.0307E+000
10	COVFO1___0620504	Check valve 62-504 fails to open on demand	1.0261E+000
11	[PMSFS1MDP00301AA PMSFS1MDP00301BB PTSFS1___00301AS]	Common cause failure to start of AFW pumps 1AA, 1BB and 1AS	1.0238E+000
12	[1DGS_1AAFS]	DG 1A-A fails to start or run	1.0229E+000
13	[PMOFR0___06700GB]	ERCW pump G-B fails during operation	1.0222E+000
14	[PMOFR0___06700EB]	ERCW pump E-B fails during operation	1.0222E+000
15	[PMOFR0___06700HB]	ERCW pump H-B fails during operation	1.0201E+000
16	[PMOFR0___06700FB]	ERCW pump F-B fails during operation	1.0201E+000
17	DHAOB1	Operator fails to initiate bleed and feed	1.0197E+000

Table 15 SAMA Candidates Identified Through RRW Review

SAMA Title	SAMA Discussion	SAMA No.
Refurbish the ERCW pumps & upgrade the capacity of the current pumps.	Improves the reliability of the ERCW pumps.	271
Provide a portable diesel powered 5000 gpm pump as a backup to the ERCW system.	Improves availability of ERCW for SBO.	272
Provide a 2 MW blackout diesel generator to power Charging Pumps, Igniters, Inverters, etc	Improves availability of AC power during SBO.	9
Use a portable pump hookup to firewater system to provide backup feedwater to Steam Generators	Improves availability of SG cooling.	75
Enhance procedures to prevent strainers from plugging during recirculation	Improves reliability of core cooling.	198
Route ERCW to B charging pump lube oil cooler	Improves reliability of charging pump. The A pump design includes this capability.	262
Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	Eliminates single failure potential of RWST check valve failure to open.	273
Cross-tie diesel generators	Increased availability of on-site AC power.	12, 244
Cross-tie CCS trains with Appendix R valve.	Improves availability of component cooling water.	45, 157, 257
Replace CCS pumps with positive displacement pumps	Improves reliability of CCS system.	274
Provide a spare battery charger	Improved availability of DC power system.	3
Provide a new inverter arrangement.	Improved reliability of AC power system.	275

SAMA Title	SAMA Discussion	SAMA No.
Provide an auto start signal for AFW on loss of Standby Feedwater Pump.	Improved reliability of AFW for low power events (<18%) before Main Feedwater Pumps are started.	276
Replace shutdown board chillers	Improved reliability of shutdown board HVAC.	277
Perform analysis to evaluate the need for ventilation to inverters, shutdown boards and ESFAS	Eliminate dependency requirement for HVAC.	278
Provide a permanent tie-in to the construction air compressor.	Improve availability of air system.	279
Add new Unit 2 air compressor similar to the Unit 1 D compressor.	Improve availability of air system.	280
Replace the ACAS compressors and dryers.	Improve reliability of air system.	281
Enhance procedures for SGTR.	Improved mitigation of steam generator tube ruptures.	123, 127, 128, 251
Enhance procedures for refill of RWST.	Extend RWST capacity.	33, 249
Provide cross-tie to Unit 1 RWST.	Extend RWST capacity.	282
Enhance procedures for feed & bleed operation.	Improve mitigation of loss of secondary cooling.	283

Table 16 Phase I SAMA Candidates

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
1	Provide additional DC battery capacity.	Extended DC power availability during a Station Blackout (SBO).	NEI 05-01 (Rev A)	Basis for Screening: A spare battery (#5) is already installed to provide additional capacity.	Already Implemented
2	Replace lead-acid batteries with fuel cells.	Extended DC power availability during an SBO.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation caused by replacing all batteries with fuel cells, including structural, electrical, and HVAC changes required, including a fuel supply which does not currently exist on site, would exceed the bounding benefit. Combine with SAMA 174.	Excessive Implementation Cost
3	Add additional battery charger or portable, diesel-driven battery charger to existing DC system.	Improved availability of DC power system.	NEI 05-01 (Rev A)	Basis for Screening: There are currently two spare chargers already in place.	Already Implemented
4	Improve DC bus load shedding.	Extended DC power availability during an SBO.	NEI 05-01 (Rev A)	SBO procedure includes shedding DC loads to extend battery availability (AOI 40 Station Blackout procedure will be duplicated for Unit 2). There is a potential for enhancement to shed additional loads to extend battery life. Therefore this SAMA is retained for Phase II analysis.	Retain For Phase II Analysis
5	Provide DC bus cross-ties.	Improved availability of DC power system.	NEI 05-01 (Rev A)	Basis for Screening: Since cross-ties are available at the 480V supplies, and the #5 spare battery can be aligned to and supply any of the 4 buses, this SAMA has very little risk benefit. Combine with SAMA 258.	Very Low Benefit
6	Provide additional DC power to the 120/240V vital AC system.	Increased availability of the 120 V vital AC bus.	NEI 05-01 (Rev A)	Basis for Screening: The #5 spare battery can supply the inverter through DC bus.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
7	Add an automatic feature to transfer the 120V vital AC bus from normal to standby power.	Increased availability of the 120 V vital AC bus.	NEI 05-01 (Rev A)	Basis for Screening: Transfer to DC supply is already an auctioneered automatic transfer.	Already Implemented
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	Improved chances of successful response to loss of two 120V AC buses.	NEI 05-01 (Rev A)	Training is conducted on inadvertent Safety Injection (SI), and loss of a single AC bus, however not on the loss of two 120V buses. Therefore this SAMA is retained for Phase II analysis. Improvements in this operator training may not be a material benefit in risk reduction.	Retain For Phase II Analysis
9	Provide an additional diesel generator.	Increased availability of on-site emergency AC power.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation ($8,500,000 to $22,800,000, representative of similar nuclear power plants, WBN specific cost estimate $5,000,000) would exceed the bounding benefit. Combine with SAMA 233.	Excessive Implementation Cost
10	Revise procedure to allow bypass of diesel generator trips.	Extended diesel generator operation.	NEI 05-01 (Rev A)	Basis for Screening: Diesel generator trips are bypassed on emergency start except generator differential and overspeed trips.	Already Implemented
11	Improve 4.16-kV bus cross-tie capability.	Increased availability of on-site AC power.	NEI 05-01 (Rev A)	Basis for Screening: Procedures AOI-43.01, 02, 03 and 04 provide proceduralized cross-tie capability for emergency power to any shutdown board from any diesel generator.	Already Implemented
12	Create AC power cross-tie capability with other unit (multi-unit site)	Increased availability of on-site AC power.	NEI 05-01 (Rev A)	Basis for Screening: AOI-43.01, 02, 03 and 04 proceduralized cross-tie capability for emergency power to any shutdown board from any diesel generator. Combine with SAMA 229.	Already Implemented
13	Install an additional, buried off-site power source.	Reduced probability of loss of off-site power.	NEI 05-01 (Rev A)	Basis for Screening: There are two existing 161 kV connections to a nearby dam switchyard above ground. The estimated cost of burying them would exceed the bounding benefit.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
14	Install a gas turbine generator.	Increased availability of on-site AC power.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($3,350,000 to $30,000,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
15	Install tornado protection on gas turbine generator.	Increased availability of on-site AC power.	NEI 05-01 (Rev A)	Basis for Screening: A gas turbine generator is not available at the Watts Bar site.	Not Applicable
16	Improve uninterruptible power supplies.	Increased availability of power supplies supporting front-line equipment.	NEI 05-01 (Rev A)	Basis for Screening: A design change is in process to add 4 inverters and a spare is available.	Already Implemented
17	Create a cross-tie for diesel fuel oil (multi-unit site).	Increased diesel generator availability.	NEI 05-01 (Rev A)	Basis for Screening: The capability exists to supply any of the four 7-day tanks (one for each EDG) from either of the unit supply tanks which are cross tied. The 7-Day tanks for each diesel has a tanker truck connection to refill the tank. Therefore the intent of this SAMA is met with the current design.	Already Implemented
18	Develop procedures for replenishing diesel fuel oil.	Increased diesel generator availability.	NEI 05-01 (Rev A)	Basis for Screening: Procedures exist for maintaining long-term operation of the EDGs when necessary, including monitoring and replenishing EDG fuel oil. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	Already Implemented
19	Use fire water system as a backup source for diesel cooling.	Increased diesel generator availability.	NEI 05-01 (Rev A)	Basis for Screening: Each diesel generator has a permanent backup supply from opposite train ERCW from the other unit. Pump, equipment, and procedures are available to provide cooling water supply from the cooling tower or river. Therefore the intent of this SAMA is met with the current design.	Already Implemented

Attachment 1 Final Watts Bar Unit 2 SAMA Report

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
20	Add a new backup source of diesel cooling.	Increased diesel generator availability.	NEI 05-01 (Rev A)	Basis for Screening: Each diesel generator has a permanent backup supply from opposite train ERCW from the other unit. Cooling water supply from the cooling tower or river is available from an alternate pump. Therefore the intent of this SAMA is met with the current design.	Already Implemented
21	Develop procedures to repair or replace failed 4 kV breakers.	Increased probability of recovery from failure of breakers that transfer 4.16 kV non-emergency buses from unit station service transformers.	NEI 05-01 (Rev A)	Basis for Screening: Spare breakers are available at the shutdown boards and are maintained in accordance with procedure MI-57.01. Procedure GOI-7 provides direction for racking breakers in if needed. Therefore this SAMA is met with the current procedures.	Already Implemented
22	In training, emphasize steps in recovery of off-site power after an SBO.	Reduced human error probability during off-site power recovery.	NEI 05-01 (Rev A)	Basis for Screening: AOIs exist for dealing with SBO events, and include a high priority for steps calling for restoration of offsite power. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	Already Implemented
23	Develop a severe weather conditions procedure.	Improved off-site power recovery following external weather-related events.	NEI 05-01 (Rev A)	Basis for Screening: Procedure AOI-8 for tornado and other severe weather procedures, exist for general site preparations and placing the plant in a safe condition depending upon severe weather conditions, and provides guidance to mitigate known vulnerabilities of equipment or systems to specific external events, including missiles generated from tornadoes or high winds and cold weather conditions. These procedures are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
24	Bury off-site power lines.	Improved off-site power reliability during severe weather.	NEI 05-01 (Rev A)	Basis for Screening: The distance that would be necessary to bury offsite power lines would be significant since severe weather to which transmission lines are susceptible typically affects a broad area. For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
25	Install an independent active or passive high pressure injection system.	Improved prevention of core melt sequences.	NEI 05-01 (Rev A)	Basis for Screening: The previous passive UHI system was removed from the Watts Bar design. For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
26	Provide an additional high pressure injection pump with independent diesel.	Reduced frequency of core melt from small LOCA and SBO sequences.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
27	Revise procedure to allow operators to inhibit automatic vessel depressurization in non-ATWS scenarios.	Extended HPCI and RCIC operation.	NEI 05-01 (Rev A)	Basis for Screening: This is a BWR item. PWRs do not implement the same logic for deliberately depressurizing the RCS upon failure of high pressure injection to allow low pressure injection that is used in BWRs. Therefore, this item is not applicable and is screened from further consideration.	Not Applicable
28	Add a diverse low pressure injection system.	Improved injection capability.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
29	Provide capability for alternate injection via diesel-driven fire pump.	Improved injection capability.	NEI 05-01 (Rev A)	Basis for Screening: There is a minimal benefit from this SAMA since it does not provide a recirculation path. Therefore it is not considered further. This SAMA is considered cost prohibitive relative to the potential benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
30	Improve ECCS suction strainers.	Enhanced reliability of ECCS suction.	NEI 05-01 (Rev A)	Basis for Screening: Watts Bar has Implemented the required GSI-191 strainer improvements. This SAMA is met by the current design.	Already Implemented
31	Add the ability to manually align emergency core cooling system recirculation.	Enhanced reliability of ECCS suction.	NEI 05-01 (Rev A)	Basis for Screening: Watts Bar has the capability to manually align ECCS recirculation. This SAMA is met with the current design. Combine with SAMA 248.	Already Implemented
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	Enhanced reliability of ECCS suction.	NEI 05-01 (Rev A)	Low pressure ECCS automatically aligns for recirculation from the containment sump, however the high head recirculation is manual and the operator action is 38% of CDF. Therefore this SAMA is retained for further analysis. Combine with SAMA 238.	Retain For Phase II Analysis
33	Provide hardware and procedure to refill the reactor water storage tank once it reaches a specified low level.	Extended reactor water storage tank capacity in the event of a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: EOPs provide directions on monitoring RWST inventory and adding water from different sources when necessary. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
34	Provide an in-containment reactor water storage tank.	Continuous source of water to the safety injection pumps during a LOCA event, since water released from a breach of the primary system collects in the in-containment reactor water storage tank, and thereby eliminates the need to realign the safety injection pumps for long-term post-LOCA recirculation.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit. There is limited room in containment to install an in-containment RWST.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
35	Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.	Extended reactor water storage tank capacity.	NEI 05-01 (Rev A)	Basis for Screening: ECA-1.1 contains criteria for shutting down a train of containment spray or low pressure injection and high pressure injection to extend RWST storage capability. Therefore, the intent of this SAMA is met.	Already Implemented
36	Emphasize timely recirculation alignment in operator training.	Reduced human error probability associated with recirculation failure.	NEI 05-01 (Rev A)	Basis for Screening: Existing EOPs provide directions for monitoring and conserving water in the containment recirculation sump, including ensuring that maximum injection of water from the RWST occurs prior to performing swapover to containment recirculation. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current operator training.	Already Implemented
37	Upgrade the chemical and volume control system to mitigate small LOCAs.	For a plant like the Westinghouse AP600, where the chemical and volume control system cannot mitigate a small LOCA, an upgrade would decrease the frequency of core damage.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation to increase CVCS flow capacity would exceed the bounding benefit.	Excessive Implementation Cost
38	Change the in-containment reactor water storage tank suction from four check valves to two check and two air-operated valves.	Reduced common mode failure of injection paths.	NEI 05-01 (Rev A)	Basis for Screening: This item only applies to AP600 plants that have the RWST located inside of containment. Therefore, this item is not applicable and is screened from further consideration.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
39	Replace two of the four electric safety injection pumps with diesel-powered pumps.	Reduced common cause failure of the safety injection system. This SAMA was originally intended for the Westinghouse-CE System 80+, which has four trains of safety injection. However, the intent of this SAMA is to provide diversity within the high- and low-pressure safety injection systems.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation to replace the SI pumps would exceed the bounding benefit.	Excessive Implementation Cost
40	Provide capability for remote, manual operation of secondary side pilot-operated relief valves in a station blackout.	Improved chance of successful operation during station blackout events in which high area temperatures may be encountered (no ventilation to main steam areas).	NEI 05-01 (Rev A)	Basis for Screening: WBN has capability for remote manual operation of the SG atmospheric dump valves via nitrogen stations. Therefore the intent of this SAMA is met.	Already Implemented
41	Create a reactor coolant depressurization system.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation to install larger PORVs would exceed the bounding benefit.	Excessive Implementation Cost
42	Make procedure changes for reactor coolant system depressurization.	Allows low pressure emergency core cooling system injection in the event of small LOCA and high-pressure safety injection failure.	NEI 05-01 (Rev A)	The current EOP network provides guidance for depressurizing RCS but may not be adequate for small LOCAs with only low head injection available. Changes to the EOPs are processed through the owners group ERG maintenance process. Since this change to the EOPs is not within TVA's control it can not be implemented at this time and therefore a cost benefit analysis is not performed.	Not Applicable
43	Add redundant DC control power for SW pumps.	Increased availability of SW.	NEI 05-01 (Rev A)	Basis for Screening: The Watts Bar design includes two DC busses for control power for the ERCW pumps. This SAMA is met with the current design.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
44	Replace ECCS pump motors with air-cooled motors.	Elimination of ECCS dependency on component cooling system.	NEI 05-01 (Rev A)	Basis for Screening: WBN has air cooled motors on the ECCS pumps. This SAMA is met with the current design.	Already Implemented
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	Reduced frequency of loss of component cooling water and service water.	NEI 05-01 (Rev A)	Watts Bar has the capability to cross-tie CCS trains and ERCW trains, and a flood mode procedure exists to supply CCS from ERCW by installing a spool piece. This SAMA will be retained for further analysis to review procedural guidance in AOI-15 for potential upgrades to comply with this SAMA.	Retain For Phase II Analysis
46	Add a service water pump.	Increased availability of cooling water.	NEI 05-01 (Rev A)	An alternate pump exists that can be temporarily connected to the ERCW system to provide ERCW capability, however a permanent diesel driven 10,000 gpm pump could be installed at the IPS flush connection to provide increased ERCW availability. Therefore this SAMA will be retained for further evaluation.	Retain For Phase II Analysis
47	Enhance the screen wash system.	Reduced potential for loss of SW due to clogging of screens.	NEI 05-01 (Rev A)	Basis for Screening: The location of the intake on the river is protected from debris therefore there is minimal benefit of this SAMA. Combine with SAMA 202	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
48	Cap downstream piping of normally closed component cooling water drain and vent valves.	Reduced frequency of loss of component cooling water initiating events, some of which can be attributed to catastrophic failure of one of the many single isolation valves.	NEI 05-01 (Rev A)	Basis for Screening: To minimize the possibility of leakage from piping, valves, and equipment, welded construction is used wherever possible. Except for the normally closed makeup line and equipment vent and drain lines, there are no direct connections between the CCS system and other systems. The equipment vent and drain lines outside the containment have manual valves which are normally closed unless the equipment is being vented or drained for maintenance or repair operations. Failure of the socket welds attaching vent and drain lines to the CCS system process piping is not likely, but is more likely than failure of manual drain and vent valves to stay closed. Therefore, additional capping of the drain and vent lines provides very little additional assurance against leakage from the CCS system that may result in a total loss of CCS, and the intent of this SAMA is met with the current design.	Already Implemented
49	Enhance loss of component cooling water (or loss of service water) procedures to facilitate stopping the reactor coolant pumps.	Reduced potential for reactor coolant pump seal damage due to pump bearing failure.	NEI 05-01 (Rev A)	Basis for Screening: AOI-15 requires tripping the RCPs immediately as a first step upon loss of CCS. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
50	Enhance loss of component cooling water procedure to underscore the desirability of cooling down the reactor coolant system prior to seal LOCA.	Reduced probability of reactor coolant pump seal failure.	NEI 05-01 (Rev A)	Basis for Screening: Upon receipt of any RCP seal no. 1 outlet temperature high alarm, AOI-15 & 24 require an RCS cooldown after isolation of the CCS path to the RCP thermal barrier and isolation of RCP seal injection. This order of actions is deemed appropriate for overall plant stabilization following a loss of CCS. Enhanced procedure will not affect the risk because of the rapid progression of the seal leak. Therefore, the intent of this SAMA is minimal benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
51	Additional training on loss of component cooling water.	Improved success of operator actions after a loss of component cooling water.	NEI 05-01 (Rev A)	Basis for Screening: AOI-15 exists for a loss of CCS, and is used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training. Combine with SAMA 260.	Already Implemented
52	Provide hardware connections to allow another essential raw cooling water system to cool charging pump seals.	Reduced effect of loss of component cooling water by providing a means to maintain the charging pump seal injection following a loss of normal cooling water.	NEI 05-01 (Rev A)	Basis for Screening: WBN does not require cooling to the charging pump seals. This SAMA is not applicable to the Watts Bar design.	Not Applicable
53	On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time.	Increased time before loss of component cooling water (and reactor coolant pump seal failure) during loss of essential raw cooling water sequences.	NEI 05-01 (Rev A)	Basis for Screening: AOI-13 for ERCW system loss or rupture does not provide directions to quickly implement loss of CCS procedure AOI-15 if ERCW cannot be restored. AOI-13, however, does provide directions to trip all of the RCPs, isolate thermal barrier cooling, cooldown the plant and cross-tie ERCW if available. There is minimal risk reduction for CCS load shedding since this is a timing issue for recovery of ERCW. The PRA model assumes loss of ERCW is non-recoverable within the 24 hr mission time. Therefore this SAMA has very low risk improvement benefit.	Very Low Benefit
54	Increase charging pump lube oil capacity.	Increased time before charging pump failure due to lube oil overheating in loss of cooling water sequences.	NEI 05-01 (Rev A)	Basis for Screening: The WBN A charging pump design has alternate ERCW supply to the lube oil cooler. Therefore the intent of this SAMA is met. Combine with SAMA 267.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
55	Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Reduced frequency of core damage from loss of component cooling water, service water, or station blackout.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	NEI 05-01 (Rev A)	There is potential to install a small pump in the PD pump room. This would be useful for loss of ERCW and loss of CCS which contributes 35% of the core damage. Suction and discharge piping and power is available in the PD pump room. Costs include dismantling current PD pump and installing new low capacity high pressure pump. Room cooling requirements will need to be evaluated. This SAMA is retained for further evaluation.	Retain For Phase II Analysis
57	Use existing hydro test pump for reactor coolant pump seal injection.	Reduced frequency of core damage from loss of component cooling water or service water, but not a station blackout.	NEI 05-01 (Rev A)	Basis for Screening: Watts Bar does not have an existing hydro test pump. This SAMA is not applicable.	Not Applicable
58	Install improved reactor coolant pump seals.	Reduced likelihood of reactor coolant pump seal LOCA.	NEI 05-01 (Rev A)	Unit 2 has the upgraded high temperature o-rings in the Reactor Coolant Pumps. A new seal insert design has been proposed by Westinghouse which could eliminate seal LOCA sequences. Pending topical report approval, this alternate seal design may prove cost effective, however costs are unknown at this time. Since this change is not within TVA's control it can not be implemented at this time and therefore a cost benefit analysis is not performed. Combine with SAMA 232	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
59	Install an additional component cooling water pump.	Reduced likelihood of loss of component cooling water leading to a reactor coolant pump seal LOCA.	NEI 05-01 (Rev A)	Basis for Screening: The Watts Bar design includes a swing 5th common spare CCS pump which can be powered from either train. There is limited space for an additional CCS pump. The cost of additional pump located in different space would be cost prohibitive. Therefore the intent of this SAMA is met by the current design.	Already Implemented
60	Prevent makeup pump flow diversion through the relief valves.	Reduced frequency of loss of reactor coolant pump seal cooling if spurious high pressure injection relief valve opening creates a flow diversion large enough to prevent reactor coolant pump seal injection.	NEI 05-01 (Rev A)	Basis for Screening: WBN does not have charging pump relief valves, the mini-flow line contains two normally open MOVs with power disconnected with orifices which recirculates flow back to the VCT. This SAMA is not applicable to the WBN design.	Not Applicable
61	Change procedures to isolate reactor coolant pump seal return flow on loss of component cooling water, and provide (or enhance) guidance on loss of injection during seal LOCA.	Reduced frequency of core damage due to loss of seal cooling.	NEI 05-01 (Rev A)	Basis for Screening: Procedure AOI-15 for loss of CCS includes instruction for isolating RCP seals. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
62	Implement procedures to stagger high pressure safety injection pump use after a loss of service water.	Extended high pressure injection prior to overheating following a loss of service water.	NEI 05-01 (Rev A)	Basis for Screening: Procedure AOI-13 directs use of fire water to cool the A charging pump on loss of ERCW. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
63	Use fire prevention system pumps as a backup seal injection and high pressure makeup source.	Reduced frequency of reactor coolant pump seal LOCA.	NEI 05-01 (Rev A)	Basis for Screening: WBN does not have high pressure fire pumps. This SAMA is not applicable to WBN.	Not Applicable
64	Implement procedure and hardware modifications to allow manual alignment of the fire water system to the component cooling water system, or install a component cooling water header cross-tie.	Improved ability to cool residual heat removal heat exchangers.	NEI 05-01 (Rev A)	Basis for Screening: The Watts Bar design includes a CCS header cross-tie. Procedure AOI-7.07 provided direction to use ERCW as a cooling medium for RHR, spent fuel pit, and sample heat exchangers. Therefore the intent of this SAMA is met.	Already Implemented
65	Install a digital feedwater upgrade.	Reduced chance of loss of main feedwater following a plant trip.	NEI 05-01 (Rev A)	Basis for Screening: Design change is in process to install digital feedwater control. This SAMA is met.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
66	Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	Increased availability of feedwater.	NEI 05-01 (Rev A)	Basis for Screening: The Watts Bar design includes provisions for emergency connection for sources to the feedwater and aux feedwater systems. The DWST can be connected to the CST to supply water to hotwell, condensate and then main feedwater. This lineup is proceduralized in SOI-59.01. The ERCW system can supply AFW via a hard pipe connection. There is a designed feature of AFW to swap over to ERCW supply on low level of CST. There also is provision for a flood mode spool piece connection from the fire protection system to the AFW discharge. Procedure AOI-7.06 directs installation of this spool piece. Pump, equipment, and procedures are available to provide cooling water supply from the cooling tower or river. These emergency connections met the intent of this SAMA.	Already Implemented
67	Install an independent diesel for the condensate storage tank makeup pumps.	Extended inventory in CST during an SBO.	NEI 05-01 (Rev A)	Basis for Screening: An alternate diesel driven pump and an alternate diesel generator are available to provide this capability. The diesel fire pump is capable of makeup to the CST. Additionally an onsite pumper truck is available for makeup to the CST. Procedures are in place to perform these actions. These means for making up to the CST meet the intent of this SAMA.	Already Implemented
68	Add a motor-driven feedwater pump.	Increased availability of feedwater.	NEI 05-01 (Rev A)	Basis for Screening: A motor-driven Standby Feedwater pump is available that can be used up to 18% load. Therefore, the intent of this SAMA is met with the current design. Combine with SAMA 196.	Already Implemented
69	Install manual isolation valves around auxiliary feedwater turbine-driven steam admission valves.	Reduced dual turbine-driven pump maintenance unavailability.	NEI 05-01 (Rev A)	Basis for Screening: The WBN design has one turbine driven AFW pump with isolation valves. Therefore this SAMA is not applicable to WBN.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	Eliminates the need for local manual action to align nitrogen bottles for control air following a loss of off-site power.	NEI 05-01 (Rev A)	The WBN turbine driven AFW pump flow control valves have a nitrogen supply that can be manually aligned. The nitrogen backup is not credited in SBO risk model. Installing accumulators to eliminate this manual action may be minimal risk benefit, however this SAMA is retained for further evaluation.	Retain For Phase II Analysis
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	Increased availability of the auxiliary feedwater system.	NEI 05-01 (Rev A)	The two unit CSTs are cross-tied so that they can supply either unit. A previous estimate of $300K to replace the existing PWST on Unit 1 with a stainless steel tank was used to estimate the cost of this SAMA. Installation of a new third CST would require a new pad, and piping to tie it in to the AFW supply. This SAMA is retained for further evaluation.	Retain For Phase II Analysis
72	Modify the turbine-driven auxiliary feedwater pump to be self-cooled.	Improved success probability during a station blackout.	NEI 05-01 (Rev A)	Basis for Screening: The current WBN turbine driven AFW pump is self-cooled, therefore this SAMA is not applicable.	Already Implemented
73	Proceduralize local manual operation of auxiliary feedwater system when control power is lost.	Extended auxiliary feedwater availability during a station blackout. Also provides a success path should auxiliary feedwater control power be lost in non-station blackout sequences.	NEI 05-01 (Rev A)	Basis for Screening: AOI-10 provides guidance for local manual operation of the turbine-driven AFW pump. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
74	Provide hookup for portable generators to power the turbine-driven auxiliary feedwater pump after station batteries are depleted.	Extended auxiliary feedwater availability.	NEI 05-01 (Rev A)	Basis for Screening: The #5 battery is available to supply one channel of control power for the turbine-driven AFW pump. An alternate power supply is also available for the battery charger. Therefore the intent of this SAMA is met with the current design.	Already Implemented
75	Use fire water system as a backup for steam generator inventory.	Increased availability of steam generator water supply.	NEI 05-01 (Rev A)	Basis for Screening: The use of fire water as a backup for steam generator inventory is implemented in the flood mode procedure. Therefore the intent of this SAMA is met with the current design.	Already Implemented

Attachment 1 Final Watts Bar Unit 2 SAMA Report

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
76	Change failure position of condenser makeup valve if the condenser makeup valve fails open on loss of air or power.	Allows greater inventory for the auxiliary feedwater pumps by preventing condensate storage tank flow diversion to the condenser.	NEI 05-01 (Rev A)	Basis for Screening: The condenser makeup valve (valve 2-9) is normally closed, air operated to open, and fails closed. Therefore this SAMA is not applicable to WBN.	Already Implemented
77	Provide a passive, secondary-side heat-rejection loop consisting of a condenser and heat sink.	Reduced potential for core damage due to loss-of-feedwater events.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
78	Modify the startup feedwater pump so that it can be used as a backup to the emergency feedwater system, including during a station blackout scenario.	Increased reliability of decay heat removal.	NEI 05-01 (Rev A)	Basis for Screening: Implementation of this SAMA requires a flow path around the isolation valves. Also for use during a station blackout the Standby Feedwater pump would have to be powered from a diesel generator. For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
79	Replace existing pilot-operated relief valves with larger ones, such that only one is required for successful feed and bleed.	Increased probability of successful feed and bleed.	NEI 05-01 (Rev A)	Basis for Screening: The Watts bar success criteria for bleed and feed is two PORVs only if charging is not available. Otherwise one PORV is sufficient. Larger valves would require piping changes, block valve changes, and analysis changes. There is a larger probability of leakage with larger valves. Based on this, this SAMA provides little benefit for the estimated cost.	Very Low Benefit
80	Provide a redundant train or means of ventilation.	Increased availability of components dependent on room cooling.	NEI 05-01 (Rev A)	Basis for Screening: Provisions for compensatory ventilation is in place for the 480V electric board rooms and margin to room heatup limits exists in the 480V transformer room. Plant chillers are being upgraded based on Freon considerations. This SAMA is considered not cost beneficial due to low risk benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
81	Add a diesel building high temperature alarm or redundant louver and thermostat.	Improved diagnosis of a loss of diesel building HVAC.	NEI 05-01 (Rev A)	Basis for Screening: The diesel generator building is manned during DG starts, and shiftly operator rounds take temperature measurements per SI-2. Therefore this SAMA is considered very low benefit.	Very Low Benefit
82	Stage backup fans in switchgear rooms.	Increased availability of ventilation in the event of a loss of switchgear ventilation.	NEI 05-01 (Rev A)	Basis for Screening: Fans are staged in the 480V electric board rooms. The shutdown board rooms have 2 trains of cooling available. Therefore the intent of this SAMA is met with the current design.	Already Implemented
83	Add a switchgear room high temperature alarm.	Improved diagnosis of a loss of switchgear HVAC.	NEI 05-01 (Rev A)	Basis for Screening: Shiftly operator rounds check temperatures per SI-2. Shutdown board room chillers swap on high temperature and provides a control room alarm. Therefore the intent of this SAMA is met with the current design.	Already Implemented
84	Create ability to switch emergency feedwater room fan power supply to station batteries in a station blackout.	Continued fan operation in a station blackout.	NEI 05-01 (Rev A)	Basis for Screening: A DC powered fan is installed in the AFW pump room in addition to the AC powered fan. Therefore the intent of this SAMA is met with the current design.	Already Implemented
85	Provide cross-unit connection of uninterruptible compressed air supply.	Increased ability to vent containment using the hardened vent.	NEI 05-01 (Rev A)	Basis for Screening: This is a BWR item and not applicable to WBN.	Not Applicable
86	Modify procedure to provide ability to align diesel power to more air compressors.	Increased availability of instrument air after a LOOP.	NEI 05-01 (Rev A)	Basis for Screening: Two of the four station non-safety related air compressors have capability to align to diesel power. Both of those are needed to supply full plant loads. The 2 safety related air compressors are diesel backed. Powering the D air compressor from the emergency diesel generator was evaluated and prohibited by diesel loading. The current design of powering the two air compressors meets the intent of this SAMA.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Elimination of instrument air system dependence on service water cooling.	NEI 05-01 (Rev A)	Watts Bar is evaluating the status of the construction air compressors. Permanent installation of this air compressor needs to consider HVAC requirements for the self-cooled compressor. This SAMA is retained for further evaluation.	Retain For Phase II Analysis
88	Install nitrogen bottles as backup gas supply for safety relief valves.	Extended SRV operation time.	NEI 05-01 (Rev A)	Basis for Screening: The steam generator PORVs are designed with a nitrogen bottle backup. Therefore the intent of this SAMA is met with the current design.	Already Implemented
89	Improve SRV and MSIV pneumatic components.	Improved availability of SRVs and MSIVs.	NEI 05-01 (Rev A)	The Main Steam System is monitored in the Maintenance Rule Program. Reliability improvements have been implemented such as replacing the single MSIV regulator with two regulators. Watts Bar has not experienced the MSIV sticking issues identified at other plants. Therefore, the intent of this SAMA is met with the current design.	Already Implemented
90	Create a reactor cavity flooding system.	Enhanced debris cool ability, reduced core concrete interaction, and increased fission product scrubbing.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($8,750,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
91	Install a passive containment spray system.	Improved containment spray capability.	NEI 05-01 (Rev A)	Basis for Screening: The source of this SAMA is the AP600 Design Certification Review submittal. For a plant with significant construction already completed, the cost of implementation ($20,000,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
92	Use the fire water system as a backup source for the containment spray system.	Improved containment spray capability.	NEI 05-01 (Rev A)	Basis for Screening: Although there are two 2-inch test connections (72-545 & 544) that could be used to connect fire water to containment spray, this lineup bypasses the containment spray heat exchangers and would not remove containment heat. It also can not recirculate water from the containment sump. The low flow rate would be ineffective for fission product removal. Therefore this SAMA is considered very low benefit. Combine with SAMA 170.	Very Low Benefit
93	Install an unfiltered, hardened containment vent.	Increased decay heat removal capability for non-ATWS events, without scrubbing released fission products.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($3,100,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
94	Install a filtered containment vent to remove decay heat. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	Increased decay heat removal capability for non-ATWS events, with scrubbing of released fission products.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($5,700,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
95	Enhance fire protection system and standby gas treatment system hardware and procedures.	Improved fission product scrubbing in severe accidents.	NEI 05-01 (Rev A)	Basis for Screening: Enhancements to the EGTS and ABGTS filters to provide scrubbing for ISLOCA source terms would exceed the bounding benefit. EPSIL already contains instructions for spraying release points with fire water, which would provide fission product scrubbing.	Excessive Implementation Cost
96	Provide post-accident containment inerting capability.	Reduced likelihood of hydrogen and carbon monoxide gas combustion.	NEI 05-01 (Rev A)	Basis for Screening: SAG-7 provides guidance for steam inerting the containment. Therefore the intent of this SAMA is met with the current design and procedures.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
97	Create a large concrete crucible with heat removal potential to contain molten core debris.	Increased cooling and containment of molten core debris. Molten core debris escaping from the vessel is contained within the crucible and a water cooling mechanism cools the molten core in the crucible, preventing melt-through of the base mat.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($90,000,000 to $108,000,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
98	Create a core melt source reduction system.	Increased 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 from the vitrified compound would be facilitated, and concrete attack would not occur.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($90,000,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
99	Strengthen primary/secondary containment (e.g., add ribbing to containment shell).	Reduced probability of containment over-pressurization.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
100	Increase depth of the concrete base mat or use an alternate concrete material to ensure melt-through does not occur.	Reduced probability of base mat melt-through.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation caused by reconstruction of the containment building would exceed the bounding benefit.	Excessive Implementation Cost
101	Provide a reactor vessel exterior cooling system.	Increased potential to cool a molten core before it causes vessel failure, by submerging the lower head in water.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation ($2,500,000 to $4,700,000, representative of similar nuclear power plants) exceeds the bounding benefit.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
102	Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	Reduced probability of containment over-pressurization.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the cost of implementation ($10,000,000 and up, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
103	Institute simulator training for severe accident scenarios.	Improved arrest of core melt progress and prevention of containment failure.	NEI 05-01 (Rev A)	Basis for Screening: The estimated cost to upgrade the simulator to extend its capability to severe accidents is estimated as a $2 million to $5 million upgrade. The estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
104	Improve leak detection procedures.	Increased piping surveillance to identify leaks prior to complete failure. Improved leak detection would reduce LOCA frequency.	NEI 05-01 (Rev A)	Basis for Screening: Visual piping inspection is performed each outage and some forced outages. Inspections of the lower compartment inside the crane wall during power operation is not possible due to dose considerations. Therefore the intent of this SAMA is met with the current inspection program.	Already Implemented
105	Delay containment spray actuation after a large LOCA.	Extended reactor water storage tank availability.	NEI 05-01 (Rev A)	Basis for Screening: Delay of containment spray actuation would require reanalysis of safety analysis. Current safety analysis does not allow actuation delay. Cost of re-analysis and implementation would exceed the maximum benefit.	Excessive Implementation Cost
106	Install automatic containment spray pump header throttle valves.	Extended time over which water remains in the reactor water storage tank, when full containment spray flow is not needed.	NEI 05-01 (Rev A)	Basis for Screening: The estimated cost of implementing a design change including reanalysis of the safety analysis is considered excessive cost compared to the risk benefit.	Excessive Implementation Cost
107	Install a redundant containment spray system.	Increased containment heat removal ability.	NEI 05-01 (Rev A)	Basis for Screening: Two containment spray trains and two RHR spray trains provides redundancy for the containment spray function. Therefore the intent of this SAMA is met with the current design.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
108	Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Reduced hydrogen detonation potential.	NEI 05-01 (Rev A)	Basis for Screening: An alternate power supply to the hydrogen igniters was implemented. Therefore the intent of this SAMA is met with the current design.	Already Implemented
109	Install a passive hydrogen control system.	Reduced hydrogen detonation potential.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation of a catalytic converter system would exceed the bounding benefit.	Excessive Implementation Cost
110	Erect a barrier that would provide enhanced protection of the containment walls (shell) from ejected core debris following a core melt scenario at high pressure.	Reduced probability of containment failure.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the risk benefit.	Excessive Implementation Cost
111	Install additional pressure or leak monitoring instruments for detection of ISLOCAs.	Reduced ISLOCA frequency.	NEI 05-01 (Rev A)	Basis for Screening: Monitoring instrumentation such as: level and temperature alarms, aux building radiation monitors, RHR leak indication, exist in the control room to cue operators to pipe breaks/leaks in the aux building. Procedures exist (i.e., ECA-1.2) to respond to a LOCA outside containment. Therefore the intent of this SAMA is met with the current design and procedures. Combine with SAMA 239.	Already Implemented
112	Add redundant and diverse limit switches to each containment isolation valve.	Reduced frequency of containment isolation failure and ISLOCAs.	NEI 05-01 (Rev A)	Most of the containment isolation valves are air operated valves, however the ECCS valves are mostly motor operated. The status of the valves have redundant indication in control room. This SAMA will be retained to evaluate the number of applicable CIVs and the cost of installing limit switches.	Retain For Phase II Analysis

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
113	Increase leak testing of valves in ISLOCA paths.	Reduced ISLOCA frequency.	NEI 05-01 (Rev A)	Basis for Screening: At WBN, valves in the ISLOCA paths are tested in accordance with approved procedures every outage. RHR suction valves are not accessible at power. Therefore, the intent of this SAMA is met with the current procedures. Combine with SAMA 181.	Already Implemented
114	Install self-actuating containment isolation valves.	Reduced frequency of isolation failure.	NEI 05-01 (Rev A)	Basis for Screening: CIVs that are not required to open during an accident are generally air operated, spring to close. Therefore the intent of this SAMA is met with the current design. Combine with SAMA 179.	Already Implemented
115	Locate residual heat removal (RHR) inside containment.	Reduced frequency of ISLOCA outside containment.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($28,000,000, representative of similar nuclear power plants) would exceed the bounding benefit . Combine with SAMA 178.	Excessive Implementation Cost
116	Ensure ISLOCA releases are scrubbed. One method is to plug drains in potential break areas so that break point will be covered with water.	Scrubbed ISLOCA releases.	NEI 05-01 (Rev A)	Basis for Screening: The cost of implementation of this SAMA has not been estimated in detail. A minimum value of $100K for a hardware change is assumed for screening purposes. Auxiliary building releases are scrubbed by the Aux Building Gas Treatment System (ABGTS), however the ABGTS may not be sized for ISLOCA releases. RHR suction and discharge lines are in the overhead and therefore would not be submerged. Therefore this SAMA is considered very low benefit. Combine with SAMA 237.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
117	Revise EOPs to improve ISLOCA identification.	Increased likelihood that LOCAs outside containment are identified as such. A plant had a scenario in which an RHR ISLOCA could direct initial leakage back to the pressurizer relief tank, giving indication that the LOCA was inside containment.	NEI 05-01 (Rev A)	Basis for Screening: ECA-1.2 for LOCA outside containment is current with current industry guidance. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
118	Improve operator training on ISLOCA coping.	Decreased ISLOCA consequences.	NEI 05-01 (Rev A)	Basis for Screening: EOP network exists for coping with ISLOCA symptoms, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	Already Implemented
119	Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Reduced frequency of steam generator tube ruptures.	NEI 05-01 (Rev A)	Basis for Screening: The current cost of steam generator eddy current inspection is approximately $1million per steam generator. The cost of performing 100% inspection including the cost of the added outage time would exceed the bounding benefit.	Excessive Implementation Cost
120	Replace steam generators with a new design.	Reduced frequency of steam generator tube ruptures.	NEI 05-01 (Rev A)	Basis for Screening: The cost of replacing the steam generators at Watts Bar Unit 1 was $221,760,000. This exceeds the bounding benefit.	Excessive Implementation Cost
121	Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Eliminates release pathway to the environment following a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
122	Install a redundant spray system to depressurize the primary system during a steam generator tube rupture.	Enhanced depressurization capabilities during steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: Normal and auxiliary pressurizer spray capability is available in the current design. The estimated cost of implementation of a new pressurizer spray system would exceed the bounding benefit.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
123	Proceduralize use of pressurizer vent valves during steam generator tube rupture sequences.	Backup method to using pressurizer sprays to reduce primary system pressure following a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: Direction for use of the pressurizer PORV valves are already proceduralized in EOP E-3. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
124	Provide improved instrumentation to detect steam generator tube ruptures, such as Nitrogen-16 monitors.	Improved mitigation of steam generator tube ruptures.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation of rad monitors for each steam generator would exceed the bounding benefit.	Excessive Implementation Cost
125	Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.	Reduced consequences of a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation of a new structure would exceed the bounding benefit.	Excessive Implementation Cost
126	Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Reduced consequences of a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation of a air cooled isolation condenser would exceed the bounding benefit.	Excessive Implementation Cost
127	Revise emergency operating procedures to direct isolation of a faulted steam generator.	Reduced consequences of a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: EOPs for response to a SGTR contain guidance to ensure that a faulted SG is isolated as long as an intact SG remains available. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
128	Direct steam generator flooding after a steam generator tube rupture, prior to core damage.	Improved scrubbing of steam generator tube rupture releases.	NEI 05-01 (Rev A)	Basis for Screening: Procedure E-3 directs maintaining level above the tubes for scrubbing. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
129	Vent main steam safety valves in containment.	Reduced consequences of a steam generator tube rupture.	NEI 05-01 (Rev A)	Basis for Screening: The estimated cost of design reanalysis and implementation of hardware changes would exceed bounding benefit. Implementation would also have negative consequences since the increase in containment pressure would result in containment isolation phase B which would empty the RWST.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
130	Add an independent boron injection system.	Improved availability of boron injection during ATWS.	NEI 05-01 (Rev A)	Basis for Screening: WBN has an independent boron injection system with multiple paths. Therefore this SAMA is not applicable to WBN.	Already Implemented
131	Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	Improved equipment availability after an ATWS.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of installing a relief valve system is judged to be excessive relative to the risk benefit since ATWS accounts for only 4.06 % of the total internal event CDF.	Excessive Implementation Cost
132	Provide an additional control system for rod insertion (e.g., AMSAC).	Improved redundancy and reduced ATWS frequency.	NEI 05-01 (Rev A)	Basis for Screening: AMSAC is installed at WBN. Therefore the intent of this SAMA is met with the current design.	Already Implemented
133	Install an ATWS sized filtered containment vent to remove decay heat.	Increased ability to remove reactor heat from ATWS events.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
134	Revise procedure to bypass MSIV isolation in turbine trip ATWS scenarios.	Affords operators more time to perform actions. Discharge of a substantial fraction of steam to the main condenser (i.e., as opposed to into the primary containment) affords the operator more time to perform actions (e.g., SLC injection, lower water level, depressurize RPV) than if the main condenser was unavailable, resulting in lower human error probabilities.	NEI 05-01 (Rev A)	Basis for Screening: This is a BWR issue. Therefore this SAMA is not applicable to WBN.	Not Applicable
135	Revise procedure to allow override of low pressure core injection during an ATWS event.	Allows immediate control of low pressure core injection. On failure of high pressure core injection and condensate, some plants direct reactor depressurization followed by five minutes of automatic low pressure core injection.	NEI 05-01 (Rev A)	Basis for Screening: This is a BWR item. PWRs do not implement the same logic for governing low pressure injection that is used in BWRs. Therefore, this item is not applicable and is screened from further consideration.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
136	Install motor generator set trip breakers in control room.	Reduced frequency of core damage due to an ATWS.	NEI 05-01 (Rev A)	Installing a low cost means for tripping the motor generator sets from the control room may reduce the risk from ATWS. This SAMA will be retained for further evaluation.	Retain For Phase II Analysis
137	Provide capability to remove power from the bus powering the control rods.	Decreased time required to insert control rods if the reactor trip breakers fail (during a loss of feedwater ATWS which has rapid pressure excursion).	NEI 05-01 (Rev A)	Basis for Screening: Implementation of this SAMA would require reevaluation of the loss of the loads on the unit boards. Training and procedure changes is estimated to cost more than the potential benefit. Therefore this SAMA is considered very low benefit.	Very Low Benefit
138	Improve inspection of rubber expansion joints on main condenser.	Reduced frequency of internal flooding due to failure of circulating water system expansion joints.	NEI 05-01 (Rev A)	Basis for Screening: The Watts Bar design does not include rubber expansion joints on the circulating water. Therefore this SAMA is not applicable to WBN. Combine with SAMA 222.	Not Applicable
139	Modify swing direction of doors separating turbine building basement from areas containing safeguards equipment.	Prevents flood propagation.	NEI 05-01 (Rev A)	Basis for Screening: The flood doors installed on elevation 708' swing so that water pressure will force them closed. Therefore the intent of this SAMA is met with the current design.	Already Implemented
140	Increase seismic ruggedness of plant components.	Increased availability of necessary plant equipment during and after seismic events.	NEI 05-01 (Rev A)	Basis for Screening: No vulnerabilities were identified in the Watts Bar IPEEE. Modifications were made to bring the plant to a 0.3 g screening value per SQUG walkdowns. Therefore the intent of this SAMA is met with the current design.	Already Implemented
141	Provide additional restraints for CO2 tanks.	Increased availability of fire protection given a seismic event.	NEI 05-01 (Rev A)	Basis for Screening: The seismic margin review for the IPEEE did not identify this vulnerability at WBN. Therefore this SAMA is not applicable to WBN.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
142	Replace mercury switches in fire protection system.	Decreased probability of spurious fire suppression system actuation.	NEI 05-01 (Rev A)	Basis for Screening: The auxiliary building, control building, IPS and reactor building fire protection systems do not include mercury switches. Also the auxiliary building and containment building fire protection systems have fusible link operated sprinkler heads, which would require multiple link failures. Therefore the intent of this SAMA is met with the current design.	Already Implemented
143	Upgrade fire compartment barriers.	Decreased consequences of a fire.	NEI 05-01 (Rev A)	Basis for Screening: Two and three hour regulatory required fire protection barriers are installed and maintained. Non regulatory required two hour fire barriers are also credited in IPEEE. For a plant with significant construction already completed, the estimated cost of upgrading to 4 hour fire barriers would exceed the bounding benefit.	Excessive Implementation Cost
144	Install additional transfer and isolation switches.	Reduced number of spurious actuations during a fire.	NEI 05-01 (Rev A)	Basis for Screening: Modifications were implemented to mitigate spurious actuations evaluated under Appendix R, which included; installation of thermolag, rerouting conduits, or use of transfer and isolation switches in combination with manual actions. The Appendix R analysis is being reexamined for unit 2 licensing. Therefore the intent of this SAMA is met with the current design.	Already Implemented
145	Enhance fire brigade awareness.	Decreased consequences of a fire.	NEI 05-01 (Rev A)	Basis for Screening: Fire protection lesson plans and fire drills are held quarterly, and offsite live fire training is held annually. Therefore the intent of this SAMA is met with the current training.	Already Implemented
146	Enhance control of combustibles and ignition sources.	Decreased fire frequency and consequences.	NEI 05-01 (Rev A)	Basis for Screening: The transient combustible control program and hot work permits control combustibles and ignition sources. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
147	Install digital large break LOCA protection system.	Reduced probability of a large break LOCA (a leak before break).	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
148	Enhance procedures to mitigate large break LOCA.	Reduced consequences of a large break LOCA.	NEI 05-01 (Rev A)	Basis for Screening: EOPs follow the current owners group guidelines. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
149	Install computer aided instrumentation system to assist the operator in assessing post-accident plant status.	Improved prevention of core melt sequences by making operator actions more reliable.	NEI 05-01 (Rev A)	Basis for Screening: The Integrated Control System (ICS) is available to operators and Tech Support Center personnel to assist in assessing post-accident plant status. Therefore the intent of this SAMA is met with the current design.	Already Implemented
150	Improve maintenance procedures.	Improved prevention of core melt sequences by increasing reliability of important equipment.	NEI 05-01 (Rev A)	Basis for Screening: Maintenance improvements to increase equipment reliability have been implemented via; Maintenance rule program and MSPI, margin management procedure, AP-913 program identification of critical components. Therefore the intent of this SAMA is met with the current procedures and maintenance practices.	Already Implemented
151	Increase training and operating experience feedback to improve operator response.	Improved likelihood of success of operator actions taken in response to abnormal conditions.	NEI 05-01 (Rev A)	Basis for Screening: Operating experience is incorporated in operator training. Feedback mechanisms are used to keep operators up to date. Therefore the intent of this SAMA is met with the current practice. Combine with SAMA 263.	Already Implemented
152	Develop procedures for transportation and nearby facility accidents.	Reduced consequences of transportation and nearby facility accidents.	NEI 05-01 (Rev A)	Basis for Screening: An anti barge boom is installed at the intake structure to reduce transportation accidents. There are no identified hazardous barge shipments near the Watts Bar site. Therefore this SAMA is considered very low benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
153	Install secondary side guard pipes up to the main steam isolation valves.	Prevents secondary side depressurization should a steam line break occur upstream of the main steam isolation valves. Also guards against or prevents consequential multiple steam generator tube ruptures following a main steam line break event.	NEI 05-01 (Rev A)	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
154	Implement procedure to open the CVCS cross-tie valve to the opposite unit early in the accident response.	Failure of RCP seal cooling was found to be a significant contributor to CDF in the loss of CCW and loss of ESW events. The initiation of charging flow from the opposite unit should provide sufficient RCP seal cooling to prevent RCP seal damage.	Cook	Basis for Screening: WBN does not have capability to cross-tie CVCS between units. It is cost prohibitive to add a cross-tie between two ASME class 2 systems. This SAMA is not applicable to the WBN design.	Not Applicable
155	Implement loss of ESW procedure changes similar to that of loss of CCW to reduce significance of RCP seal LOCAs.	Potentially reduces CDF due to RCP seal LOCAs from loss of ESW.	Cook	Basis for Screening: AOI-13 for ERCW system loss or rupture, provides directions to stop the RCPs, and cooldown and depressurize the RCS by depressurizing the steam generators. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
156	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	Prevents loss of RCP seal integrity after a loss of CCW. Watts Bar Nuclear Plant IPE identified that an ERCW connection to charging pump seals could be used.	Cook	Procedure AOI-7.07 provides direction to connect ERCW to CCS to supply the thermal barrier coolers. AOI-15 for loss of CCS should be revised to refer to AOI-7.07 (may be minimal cost). This SAMA will be retained for further evaluation. Combine with SAMA 268.	Retain For Phase II Analysis
157	Implement procedure guidance for use of cross-tied CCW or SW pumps.	Potentially reduces the frequency of the loss of either of these.	Cook	Basis for Screening: AOI-13 provides guidance on cross-tying ERCW headers and SOI-70.01 contains instructions for CCS configurations. Therefore, the intent of this SAMA is met with the current design and current procedures.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
158	Implement procedure and operator training enhancements in support system failure sequences, with emphasis on anticipating problems and coping.	Potentially improves success rate of operator actions after support system failures.	Cook	Basis for Screening: AOIs exist for coping with the loss of support systems, such as a loss of ERCW, CCS, and control air, and are used extensively in license operator initial training and license operator continuing training programs. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training. Combine with SAMA 263.	Already Implemented
159	Improve ability to cool RHR heat exchangers.	Reduces probability of loss of decay heat removal. Options considered include 1) performing procedure and hardware modification to allow manual alignment of fire protection system to the CCW system, or 2) installing a CCW header cross-tie.	Cook	Basis for Screening: Procedure AOI-7.07 contains instructions to install ERCW flood mode spool pieces to CCS which would provide alternate RHR heat exchanger cooling. Therefore the intent of this SAMA is met.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
160	Implement procedures for temporary HVAC.	Provides for improved credit to be taken for loss of HVAC sequences.	Cook	Basis for Screening: 1) The motor-driven AFW pumps, CCS pumps, and ERCW pumps do not depend on HVAC systems to be operable. Therefore, the intent of this SAMA is met for these HVAC systems with the current design and current procedures. 2) The TD AFW pump, SI pumps, RHR pumps, and Containment Spray pumps do depend on HVAC systems to be operable. There is a DC powered fan available for the TD AFW pump room. Installation of temporary HVAC would be dose prohibitive in other rooms during a LOCA. 3) There are compensatory measures and SOI-82 procedures for abnormal operation of the Diesel Generator electric board room ventilation system in the event of an equipment failure to providing alternate ventilation alignments, including use of the adjacent room exhaust fans and cross flow between rooms. Therefore, this item is not further evaluated.	Already Implemented
161	Provide backup ventilation for the EDG rooms, should their normal HVAC supply fail.	Provides enhanced ventilation for EDG rooms.	Cook	Basis for Screening: There are compensatory measures and SOI-82 procedures for abnormal operation of the Diesel Generator electric board room ventilation system in the event of an equipment failure for providing alternate ventilation alignments, including use of the adjacent room exhaust fans and cross flow between rooms. Therefore the intent of this SAMA is met with the current design.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
162	Install an independent method of suppression pool cooling.	Potentially decreases frequency of loss of containment heat removal.	Cook	Basis for Screening: Sump water goes through RHR and containment spray heat exchangers, The RHR heat exchanger is cooled by CCS and Containment Spray heat exchanger is cooled by ERCW. Therefore there is independent means of cooling the sump, and the intent of the SAMA is met.	Already Implemented
163	Develop an enhanced drywell spray system.	Provides a redundant source of water to containment to control containment pressure, when used in conjunction with containment heat removal.	Cook	Basis for Screening: This is a BWR SAMA. Therefore this SAMA is not applicable to WBN.	Not Applicable
164	Provide a dedicated existing drywell spray system.	Identical to the previous concept, except that one of the existing spray loops would be used instead of developing a new spray system.	Cook	Basis for Screening: This is a BWR SAMA. Therefore this SAMA is not applicable to WBN.	Not Applicable
165	The action to turn on hydrogen igniters fails frequently due to the time needed to remotely turn off the ice condenser air handling units, as committed to during the original installation of the hydrogen igniter system. This commitment will be investigated and removed if justifiable.	Turning on the hydrogen igniters sooner would reduce containment failure probability for some sequences.	Cook	Basis for Screening: Near term procedure changes are in progress (PER 121426) to revise the EOP network to turn on the hydrogen igniters in E-0. Therefore the intent of this SAMA will be met with the revised procedures.	Already Implemented
166	Create a water-cooled rubble bed on the pedestal.	This rubble bed would contain a molten core dropping onto the pedestal, and would allow the debris to be cooled.	Cook	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation ($18,000,000, representative of similar nuclear power plants) would exceed the bounding benefit.	Excessive Implementation Cost
167	Enhance air return fans (ice condenser containment).	Provide an independent power supply for the air return fans, potentially reducing containment failure probability during SBO sequences.	Cook	Basis for Screening: 10 CFR 50.44 analysis shows these fans are a negligible contribution to the containment's ability to handle a hydrogen burn. Therefore this SAMA is considered very low benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
168	Create other options for reactor cavity flooding (Part a).	(a) Use water from dead-ended volumes, the condensed blowdown of the RCS, or secondary system by drilling pathways in the reactor vessel support structure to allow drainage from the SG compartments, refueling canal, sumps, etc., to the reactor cavity. Also (for ice condensers), allow drainage of water from melted ice into the reactor cavity.	Cook	Basis for Screening: The crane wall is sealed to elevation 715' or approximately 13 feet above the compartment floor. The hot leg is at elevation 718' and the maximum water level post accident is elevation 721', therefore water will overflow to flood the reactor cavity. Therefore the intent of this SAMA is met with the current design.	Already Implemented
169	Create other options for reactor cavity flooding (Part b).	(b) Flood cavity via systems such as diesel-driven fire pumps.	Cook	Basis for Screening: EPSIL provides direction to connect fire water to the containment spray test connection to fill up containment, which would result in flooding the reactor cavity. Therefore the intent of this SAMA is met with the current design and procedures.	Already Implemented
170	Use firewater spray pump for Containment Spray.	Provides for redundant Containment Spray method without high cost.	Cook	Combined with SAMA 169.	Combined
171	Install secondary containment filtered ventilation.	For plants with a secondary containment, would filter fission products released from the primary containment.	Cook	Basis for Screening: The ABGTS scrubs anything from the ABSCE. Therefore the intent of this SAMA is met with the current design.	Already Implemented
172	Increase containment design pressure.	Reduces chance of containment overpressure failures.	Cook	Basis for Screening: For a plant with significant construction already completed, the cost of implementation caused by reconstruction of the containment building would exceed the bounding benefit.	Excessive Implementation Cost
173	Implement procedure for alignment of spare EDG to shutdown board after LOSP and failure of the EDG normally supplying it.	Reduced SBO frequency.	Cook	Basis for Screening: WBN has no spare EDG for use during an SBO. An additional EDG would be required before benefiting from this SAMA. Therefore, this item is not applicable and is screened from further consideration.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
174	Replace batteries.	Improves reliability.	Cook	Basis for Screening: Work Orders 827018 (batteries I and II) and 819658 (batteries III and IV) are in process to replace the existing Unit 1 batteries since the current batteries are reaching end of life. The cost of replacing batteries I and II is approximately $300,000. Unit 2 batteries will also be replaced to match the Unit 1 design. Therefore the intent of this SAMA is met.	Already Implemented
175	Create a lake water backup for EDG cooling.	Provides redundant source of EDG cooling.	Cook	Basis for Screening: Supplemental cooling water for condenser circulating water is available which originates upstream of the dam. Loss of offsite power only contributes 5% to CDF, therefore cross-tying this system to the diesel generator cooling water would exceed the potential risk benefit.	Excessive Implementation Cost
176	Provide a connection to alternate offsite power source.	Increases offsite power redundancy.	Cook	Two 161kV lines come into the Watts Bar switchyard from the nearby hydro plant switchyard. There are 5 redundant lines into hydro switchyard. Additional lines into the Watts Bar switchyard may exceed the maximum cost, however this SAMA will be retained for further cost-benefit analysis. A procedure exists for backfeed when a unit is shutdown which requires the main generator links be removed.	Retain For Phase II Analysis
177	Replace anchor bolts on EDG oil cooler.	Millstone found a high seismic SBO risk due to failure of the EDG oil cooler anchor bolts. For plants with a similar problem, this would reduce seismic risk.	Cook	Basis for Screening: The seismic margin review for the IPEEE did not identify this vulnerability at WBN. Therefore this SAMA is not applicable to WBN.	Not Applicable
178	Locate RHR inside of containment.	Prevents ISLOCA from the RHR pathway.	Cook	Combine with SAMA 115.	Combined
179	Install self-actuating CIVs.	For plants that don't have this, it potentially reduces the frequency of isolation failure.	Cook	Combine with SAMA 114.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
180	Install relief valves in the CCW system	Relieves pressure buildup in CCW piping caused by an RCP thermal barrier tube rupture, preventing an ISLOCA.	Cook	Basis for Screening: CCS is designed for RCS pressure back to the isolation points and differential flow isolates the inlet and outlet, and stops the RCP. Therefore, the intent of this SAMA is met with the current design.	Already Implemented
181	Provide leak testing of valves in ISLOCA paths.	At Kewaunee Nuclear Power Plant, four MOVs isolating RHR from the RCS were not leak tested. Potentially reduces ISLOCA frequency.	Cook	Combine with SAMA 113.	Combined
182	Revise ISLOCA procedure to specifically address the ISLOCA sequence with the frequency that was dominant in the PRA.	Potentially reduces ISLOCA CDF.	Cook	Basis for Screening: Procedure ECA-1.2 for a LOCA outside containment meets current industry guidance. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
183	Implement internal flood prevention and mitigation enhancements.	Options considered include 1) use of submersible MOV operators, and 2) back flow prevention in drain lines.	Cook	Basis for Screening: The current modeling of flooding concerns in the WBN PRA does not indicate a vulnerability to this item. Therefore this SAMA is considered very low benefit.	Very Low Benefit
184	Implement internal flooding improvements identified at Fort Calhoun Station.	Implement improvements to prevent or mitigate 1) a rupture in the RCP seal cooler of the CCW system, 2) an ISLOCA in a shutdown cooling line, and 3) an AFW flood involving the need to possibly remove a watertight door. For a plant where any of these apply, potentially reduces flooding risk.	Cook	Basis for Screening: The current modeling of flooding concerns in the WBN PRA does not indicate a vulnerability to this item. Therefore this SAMA is considered very low benefit.	Very Low Benefit
185	Perform surveillances on manual valves used for backup AFW pump suction.	Improves success probability for providing alternate water supply to AFW pumps.	Cook	Basis for Screening: Procedures exist to perform surveillance of the ERCW supply valves to the AFW pumps. Therefore, the intent of this SAMA is met with the current procedures.	Already Implemented
186	Prevent overpressurization of RHR piping by SI system.	Failure of check valve SI-151W fails HPI. A redundant path, parallel to the check valve, would improve reliability.	Cook	Basis for Screening: This is a Cook specific issue, and therefore not applicable to WBN.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
187	Create automatic swapover to implement low pressure pump to HPSI pump piggyback operation during recirculation following RWST depletion.	Removes human error contribution from recirculation failure.	Cook	Combine with SAMA 32	Combined
188	Implement modifications to the compressed air system (Unit 1 control air compressor) to increase the capacity of the system.	In the IPE, failure of the compressed air system was found to be a significant contributor to CDF. Even though acceptable event tree modeling modifications would lower compressed air contributions and virtually eliminate this vulnerability, evaluate cost-beneficial upgrades to the capacity of the Unit 1 control air compressor.	Cook	Basis for Screening: The Unit 2 requirements for compressed air are being evaluated. The safety related compressors including dryers, which are common to both units are being replaced to meet the needs of 2 unit operation. This modification includes consideration of eliminating the ERCW dependency. Therefore the intent of this SAMA is met with the design modification.	Already Implemented
189	Provide an additional instrumentation system for ATWS mitigation (e.g., AMSAC).	Improves I&C redundancy and reduces ATWS frequency.	Cook	Basis for Screening: AMSAC has already been provided to reduce ATWS frequency at WBN. Therefore, the intent of this SAMA is met with the current design.	Already Implemented
190	Defeat 100 percent load rejection capability.	Eliminates the possibility of a stuck open PORV after a LOSP, since PORV opening wouldn't be needed.	Cook	Basis for Screening: 100 percent load rejection is not part of the WBN design. Therefore this SAMA is not applicable to WBN.	Not Applicable
191	Provide self-cooled ECCS seals.	ECCS pump seals are CCW cooled. Self-cooled seals would remove this dependency.	Cook	Basis for Screening: The WBN Charging and SI pumps have mechanical seals which do not require a cooling source. The RHR pump seals are CCS cooled. Providing mechanical seals for RHR pumps would exceed the maximum benefit cost.	Excessive Implementation Cost
192	Separate non-vital buses from vital buses.	Some non-vital loads mixed with vital loads on load centers potential cause load shedding difficulties.	Cook	Basis for Screening: The Watts Bar vital and non-vital buses are separated. Therefore this SAMA is met by the current design.	Already Implemented
193	Make CCW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	Cook	Basis for Screening: This SAMA is not applicable to WBN. The CCS trains are separate.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
194	Make ICW trains separate.	Current cross-tie capability creates a potential common mode failure mechanism for both trains (and both stations).	Cook	Basis for Screening: The ICW system is not applicable to WBN.	Not Applicable
195	Provide a centrifugal charging pump.	Currently charging pumps are positive displacement pumps.	Cook	Basis for Screening: WBN has two centrifugal charging pumps for each unit that are used for high pressure injection of borated water during emergency conditions requiring actuation of the ECCS. Therefore this SAMA is not applicable to WBN.	Already Implemented
196	Provide a motor-operated AFW pump.	Provides redundancy for plants with only turbine-driven AFW pumps.	Cook	Basis for Screening: The AFW system for each unit includes two motor-driven AFW pump trains. Therefore, the intent of this SAMA is met with the current design.	Already Implemented
197	Provide containment isolation design per GDC and SRP.	Potentially enhances containment isolation capability.	Cook	Basis for Screening: WBN meets the GDC and SRP. Therefore the intent of this SAMA is met with the current design.	Already Implemented
198	Improve RHR sump reliability.	Reduces potential for common mode failure of RHR due to debris in sump.	Cook	Basis for Screening: The required GSI-191 sump modifications were implemented at unit 1 and will be included in unit 2.	Already Implemented
199	Provide auxiliary building vent/seal structure.	Enhances ventilation in auxiliary building.	Cook	Basis for Screening: Normal auxiliary building ventilation is not risk significant. Therefore this SAMA is considered very low benefit.	Very Low Benefit
200	Add charcoal filters on auxiliary building exhaust.	Enhances fission product removal after ISLOCA.	Cook	Basis for Screening: The ABGTS already contains charcoal filters. Therefore the intent of this SAMA is met with the current design.	Already Implemented
201	Add penetration valve leakage control system.	Enhances capability to detect/control leakage from penetration valves.	Cook	Basis for Screening: Temperature indication and level detectors exist for the operators to detect and control leakage. Containment penetration valves are tested every outage. Therefore the intent of this SAMA is met with the current design and operating practices.	Already Implemented
202	Enhance screen wash.	Reduces potential for loss of ICW due to clogging of lake water screens.	Cook	Combine with SAMA 47.	Combined

Attachment 1 Final Watts Bar Unit 2 SAMA Report

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
203	Enhance training for important operator actions.	The Fussell-Vesely importance list was reviewed to identify any significant human errors. Those with a F-V importance of 5E-03 or greater are considered for training enhancement.	Cook	Basis for Screening: The PRA identified important operator actions have been incorporated into operator training. Therefore the intent of this SAMA is met with the current training program. Combine with SAMA 263.	Already Implemented
204	Foldout pages are used inconsistently by Unit Supervisors. The possibility of revising the usage of the foldout pages will be investigated to see if diagnosis of red path conditions can be improved.	Potentially reduces CDF related to operator error in red path sequences.	Cook	Basis for Screening: Foldout pages are on the back of every page. WBN is not using them inconsistently. Therefore this SAMA is not applicable to WBN.	Not Applicable
205	A clear definition of the coordination strategy for local recovery actions (e.g., between units during cross-tying operations) could save considerable action time.	Reduces human error related to cross-tie actions.	Cook	Basis for Screening: The only shared system between the Watts Bar units is the B train of CCS. The common control room and single shift manager minimizes lack of coordination. Therefore this SAMA is not applicable to WBN.	Not Applicable
206	Implement operator training on the impact of primary and secondary system heat removal on containment pressure response and the possibility of containment failure preceding core melt. In addition, consider procedural upgrades to minimize the possibility of such situations arising.	Reduces likelihood of core melt into a failed containment.	Cook	Basis for Screening: EOPs for responding to loss-of-coolant accidents and secondary side breaks address operator actions for monitoring and reducing the pressure rise in containment as a result of inadequate heat removal from the containment. These procedures are used extensively in license operator initial training and license operator continuing training programs, and are practiced in the plant simulator. Therefore, the intent of this SAMA is met with the current procedures and the associated operator training.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase 1 Comments	Disposition
207	Implement operator training on the importance of a wet reactor cavity on potential fission product releases.	This training will emphasize injecting the maximum amount of water possible from the RWST to the containment prior to switchover to recirculation.	Cook	Basis for Screening: Sump swapover instructions in the EOPs provides instructions to maximize RWST transfer to containment sump and EPSIL and SAMG procedures provides guidance to flood containment if needed. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
208	Add protection to prevent tornado damage to RWST and penetration rooms.	Penetration rooms are tornado protected. Tornado category F2 and higher can generate heavy enough missiles that they could impact and damage the RWST.	Cook	Basis for Screening: The Watts Bar design includes a moat around the RWST to retain a minimum amount of water in case of tank damage. The penetration room inside auxiliary bldg is tornado protected. Therefore this SAMA is not applicable to WBN.	Already Implemented
209	Man SSF continuously to align coolant makeup system for RCP seal cooling.	At Oconee Nuclear Station a dedicated operator for seals or for the highest value operator action could be considered.	Cook	Basis for Screening: This is an Oconee Nuclear Station specific item. Therefore, this item is not applicable and is screened from further consideration.	Not Applicable
210	Add protection to prevent tornado damage causing failure of power and upper surge tanks.	Consider tornado protection for tanks or switchgear in turbine building. Surge tanks are suction source for emergency FW pumps.	Cook	Basis for Screening: The ERCW system is the safety related source for AFW. Switchgear for AFW pumps in auxiliary building are tornado protected. Therefore this SAMA is not applicable to WBN.	Already Implemented
211	Replace reactor vessel with stronger vessel.	Reduces core damage contribution due to vessel failure.	Cook	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
212	Improve seismic capacity of walls near 4160/600 VAC transformers.	Failure of these transformers caused by a seismically induced failure of the walls contributed approximately 25% of seismic CDF. Reinforcing the walls potentially eliminates this failure mode.	Cook	Basis for Screening: The seismic margin review for the IPEEE did not identify this vulnerability at WBN. Therefore this SAMA is not applicable to WBN.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
213	Improve seismic capacity of the EDG fuel oil day tanks.	Seismically induced failure of the EDG fuel oil day tanks contributed approximately 20% of seismic CDF. A modification to prevent seismic impact potentially eliminates this failure mode.	Cook	Basis for Screening: Modifications were incorporated from SQUG walkdowns to bring the EDG up to 0.3g seismic margin. Therefore the intent of this SAMA is met with the current design.	Already Implemented
214	Reinforce the seismic capacity of the steel structure supporting the auxiliary building.	Seismic failure of the steel structure supporting the auxiliary building would lead to collapse of the building. Reinforcing the building potentially precludes or lessens this failure mode.	Cook	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation to reinforce the auxiliary building to withstand beyond-design-basis earthquake levels would exceed the bounding benefit .	Excessive Implementation Cost
215	Provide a means to ensure RCP seal cooling so that RCP seal LOCAs are precluded for SBO events.	Options to consider include using the CVCS cross-tie, installation of a new, independently powered pump, or a temporary connection to provide cooling to RCP thermal barriers. Such a strategy would also benefit loss of ESW and loss of CCW events.	Cook	Basis for Screening: Any of these options are considered not cost beneficial. To meet SBO conditions any of these options would require a diesel backed pump. For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
216	Improve EDG reliability.	Minimizes the probability of a SBO event given a LOSP.	Cook	Basis for Screening: The Watts Bar EDG reliability meets the maintenance rule with no valid failures. WBN follows all applicable owners group, INPO TR-7-60 and industry recommendations for diesel generator preventive maintenance. PER 124298 evaluated these recommendations for implementation at WBN. Therefore this SAMA is met by the current design and operating practices.	Already Implemented
217	Improve circulating water screens and debris removal.	Minimizes the chance of clogging heat exchangers and condensers and initiating transient events.	Cook	Basis for Screening: Duplex screens, trash racks, and pre-screen improvements have been implemented to improve debris removal. The intent of this SAMA is met with the current design.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
218	Improve reliability of power supplies.	Reduces reactor trip frequency.	Cook	Basis for Screening: WBN is currently improving vital AC reliability, upgrading the 500kV switchyard, replacing batteries, separating vital AC for dual unit operation, installing new inverters for Unit 2, incorporating a double breaker scheme in the switchyard, and adding load tap changers. These reliability improvements met the intent of this SAMA.	Already Implemented
219	Improve switchyard and transformer reliability.	This initiative is to reduce human errors in the switchyard and alarms on plant transformers. This initiative potentially lowers the frequency of transient events initiated by the electrical system.	Cook	Basis for Screening: WBN is implementing an improved double breaker scheme in 500kV switchyard, adding load tap changers, and has eliminated the single point failure of main transformer due to overpressure trips. These reliability improvements meet the intent of this SAMA.	Already Implemented
220	Reduce biofouling of raw water systems.	Improves control of zebra mussels.	Cook	Basis for Screening: WBN treats raw water to eliminate biofouling. This SAMA is met with current operating practice.	Already Implemented
221	Improve reliability of main feedwater pumps.	Potentially reduces transient initiating event frequency.	Cook	Basis for Screening: Several reliability improvements have been made to the main feedwater system. A design change is in process to upgrade to digital feedwater control. The main feedwater pump shaft material was upgraded. Changes were incorporated based on recommendations in availability improvement bulletins. Bentley Nevada supervisory instrumentation was installed. WBN has an extensive oil analysis program, and single point failures have been eliminated. Therefore the intent of this SAMA is met with the current design and operating practices.	Already Implemented
222	Establish a preventive maintenance program for expansion joints, bellows, and boots.	Potentially reduces flooding initiating event frequency and the failure probability of plant components.	Cook	Basis for Screening: There is a limited use of expansion joints at Watts Bar and no indication of a vulnerability. Therefore this SAMA is considered very low benefit.	Very Low Benefit

Attachment 1 Final Watts Bar Unit 2 SAMA Report

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
223	Improve reliability of AFW pumps and valves.	Potentially reduces occurrence of loss of secondary heat sink.	Cook	Basis for Screening: Several reliability improvements have been made to the AFW system. The AFW pumps and valves will be monitored in accordance with the maintenance rule and MSPI. There are predictive maintenance oil analysis and vibration programs. The Unit 1 EGM controller capacitor was changed out, and Unit 2 will incorporate the same design based on obsolete components. Additional changes on Unit 1 which will be incorporated into Unit 2 include governor stem changes, a new positioner and I to P converter, and short stroke LCVs to gain design margin for closure for SG isolation. Unit 2 design is evaluating the Unit 1 corrective actions to identify additional reliability improvements. Therefore the intent of this SAMA is met with the current design and operating practice.	Already Implemented
224	Eliminate MSIV vulnerabilities.	Reduces the chance that MSIVs will drift off their open seat during low-power operations.	Cook	Basis for Screening: Design changes to the valves and air supplies, and maintenance improvements have been made on the unit 1 MSIVs, which will be duplicated on unit 2. Therefore the intent of this SAMA is met with the current design.	Already Implemented
225	Upgrade main turbine controls.	Potentially reduces turbine trip frequency.	Cook	Basis for Screening: Since the turbine trip initiator contributes less than 1% CDF, the estimated cost of implementation would exceed the minimal risk benefit from this SAMA. Therefore this SAMA is considered very low benefit. Therefore this SAMA is considered very low benefit.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
226	Permanent, self- powered pump to backup normal charging pump.	This SAMA provides a means of limiting the size of a seal LOCA. This SAMA would provide a self powered pump that can be automatically or rapidly aligned to the RCP seals from the MCR. Long term secondary side cooling can be provided through the operation of the turbine driven AFW pump using existing Vogtle procedures. This arrangement would make it possible to provide adequate core cooling in extended SBO evolutions.	Vogtle	Basis for Screening: The cost of this enhancement has been estimated at other nuclear plants to be $2.7M based on a conceptual design of the backup pump which exceeds the bounding benefit.	Excessive Implementation Cost
227	Maintain full- time black start capability of the Wilson Switchyard combustion turbines	The combustion turbines (CTs) in the Plant Wilson Switchyard have black start diesel generators, but these are only verified to be operable prior to extended EDG AOTs. The use of the black start diesels would be necessary to start the CTs given unavailability of offsite power at Plant Wilson. This SAMA would add surveillance or maintenance activities to ensure the combustion turbines would be available much more often than is currently credited in the PRA model.	Vogtle	Basis for Screening: This SAMA is not applicable to WBN since a combustion turbine not available to the WBN site. An agreement exists with the nearby hydro plant to provide power if needed per procedure TRO-TO-SOP-10.134.	Not Applicable
228	Provide enhanced structural protection of Plant Wilson Switchyard.	This SAMA would provide enhanced structural protection of Plant Wilson Switchyard such that it would be more likely to survive in severe weather and extreme weather events.	Vogtle	Basis for Screening: This SAMA is not applicable to WBN since a combustion turbine not available to the WBN site.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
229	Opposite unit AC cross-tie capability.	The current PRA human reliability assessment for this action is that the cross-tie action will not succeed (i.e., HEP failure probability = 1.0) until at least seven hours after event initiation. Providing the ability to perform a timely 4kV AC cross-tie using an available emergency diesel generator under emergency conditions would allow operators more flexibility to operate required equipment to protect the core.	Vogtle	Basis for Screening: The capability exists via the AOI-43.01 procedure series to cross-tie diesel generators between units and trains. Therefore this SAMA is met with the current design and procedures.	Already Implemented
230	Permanent, dedicated generator for one motor driven AFW pump and a battery charger.	Installation of a dedicated generator for continued operation and control of a MD AFW pump would reduce the overall contribution to CDF risk. This generator would need to have the capacity to operate a MD AFW pump and an associated battery charger required for DC power control of the AFW pump.	Vogtle	Basis for Screening: An alternate power source is available capable of supplying power to an AFW pump and there is a spare battery capable of supplying DC control power. Procedure MA-1 provides direction for connecting the alternate power source. Therefore the intent of this SAMA is met with the current design and procedures.	Already Implemented
231	Add bypass line around cooling tower return valves.	Failure of the Loop CT return valves results in failure of cooling water to one of the EDGs and other systems. A bypass line around the 1668A (Loop "A") and 1669A (Loop "B") valves that could be remotely or manually opened given failure of the existing valves could greatly reduce the CDF risk from this failure mode.	Vogtle	Basis for Screening: This is a Vogtle specific feature that does not apply to WBN.	Not Applicable

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
232	Implement enhanced RCP seal design.	For Vogtle, a dominant contributor to the current risk profile is that without RCP seal cooling, it is assumed (based on Westinghouse and NRC consensus modeling) that an RCP seal LOCA of sufficient magnitude to require RCS injection occurs within 13 minutes. This SAMA would implement enhanced RCP seal designs that virtually eliminate this failure mode.	Vogtle	Combine with SAMA 58.	Combined
233	Implement alternate AC power source.	The implementation of an alternate AC power source would most likely take the form of an additional EDG. This SAMA would help mitigate LOSP events and would reduce the risk during time frames of on-line EDG maintenance. The benefit would be increased if the additional DG could 1) be substituted for any current diesel that is in maintenance, and 2) if the diesel was of a diverse design such that CCF dependence was minimized.	Vogtle	Basis for Screening: The cost of installing an additional EDG has been estimated to be greater than $20 million in the Calvert Cliffs Application for License Renewal. It was similarly estimated to be about $26.09M for both units at Vogtle. As the per unit cost of approximately $10M to $13M is greater than the Watts Bar maximum benefit, it has been screened from further analysis.	Excessive Implementation Cost
234	Implement automatic initiation of HPI on low RCS level (after AC power recovery).	The implementation of an automatic HPI initiation system would reduce the potential for core damage from occurring following events where ac power is recovered, but where a seal LOCA has already occurred. In these cases, RCS level must be restored to avoid core damage from occurring.	Vogtle	Basis for Screening: The WBN design initiates HPSI on low RCS pressure which would result from an RCP seal LOCA. The PRA model does not include operator actions to restore the pumps after AC power recovery since this sequence is dominated by recovery of AC power sources. Including this operator action would result in limited risk benefit and therefore is not analyzed further.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
235	Additional training and/or procedural enhancement to implement timely RCS depressurization.	Enhanced training and/or procedure enhancements could reduce the potential for thermally induced steam generator tube ruptures, thereby reducing the overall Level 2 risk contribution.	Vogtle	Basis for Screening: Revision 2 of E-2 limits the heat up of the RCS by adjusting intact SG PORVs to hottest RCS hot leg temperature and enhances the time to get to SI termination. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
236	Use the hydrostatic test pump as an alternate means of providing seal injection.	For Vogtle, a dominant contributor to the current risk profile is that without RCP seal cooling, it is assumed (based on Westinghouse and NRC consensus modeling) that an RCP seal LOCA of sufficient magnitude to require RCS injection occurs within 13 minutes. This SAMA would implement enhanced RCP seal designs that virtually eliminate this failure mode.	Vogtle	Combine with SAMA 57.	Not Applicable
237	Ensure all ISLOCA releases are scrubbed.	SAMA would scrub all ISLOCA releases. One example is to plug all drains in the break areas so that the break location would quickly be covered with water.	Vogtle	Combine with SAMA 116.	Combined
238	Completely automate swap over to recirculation on RWST depletion.	SAMA would ensure that automatic swap over to recirculation would occur in cases where high pressure injection from the charging and SI pumps is required (compared to the current capability at Vogtle that only automates the swap over for LPI).	Vogtle	Combine with SAMA 32.	Combined
239	Install additional instrumentation for ISLOCA detection.	SAMA would provide additional confidence that detection and response to ISLOCAs could be implemented to reduce the risk from these types of events.	Vogtle	Combine with SAMA 111.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
240	Install permanent dedicated generator for normal charging pump.	SAMA provides a means of limiting the size of a seal LOCA. The NCP can be automatically or rapidly aligned to the RCP seals from the MCR. This is an alternative approach to SAMA 226 that provided for a backup NCP, but with similar impacts. Long term secondary side cooling can be provided through the operation of the turbine driven AFW pump using existing Vogtle procedures. This arrangement would make it possible to provide adequate core cooling in extended SBO evolutions.	Vogtle	Basis for Screening: an alternate power source capable of supplying a charging pump exists. Therefore the intent of this SAMA is met with the current design. Combine with SAMA 242.	Already Implemented
241	Enhance procedures for ISLOCA response.	SAMA would provide additional confidence that the response to ISLOCAs could be implemented to reduce the risk from these types of events.	Vogtle	Basis for Screening: ECA-1.2 for a LOCA outside containment meets current industry guidance. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
242	Permanent, Dedicated Generator for the NCP with Local Operation of TD AFW after 125V Battery Depletion.	This SAMA provides a means of limiting the size of a seal LOCA and providing primary side makeup through the installation of a diesel generator that can be rapidly aligned to the NCP from the MCR. Long term secondary side cooling can be provided through the operation of the turbine driven AFW pump using existing Wolf Creek procedures. This arrangement would make it possible to provide adequate core cooling in extended SBO evolutions.	Wolf Creek	Basis for Screening: This requires a dedicated DG with auto start capability and auto transfer to meet the 13 minute criteria to prevent seal LOCA. Additionally the DG and Charging Pump lube oil cooling and seal cooling would require CCS and ERCW. The estimated cost of implementation of a dedicated DG would exceed the bounding benefit.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
243	Modify the Controls and Operating Procedures for Sharpe Station to allow for Rapid Response.	An off-site diesel generating plant (Sharpe Station) has an agreement with Wolf Creek to provide power to the site in the event that Wolf Creek experiences a Station Blackout. While the ten 2MW diesel generators have the capacity to power the emergency loads, the time to align power to WCGS is long and is not expected to be complete before 4 hours after the onset of degraded AC conditions. Providing the WCGS control room with the ability to start and align these generators to the WCGS emergency buses through the switchyard would be a means of restoring power to WCGS in non-weather related LOOP events.	Wolf Creek	The WBN site has an agreement with the nearby Hydro plant to supply power when needed per procedure TRO-TO-SOP-10.134. This facility has black-start capability and the procedure gives the highest priority to the TVA nuclear units.	Already Implemented
244	AC Cross-tie Capability.	Providing the ability to perform a timely 4kV AC cross-tie under emergency conditions would allow operators more flexibility to operate required equipment to protect the core.	Wolf Creek	Combined with SAMA 229.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase 1 Comments	Disposition
245	ISLOCA Isolation.	The current Wolf Creek PSA model does not credit operator actions to isolate ISLOCAs using available MOVs as it has not been confirmed that those valves can isolate with RCS pressure against them. The plant engineering staff estimates that the motors could move the valves to a partially closed position before exceeding the torque limit of the valve operator. From that point, it would be possible to complete the valve closure locally assuming that the valves are accessible. Ensuring that procedures direct this isolation in ISLOCA events is a potential means of addressing some of the ISLOCA scenarios (those where access is possible). Alternatively, the valves could be replaced with a type that can close against RCS pressure.	Wolf Creek	Basis for Screening: This is a Wolf Creek specific SAMA. There are no known issues with the WBN valves. Therefore this SAMA is not applicable to WBN.	Not Applicable
246	Open Doors for Alternate DG Room Cooling.	For cases when DGHVAC fails and inside air temperatures are high, the EDG room doors could be opened to provide outside air exchange cooling to the EDG rooms.	Wolf Creek	Basis for Screening: EPSIL contains instructions for opening the EDG building room doors to provide cooling. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
247	Manual Recirculation with RWST Level Instrumentation Failure.	This SAMA is specifically related to the failure of auto swap to recirculation mode due to the RWST level instrumentation. Because this instrumentation is responsible for both the auto swap signal and the annunciator that would alert the operator that recirculation mode is required, the main cue that would instigate operator action is not available. While other means of identifying the need for manual swap are available, the PSA model currently assumes that manual alignment of recirculation always fails in these scenarios because the low RWST level signal has failed. If reasonable credit is taken for the operators to use other means to diagnose the need to align recirculation mode, the importance of the level instrumentation failure is greatly reduced.	Wolf Creek	Basis for Screening: The Watts Bar design includes the capability for manual recirculation and the current EOPs require operators to monitor RWST and containment sump level. Level indication would require multiple failures to fail recirculation initiation. Therefore, the intent of this SAMA is met with the current design and procedures.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
248	Manual Recirculation with Auto Initiation Failure.	Failure to auto swap to recirculation mode can be caused by failure of the logic components responsible for governing the swap, by power failure to the logic, or other hardware failures. For the majority of these cases, a cue would be available to alert the operators of the need to swap to recirculation mode; however, no credit is currently taken for manual swap to recirculation mode after auto initiation failure due to modeling complexities. If reasonable credit is taken for the operators to align recirculation mode, the importance of the scenarios including automatic swap failure is greatly reduced.	Wolf Creek	Combine with SAMA 31.	Combined
249	High Volume Makeup to the RWST.	For SGTR, and ISLOCA scenarios where the RWST will be depleted and HPI fails or the sump will be unavailable for recirculation mode, the addition of water to the RWST will allow for continued core cooling. A hard piped connection to the FPS is a possible means of providing this capability.	Wolf Creek	Basis for Screening; Procedure EPSIL contains guidance for refilling RWST with fire water and boric acid. Therefore the intent of this SAMA is met with the current procedures.	Already Implemented
250	Additional Instrumentation in the SG to Measure Radioactivity.	Early detection of a SGTR may increase the probability of successful isolation and mitigation.	Wolf Creek	Combine with SAMA 124.	Combined

Attachment 1 Final Watts Bar Unit 2 SAMA Report

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
251	Additional Training on SGTR Accidents.	Enhanced training on detection and mitigation of SGTR scenarios may improve operator response.	Wolf Creek	Basis for Screening: The WBN operators are currently trained on SGTR scenarios in both classroom and simulator exercises. The instruction program is continually reviewed and improved, as required. While it may be possible to further improve the SGTR training program, the results of such changes would be difficult to measure using current HRA methods.	Already Implemented
252	SG Tube Inspection, Replacement.	Improved maintenance on the SG tubes may reduce the frequency of tube ruptures.	Wolf Creek	Combine with SAMAs 119 &120.	Combined
253	Install SG Isolation Valves on the Primary Loop Side.	Installation of primary side isolation valves provides an additional means of isolating and controlling an SGTR event. These valves would also eliminate the need for local action to complete a steam generator isolation after a tube rupture has occurred.	Wolf Creek	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
254	Alternate Fuel Oil Tank with Gravity Feed Capability.	EDG failures related to failure of the fuel oil transfer pumps are currently considered to be unrecoverable in the PSA model. The installation of a large volume tank at an elevation greater than the EDG fuel oil day tanks would allow for emergency refill of the day tanks in the event of fuel oil transfer pump failure.	Wolf Creek	Basis for Screening: Failure of the fuel oil transfer pumps contributes only 2% the internal event CDF based on RRW review. Improvements in the fuel oil transfer system are judged to be a minimal risk benefit. The cost of this enhancement has been estimated to be $150,000 by Wolf Creek.	Very Low Benefit

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
255	Permanent, Dedicated Generator for the NCP, one Motor Driven AFW Pump, and a Battery Charger.	This is similar to SAMA 242, but addresses the additional scenarios in which the TD AFW pump is unavailable. Increasing the capacity of the diesel generator would be required to carry the additional load of the AFW pump and a battery charger for long term SBO success. Fire Protection is not suggested as an alternate source of SG makeup given that it is a low pressure system and would not be available early in an accident.	Wolf Creek	Basis for Screening: This requires a dedicated DG with auto start capability and auto transfer to meet the 13 minute criteria to prevent seal LOCA. Additionally the DG and Charging Pump lube oil cooling and seal cooling would require CCS and ERCW. The estimated cost of implementation of a dedicated DG would exceed the bounding benefit.	Excessive Implementation Cost
256	Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.	Equipment fires have the potential to damage safety systems that are not directly related to the original equipment fires. If cables required for safety system operation are located above ignition sources or equipment to which fires may propagate, all associated safety systems depending on those cables may fail. Protecting the overhead cables or rerouting them away from equipment could reduce the consequences of fires in these areas.	Wolf Creek	Basis for Screening: The Appendix R program rerouted permanent cables and conduits as necessary, however procedure enhancements for control of temporary cable impacts on fire protection will be reviewed. This SAMA is retained for further evaluation.	Retain For Phase II Analysis

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
257	Inter-Train CCW Cross-tie for Emergency Operation.	A cross-tie between the CCW loops could increase the availability of CCW flow to cooling loads. Certain failure combinations that disable CCW could be eliminated if the use of a cross-tie valve was available to provide flow to required loads. For example, if the "A" loop CCW heat exchanger is out of service and the "B" loop of CCW has failed, the "A" loop of CCW could be used to cool the "B" loop CCW heat exchanger pending isolation of unused loads. For Wolf Creek, an entire cross-tie line with isolation valves would have to be installed, as there is no existing cross-tie.	Wolf Creek	Basis for Screening: WBN has the capability to cross-tie CCS trains, therefore this SAMA is met.	Already Implemented
258	Install DC Cross-tie Capability.	This SAMA would improve DC capability/flexibility in accident conditions.	Wolf Creek	Combined with SAMA 5.	Combined
259	Revise AOI-15 "Loss of Component Cooling Water".	Revise AOI 15, "Loss of Component Cooling Water," to facilitate stopping the RCPs on loss of CCS train A to minimize the potential for RCP seal damage due to pump bearing failure.	IPE	Basis for Screening: AOI-15 has been modified to incorporate this item.	Already Implemented
260	Improve training on loss of CCS.	In the event of a total loss of CCS, clearer guidance on the desirability of cooling down the RCS prior to a seal LOCA developing to minimize the potential for seal damage should be considered. In general, additional training on the loss of CCS initiator is suggested.	IPE	Combine with SAMA 51.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
261	Guidance to align the C-S diesel generator.	In the event of a loss of offsite power followed by the failure of both shutdown boards on one unit, the procedures would be enhanced by adding the guidance to align the C-S diesel generator (i.e., the fifth diesel generator) to one of the shutdown buses not powered in the accident sequence due to the loss of a normally aligned diesel generator. This alignment could be accommodated by including a reference to the spare diesel generator in AOI 35, "Loss of Offsite Power."	IPE	Basis for Screening: The cost to refurbish, complete and license the spare 5th DG was estimated at ~2 to 3 million in 1996. The estimated cost exceeds the bounding benefit.	Excessive Implementation Cost
262	Provide connections for centrifugal charging pumps to the ERCW system.	A potential improvement that could be evaluated is a plant change to provide connections for both centrifugal charging pumps, on both units, to the ERCW system for lube oil cooling in the event of a loss of CCS cooling to the associated pump. Currently, this capability is only available for centrifugal charging pump A on Unit 1.	IPE	Basis for Screening: The potential improvement was evaluated and there is low benefit to aligning a second charging pump to ERCW.	Very Low Benefit
263	Enhance operator training and procedures.	Enhancements to the operator training and procedures for responding to failures of support systems could potentially be beneficial, with emphasis on anticipating problems and coping.	IPE	See SAMA 151.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
264	Evaluate CCS/AFW cooling requirements.	Ventilation has been conservatively modeled in this study. Area ventilation is provided to the motor driven AFW pumps and the CCS pumps from multiple systems serving the plant elevation where these pumps are located. Beyond design basis concurrent failures of the available Unit 1 ventilation is assumed to impact the long term availability of the AFW and CCS. An evaluation of the CCS/AFW area cooling requirements could be performed which could reduce this interdependence by crediting natural convection and availability of other coolers at this plant elevation.	IPE	Basis for Screening: This SAMA was implemented in the current PRA model. Therefore this SAMA was implemented.	Already Implemented
265	Revise procedures to shed CCS loads prior to CCS heatup.	In the event of a loss of ERCW, which would eventually lead to a loss of CCS cooling, additional guidance on the relationship of CCS to ERCW and the desirability of eliminating CCS loads to extend the time of suitable CCS temperatures is a potential consideration for evaluation. This could be accomplished by revising AOI 13, "Loss of ERCW," to alert the operators to shed CCS loads prior to CCS heatup.	IPE	Combine with SAMA 53.	Combined

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
266	Provide remote-local operation of steam generator PORVs.	During a loss of all AC, the steam generator power-operated relief valves (PORV) are to be locally operated to depressurize the steam generators, thereby cooling down the RCS. The addition of provisions for remote operation of these valves could potentially be beneficial due to the high area temperatures that may be encountered.	IPE	Basis for Screening: Local manual operation in the high temperature area is no longer required due to installation of nitrogen bottles. Therefore the intent of this SAMA is met with the current design.	Already Implemented
267	Increase charging pump lube oil capacity.	In the event of a loss of CCS cooling to the charging pumps, the time available for operation of the pumps would be limited by the loss of lube oil heat exchanger cooling. To extend the time available to protect the pumps, consideration could be given to increasing the oil capacity.	IPE	Combine with SAMA 54.	Combined
268	Eliminate RCP thermal barrier cooling dependence on component cooling water.	Losses of RCP seal cooling could potentially be reduced if the RCP thermal barrier cooling dependence on component cooling water, which is required for the charging pumps that provide RCP seal injection, could be eliminated.	IPE	Combine with SAMA 156.	Combined
269	Provide 2 trains of cooling to the 480V board room.	Currently, ventilation for the 480V board room that contains the unit vital inverters is provided by one train of ventilation. The current models rely substantially on recovery actions by the operators. Consideration could be given to providing two trains.	IPE	Basis for Screening: This SAMA was implemented by a modification to provide spot cooling by the alternate train to the area where the inverters are located. Therefore this SAMA was implemented.	Already Implemented

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
270	Delay containment spray operation relative to phase B conditions.	From a severe accident point of view, one potential change, for consideration, would be the delaying of spray operations relative to the Phase B condition. Currently, containment sprays actuate immediately in response to a Phase B condition, and air return fans (ARF) actuate after a 10 minute delay. This is currently a requirement of the design basis LOCA where switchover to containment spray recirculation occurs prior to ice melt; thereby limiting pressure increases below containment design pressure. Modular Accident Analysis Program analyses of representative core damage sequences indicate that actuation of the containment sprays while ice remains in the ice condenser has little impact on severe accident containment performance and may be detrimental in that operation of the sprays rapidly depletes the inventory of the RWST, making its contents unavailable for vessel injection. Since many scenarios have successful injection but failure at recirculation, the rapid depletion of the RWST due to spray operation accelerates the time to core damage. Therefore, an evaluation balancing the severe accident versus design basis requirements could be made.	IPE	Basis for Screening: The current Watts Bar design basis calculations require sprays to initiate at containment phase B conditions. This SAMA would require reanalysis of Safety analysis, therefore it is considered cost prohibitive.	Excessive Implementation Cost

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
271	Refurbish the ERCW pumps & upgrade the capacity of the current pumps.	Improves the reliability of the ERCW pumps.	RRW Review	Basis for Screening: Unit 2 will be refurbishing and upgrading ERCW pumps as required. This SAMA is met.	Already Implemented
272	Provide a portable diesel powered 5,000 gpm pump as a backup to the ERCW system.	Improves availability of ERCW for SBO.	RRW Review	Basis for Screening: This SAMA has been implemented.	Already Implemented
273	Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	Eliminates single failure potential of RWST check valve failure to open.	RRW Review	Check valve 62-504 is a single failure point for ECCS injection and contributes 7% to CDF. The cost of a design change, new hardware and analysis may exceed the risk reduction benefit, however this SAMA will be retained for further analysis.	Retain For Phase II Analysis
274	Replace CCS pumps with positive displacement pumps.	Improves reliability of CCS system.	RRW Review	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation would exceed the bounding benefit.	Excessive Implementation Cost
275	Provide a new inverter arrangement.	Improved reliability of AC power system.	RRW Review	Basis for Screening: A design change is in process to install new inverters. Therefore the intent of this SAMA is met.	Already Implemented
276	Provide an auto start signal for AFW on loss of Standby Feedwater pump.	Improved reliability of AFW for low power events (<18%) before Main Feedwater pumps are started.	RRW Review	Incorporation of an AFW auto start signal on loss of the Standby Feedwater pump is under review. This is a low power / shutdown issue which is not quantitatively addressed in the current PRA risk model. This SAMA is retained for further evaluation.	Retain For Phase II Analysis
277	Replace shutdown board chillers.	Improved reliability of shutdown board HVAC.	RRW Review	Basis for Screening: The potential improvement was evaluated by reviewing the risk reduction worth (RRW) of the 6.9 kV board room ventilation and ventilation recovery. There is low benefit to these ventilation systems.	Very Low Benefit
278	Perform analysis to evaluate the need for ventilation to inverters, shutdown boards and ESFAS.	Eliminate dependency requirement for HVAC.	RRW Review	Basis for Screening: Analysis evaluating the need for ventilation has been performed for Unit 1 and will be updated for Unit 2. Therefore this SAMA is met.	Already Implemented
279	Provide a permanent tie-in to the construction air compressor.	Improve availability of air system.	RRW Review	The final disposition of the construction air compressor is under evaluation. This SAMA is retained for further cost-benefit evaluation.	Retain For Phase II Analysis

SAMA Number	SAMA Title	SAMA Discussion	Source	Phase I Comments	Disposition
280	Add new Unit 2 air compressor similar to the Unit 1 D compressor.	Improve availability of air system.	RRW Review	The final disposition of installing a compressor similar to the Unit 1 D compressor is under evaluation. This SAMA is retained for further cost-benefit evaluation.	Retain For Phase II Analysis
281	Replace the ACAS compressors and dryers.	Improve reliability of air system.	RRW Review	Basis for Screening: A design change to replace the ACAS compressors and dryers is in progress. Therefore the intent of this SAMA is met.	Already Implemented
282	Provide cross-tie to Unit 1 RWST.	Extend RWST capacity.	RRW Review	Basis for Screening: For a plant with significant construction already completed, the estimated cost of implementation to cross-tie the RWSTs would exceed the bounding benefit. Implementation would require analysis of technical specification implications for the opposite unit.	Excessive Implementation Cost
283	Enhance procedures for feed & bleed operation.	Improve mitigation of loss of secondary cooling.	RRW Review	Basis for Screening: Procedure FR-H1 is written to owners group guidelines and EOPs are continually updated as ERG maintenance items are issued. Operator actions required for bleed and feed operation are included on regular basis in operator requal training. The intent of this SAMA is met with the current procedures and operator training program.	Already Implemented

Table 17 Phase II Analysis Results

SAMA Number	*SAMA Title*	*Estimated Benefit*	*Estimated Cost*	*Benefit/ Cost Ratio*	*Conclusion*
4	Improve DC bus load shedding.	$ 83,399	$ 31,675	2.6	Potentially Cost Beneficial
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	$ 21,469	$ 26,773	0.8	Not Cost Beneficial
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	$ 530,264	$ 2,100,000	0.3	Not Cost Beneficial
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	$ 89,003	$ 31,675	2.8	Potentially Cost Beneficial
46	Add a service water pump.	$ 102,000	$ 1,042,511	0.1	Not Cost Beneficial
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	$ 675,053	$ 2,400,000	0.3	Not Cost Beneficial
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	$ 1,945	$ 256,204	~0	Not Cost Beneficial
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	$0	$ 1,706,586	0	Not Cost Beneficial
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	$ 121,460	$ 886,205	0.1	Not Cost Beneficial
112	Add redundant and diverse limit switches to each containment isolation valve.	$ 4,565	$ 691,524	~0	Not Cost Beneficial
136	Install motor generator set trip breakers in control room.	$ 7,397	$ 241,795	~0	Not Cost Beneficial
156	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	$ 675,053	$ 31,675	21.3	Potentially Cost Beneficial
176	Provide a connection to alternate offsite power source.	$ 42,247	$9,126,460	~0	Not Cost Beneficial
256	Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.	$ 426,340	$ 19,608	21.7	Potentially Cost Beneficial
273	Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	$ 87,379	$ 439,945	0.2	Not Cost Beneficial
276	Provide an auto start signal for AFW on loss of Standby Feedwater pump.	$ 5,926	$ 615,605	~0	Not Cost Beneficial
279	Provide a permanent tie-in to the construction air compressor.	$ 121,460	$ 909,893	0.1	Not Cost Beneficial
280	Add new Unit 2 air compressor similar to the Unit 1 D compressor.	$ 121,460	$ 814,546	0.1	Not Cost Beneficial

Table 18 RDR Sensitivity Results

SAMA Number	SAMA Title	Benefit/Cost Ratio 7% RDR	Benefit/Cost Ratio 3% RDR	Change in Conclusion
4	Improve DC bus load shedding.	2.6	4.7	No
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	0.8	1.4	Yes
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	0.3	0.5	No
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	2.8	5.1	No
46	Add a service water pump.	0.1	0.2	No
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	0.3	0.5	No
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	~0	~0	No
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	~0	~0	No
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	0.1	0.2	No
112	Add redundant and diverse limit switches to each containment isolation valve.	~0	~0	No
136	Install motor generator set trip breakers in control room.	~0	0.1	No
156	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	21	39	No
176	Provide a connection to alternate offsite power source.	~0	~0	No
256	Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.	22	39	No
273	Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	0.2	0.4	No
276	Provide an auto start signal for AFW on loss of Standby Feedwater pump.	~0	~0	No
279	Provide a permanent tie-in to the construction air compressor.	0.1	0.2	No
280	Add new Unit 2 air compressor similar to the Unit 1 D compressor.	0.1	0.2	No

Table 19 CDF/LERF Sensitivity Results

SAMA Number	*SAMA Title*	*Benefit/Cost Ratio Mean CDF*	*Benefit/Cost Ratio 95th%CDF*	*Change in Conclusion*
4	Improve DC bus load shedding.	2.6	7.4	No
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	0.8	2.2	Yes
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	0.3	0.7	No
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	2.8	7.9	No
46	Add a service water pump.	0.1	0.3	No
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	0.3	0.8	No
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	~0	~0	No
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	~0	~0	No
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	0.1	0.4	No
112	Add redundant and diverse limit switches to each containment isolation valve.	~0	~0	No
136	Install motor generator set trip breakers in control room.	~0	0.1	No
156	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	21	60	No
176	Provide a connection to alternate offsite power source.	~0	~0	No
256	Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.	22	61	No
273	Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	0.2	0.6	No
276	Provide an auto start signal for AFW on loss of Standby Feedwater pump.	~0	~0	No
279	Provide a permanent tie-in to the construction air compressor.	0.1	0.4	No
280	Add new Unit 2 air compressor similar to the Unit 1 D compressor.	0.1	0.4	No

Table 20 Evacuation Speed Sensitivity Results

SAMA Number	*SAMA Title*	*Benefit/Cost Ratio 2.2 mph Evacuation*	*Benefit/Cost Ratio 3.4 mph Evacuation*	*Benefit/Cost Ratio 1.6 mph Evacuation*	*Change in Conclusion*
4	Improve DC bus load shedding.	2.6	2.6	2.6	No
8	Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.	0.8	0.8	0.8	No
32	Add the ability to automatically align emergency core cooling system to recirculation mode upon refueling water storage tank depletion.	0.3	0.3	0.3	No
45	Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	2.8	2.8	2.8	No
46	Add a service water pump.	0.1	0.1	0.1	No
56	Install an independent reactor coolant pump seal injection system, without dedicated diesel.	0.3	0.3	0.3	No
70	Install accumulators for turbine-driven auxiliary feedwater pump flow control valves.	~0	~0	~0	No
71	Install a new condensate storage tank (auxiliary feedwater storage tank).	~0	~0	~0	No
87	Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	0.1	0.1	0.1	No
112	Add redundant and diverse limit switches to each containment isolation valve.	~0	~0	~0	No
136	Install motor generator set trip breakers in control room.	~0	~0	~0	No
156	Eliminate RCP thermal barrier dependence on CCW, such that loss of CCW does not result directly in core damage.	21	21	21	No
176	Provide a connection to alternate offsite power source.	~0	~0	~0	No
256	Install Fire Barriers Around Cables or Reroute the Cables Away from Fire Sources.	22	22	22	No
273	Provide a redundant path for ECCS suction from the RWST around check valve 62-504.	0.2	0.2	0.2	No
276	Provide an auto start signal for AFW on loss of Standby Feedwater pump.	~0	~0	~0	No
279	Provide a permanent tie-in to the construction air compressor.	0.1	0.1	0.1	No
280	Add new Unit 2 air compressor similar to the Unit 1 D compressor.	0.1	0.1	0.1	No

11 REFERENCES

AEP 2003 D.C. Cook, Units 1 & 2, Application for Renewed Operating Licenses, Appendix E, Environmental Report Appendices D - F. (ML033070190)

DUKE 2001 Applicant's Environmental Report Operating License Renewal Stage Catawba Nuclear Station Attachment H Severe Accident Mitigation Alternatives (SAMAs) Analysis May 2001 Final Report

DUKE 2001a Applicant's Environmental Report Operating License Renewal Stage McGuire Nuclear Station Attachment K Severe Accident Mitigation Alternatives (SAMAs) Analysis May 2001 Final Report

NEI 2005 Nuclear Energy Institute (NEI) Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document Revision A. NEI 05-01. November 2005.

NRC 1989 U.S. Nuclear Regulatory Commission (NRC).NUREG 1150 "Severe Accident Risks: An assessment for Five U. S. Nuclear Power Plants," June 1989

NRC 1990 U.S. Nuclear Regulatory Commission (NRC). *MELCOR Accident Consequence Code System (MACCS) - Model Description*, NUREG/CR-4691, Vol. 2, Division of Systems Research, February 1990.

NRC 1996 Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS)

NRC 1997 U.S. Nuclear Regulatory Commission (NRC). 1997. Regulatory Analysis Technical Evaluation Handbook. NUREG/BR-0184.

NRC 1998 U.S. Nuclear Regulatory Commission (NRC).*Code Manual for MACCS2*, NUREG/CR-6613, Vol. 1, prepared by D. Channing and M. L. Young, Division of System Research, May 1998

NRC 2007 WinMACCS, a MACCS2 Interface for Calculating Health and Economic Consequences from Accidental Release of Radioactive Materials into the Atmosphere. User's Guide and Reference Manual WinMACCS Version 3, July 2007

SAIC 2007 Science Applications International Corporation. "Watts Bar Nuclear Plant Severe Reactor Accident Analysis", May 30, 2007

SNC 2007 Vogtle, Units 1 and 2, License Renewal Application (ML071840360, ML071840357)

TVA 1992 "Watts Bar Nuclear Plant Unit 1 PRA Individual Plant Exam." (ML080090324)

TVA 1998 "Watts Bar Nuclear Plant (WBNP) Individual Plant Evaluation of External Events (IPEEE) Final Report

TVA 2006 Tennessee Multi-Jurisdictional Radiological Emergency Response Plan for the Watts Bar Nuclear Plant, Annex H

WCNOC 2006 "Wolf Creek Generating Station, Applicant's Environmental Report; Operating License Renewal Stage," September 2006, (ML062770305)

Enclosure 2
WBN Unit 2
Listing of Open Actions Required for Licensing

1. Prior to fuel load, evaluate the potential for procedural enhancements in the Station Blackout procedures to shed additional loads to extend battery life (SAMA 4).

2. Prior to fuel load, provide procedural enhancements in AOI-15 to cross-tie Component Cooling Water (CCS) trains and Emergency Raw Cooling Water (ERCW) trains (SAMA 45).

3. Prior to fuel load, provide procedural enhancements in AOI-15 for loss of CCS to connect ERCW to supply the thermal barrier coolers (SAMA 156).

4. Prior to fuel load, provide procedural enhancements for the procedure controlling temporary alterations to reduce fire risk from temporary cables (SAMA 256).

5. Prior to fuel load, expand operator training to include response to loss of two 120-V AC buses (SAMA 8).