APPENDIX F. SEVERE ACCIDENT MITIGATION ALTERNATIVES (SAMAs)

F.1 NMP PRA MODELS AND RISK PROFILES

F.1.1 PRA MODEL BACKGROUND

The Nine Mile Point Units 1 & 2 (NMP) Probabilistic Risk Assessment (PRA) was initiated in response to Generic Letter 88-20, which resulted in Individual Plant Examination (IPE) and IPE for External Events (IPEEE) analyses (Refs. F.1-1 through F.1-4). The updated Unit-specific PRAs (PRA01B) are consolidated models that include internal and external initiating events (consolidates IPE and IPEEE studies into a single PRA model) for power operation. Each is a Level 2 PRA that includes both internal and external events. This means that severe accident sequences have been developed from internally and externally initiated events, including internal and external floods, internal fires, and seismic events. Also, Level 2 means that the sequences have been developed to the radiological release end state (e.g., source term release to environment).

Changes made to the models since the original IPE/IPEEE submittals include:

- Incorporation of changes to maintain the PRA models current with Unit design and operation, including plant-specific data for initiating events and equipment unreliability and unavailability.
- Incorporation of insights from the Boiling Water Reactor Owners' Group (BWROG) certification review and U.S. Nuclear Regulatory Commission (NRC) staff evaluations of the IPE and IPEEE submittals. Resolution of these comments is documented in the PRAs. There was no review observation that had a significant impact on the original IPE findings.
- Incorporation of insights from applications of the PRAs. During applications (e.g., online risk management, significance determinations, risk-informed decisions), modeling improvements are identified and included in the next update where practical and important.

While these changes have updated and improved the quality of the model, the overall conclusions of the IPE/IPEEE have not changed significantly. The following summarizes the IPE and IPEEE results, the first update results after consolidation of the IPE and IPEEE (U1PRA99 and U2PRA98), and the current PRA (PRA01B) results:

Unit Risk	IPE/IPEEE Results			U1PRA99/U2PRA98			U1/U2PRA01B (current)		
	IPE	IPEEE	Total	Internal	External	Total	Internal	External	Total
Unit 1 CDF	5.5E-6	2.3E-5	2.8E-5	1.3E-5	1.4E-5	2.7E-5	1.2E-5	1.4E-5	2.7E-5
Unit 1 LERF	6.9E-7	3.3E-6	4.0E-6	1.4E-6	8.4E-7	2.3E-6	1.3E-6	8.4E-7	2.2E-6
Unit 2 CDF	3.1E-5	~2E-6	3.3E-5	4.7E-5	6.8E-6	5.4E-5	5.7E-5	4.2E-6	6.2E-5
Unit 2 LERF	8.0E-7	~1E-7	9.0E-7	1.1E-6	3.9E-7	1.5E-6	9.8E-7	2.5E-7	1.2E-6

CDF = core damage frequency
LERF = large early release frequency

F.1.1.1 NMPNS Unit 1 Major Model Changes

Nine Mile Point Nuclear Station, LLC (NMPNS), has made significant changes over the years since the IPE/IPEEE, as mentioned above, due to numerous improvements to the model, including the incorporation of plant data and more detailed modeling. No major changes have been made to the Level 2 evaluations. The following summarizes the major changes to the Unit 1 PRA since the IPE and IPEEE analyses were performed:

1. Added several initiating events to improve completeness. These were support systems failures that do not necessarily cause an automatic plant trip, but they put the plant in a short allowed outage time that could require manual shutdown without the failed support system. These contributed to an increase in the core damage frequency (CDF).

2. Updated and improved reactor pressure vessel (RPV) overfill modeling to be consistent with unit modifications to reduce the probability of the event.

3. Improved modeling of “Loss of Instrumentation” scenarios, which were optimistically neglected in the IPE. This contributed to an increase in CDF.

4. Improved modeling of containment heat removal recovery, which was conservatively neglected in the IPE. This tended to reduce CDF.

5. The addition of external events to the PRA improved the modeling from the IPEEE and resulted in a reduction in external risk.

F.1.1.2 NMPNS Unit 2 Major Model Changes

The following summarizes major changes to the Unit 2 PRA since the IPE and IPEEE analyses were performed:

1. Revised and improved the station blackout model based on updated human reliability evaluations and the desire to evaluate potential plant modifications to reduce this risk. This risk has increased during each update. First, the loss of offsite

power (LOOP) initiating event probability increased (U2PRA98) as a result of plant-specific events. Then, the credit given to crosstie Division III to Division I or II was found to be optimistic during the U2PRA01B update. The contribution from external events was improved during the U2PRA01B update as a result of improved modeling.

2. Improved modeling of the safety relief valves (SRVs) to allow recovery of dominant failure modes (long term nitrogen supply from outside the drywell). This led to a reduction in the large early release frequency (LERF) during the U2PRA01B update.

3. Improved modeling of containment heat removal recovery, which was conservatively neglected in the IPE. This tended to reduce CDF.

4. Added more detailed modeling of electrical switchgear to improve the modeling of dependencies. This had a relatively minor impact on risk during U2PRA98.

5. Added more detailed modeling of service water and improved the success criteria. This resulted in an improvement in CDF during U2PRA98.

6. Added external events to the PRA. This improved the modeling from the IPEEE and resulted in an increase in external risk during the U2PRA98 update. The estimates presented in the IPEEE without the benefit of the PRA were underestimated.

F.1.2 MODEL COMPLETENESS

The NMP PRAs have been under continuous development since the IPE and IPEEE studies were initiated. As described previously, the PRA is a consolidation of internal and external events analyzed for power operation in support of the IPE and IPEEE development. Potential technical update items are tracked on a list that is used as a checklist for applications. The items on the list were checked for their potential impact on this application. No major impacts were identified.

In addition, shutdown PRA models (SDPRA) have been under development for both Units. NMPNS has completed a Unit 2 SDPRA model and the Unit 1 SDPRA is under development. Modeling completeness can be viewed from three perspectives:

1. Plant Initiating Event

2. PRA End State

3. Plant Operating Mode

There are no major completeness issues identified with the present PRA models. The following summarizes the present state of model development:

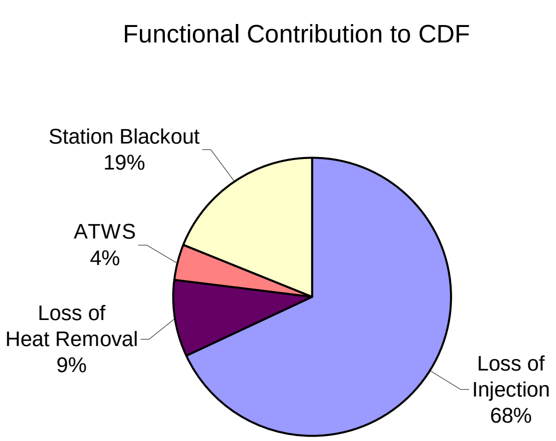
Plant Initiating Event	PRA End State	Plant Operating Mode					
		1	2	3	4	5	SFP
Internal (transient, LOCA)	Level 1 – Core Damage	PRA	PRA	Note 1	SDPRA	SDPRA	Note 3
	Level 2 – Cont. Release	PRA	PRA	Note 1	Note 2	Note 2	Note 3
External (seismic, fire, flood)	Level 1 – Core Damage	PRA	PRA	Note 1	Note 2	Note 2	Note 3
	Level 2 – Cont. Release	PRA	PRA	Note 1	Note 2	Note 2	Note 3

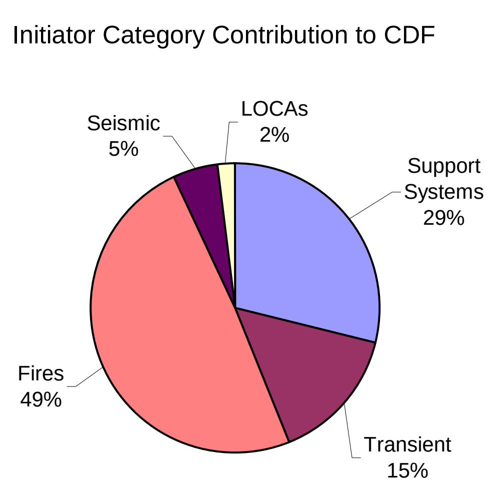
1. Generally, power operation (Plant Operating Mode 1) envelopes Modes 2 and 3. The likelihood of an anticipated transient without scram (ATWS) and other severe transients is reduced, technical specifications are not significantly different, and the time spent in Modes 2 and 3 is much less. The PRA is conservatively used while in Mode 3 until residual heat removal (RHR) shutdown cooling (SDC) is aligned and after SDC is secured during startup. Otherwise, the SDPRA applies when SDC is in operation.
2. The SDPRA models Level 1 internal events for Plant Operating Modes 4 and 5. External events and Level 2 modeling may be added to the SDPRA in the future.
3. The risk attributed to the fuel in the spent fuel pool (SFP) is enveloped by the SDPRA. It is not presently in the SDPRA, but additional modeling could be considered later.

F.1.3 NINE MILE POINT UNIT 1 RISK PROFILE

The estimated Unit 1 CDF is 2.7E-5 per year. This is the output of the Level 1 analysis and represents the frequency at which core integrity is challenged due to a severe accident.

Contributors to (or causes of) core damage can be presented in numerous ways utilizing the PRA model. For example, the importance of equipment, systems, and human actions can provide insights, presented in the form of pie charts, to contributions from a functional or initiator perspective. The following figures provide high level results, showing how safety functions [e.g., sequences associated with reactivity control failure that lead to anticipated transients without scram (ATWS)] and initiating event categories contribute to CDF.



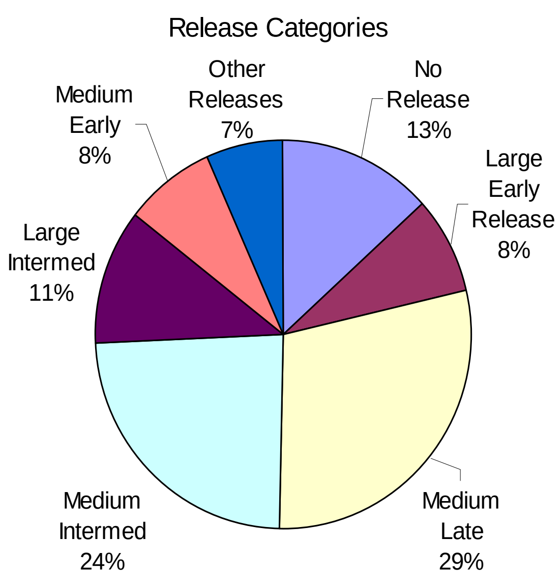


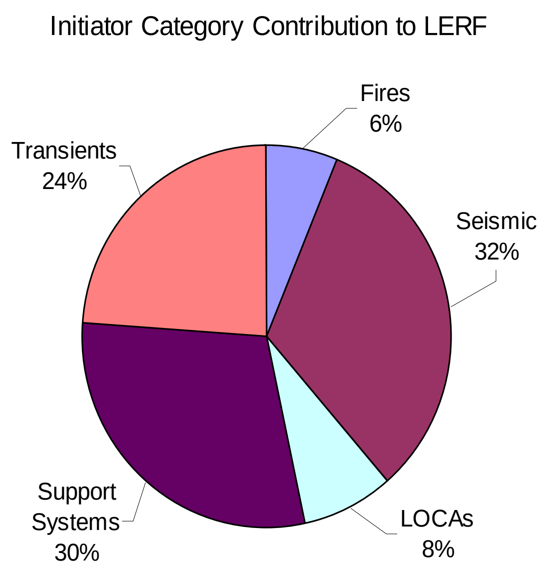
As shown, fires are the dominant initiating events (49 percent). Fire events also dominate the loss of injection function. Typical of older plants like Unit 1, external hazards such as fires tend to dominate and internal events, such as transients and loss of coolant accidents (LOCAs), are less important.

Seismic initiating event risk is dominated by the 0.3g high confidence low probability of failure (HCLPF) seismic screening level.

LOOP is the most important support systems initiating event (approximately nine percent of CDF), and station blackout sequences dominate. Loss of instrument air (approximately five percent of CDF) is another important loss of support systems initiating event. It is assumed to cause main steam isolation valve (MSIV) closure and the potential for overfilling the RPV. Dominant sequences are the result of emergency condenser (EC) isolation during RPV overfill; it is assumed EC actuation occurs with water in the EC lines. Operator actions are important for the loss of instrument air sequences [failure to recover an EC, failure to open condensate storage tank (CST) water supply to condenser hot well in support of feedwater, and failure to emergency depressurize for core spray].

The Level 2 analysis investigates the sequences that comprise the contributors to CDF and determines their potential impact on containment performance. The containment event tree (CET), with input from thermal-hydraulic analyses and structural analyses, is used to model the response of the containment to the Level 1 accident sequences. The LERF is an indicator of containment performance from the Level 2 results because the magnitude and timing of these releases provide the greatest potential for early health effects to the public. The frequency calculated is approximately 2.2E-6 per year. The following figures summarize the Level 2 results.





As shown above, LERF represents a small fraction (eight percent) of all release end states. Seismic events (32 percent of LERF) are dominated by the 0.3g HCLPF seismic screening level, which is assumed to cause containment failure. ATWS (approximately 13 percent of LERF) is the largest portion of transient LERF risk. LOOP (approximately 10 percent of LERF) and loss of instrument air (approximately 7 percent of LERF), which are included in the support systems initiator category, are the next most important LERF initiators and are discussed above for CDF.

Plant trip and subsequent station blackout (approximately seven percent of LERF) are also important contributors that are contained in the transient initiator category. Contributors to this event include common-cause failure of batteries on demand and then failure of emergency alternating current (AC) power due to operator failure to control loads (transformers become overloaded and fail).

Interfacing system LOCA (ISLOCA) only contributes approximately six percent to LERF. Operator actions to provide long-term makeup from external water sources (fire water or containment spray raw water) are important.

IMPORTANCE ANALYSIS RESULTS

The risk reduction worth (RRW) importance measure is a methodology to determine relative failure probability and risk improvement. It describes the decrease in risk (CDF, LERF) when a system or component is set to guarantee success (e.g., a significant improvement in reliability and availability is made to reduce risk). RRW has a value $\geq$1.0. When it is multiplied by the baseline CDF or LERF and then the baseline quantity subtracted, the fraction of CDF or LERF reduction is provided. For example, an RRW value of 1.1 is indicative of a 10 percent reduction of risk; therefore, the higher the RRW, the greater the potential for reduction of risk, making it a useful tool for investigating cost beneficial improvements in reliability and availability. It is also useful for ranking the relative significance of risk contributors.

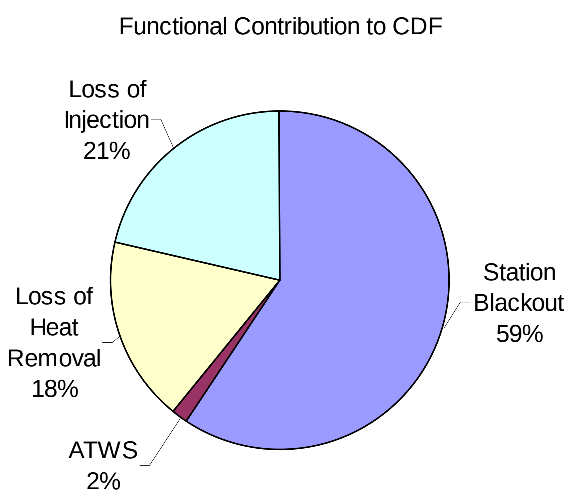
Utilizing the RRW methodology, the following two tables provide the rankings of the top five (5) risk-significant systems or functions, and operator actions for Unit 1 CDF and LERF.

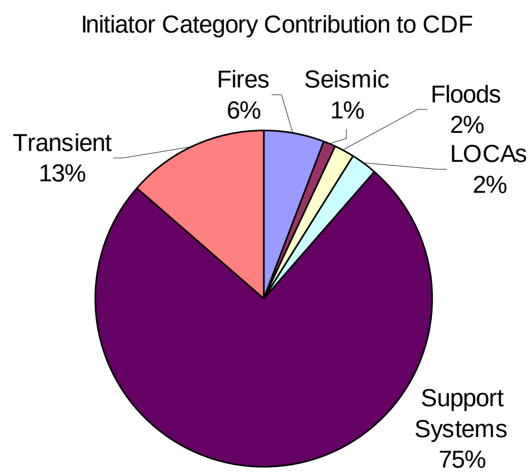
System or Function	RRW Rank	
	CDF	LERF
AC Power	1	4
Firewater	2	
Reactor Recirc Seals	3	5
LOOP/EDG recovery	4	
Relief Valves Close	5	
Seismic Fragility		1
RPS Scram Function		2
DC Power		3

Operator Action	RRW Rank CDF	RRW Rank LERF
East/West Instrument Room (SOP-14)	1	
Load Shed to Protect Transformer	2	1
Late injection after containment failure	3	
Emergency Depressurize RPV	4	3
Feedwater (loss of air)	5	2
Shed DC loads during station blackout		4
ATWS Response		5

F.1.4 NINE MILE POINT UNIT 2 RISK PROFILE

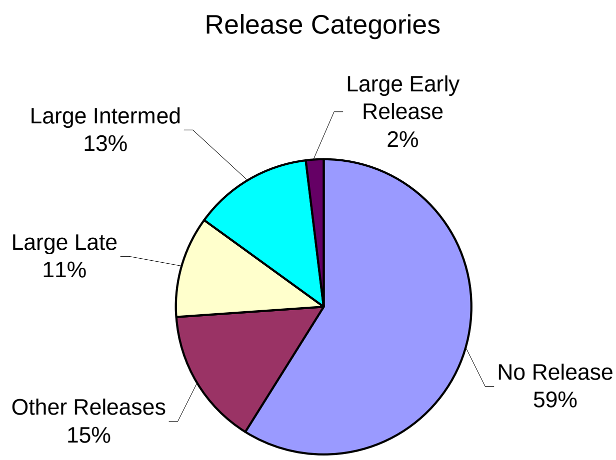
The estimated Unit 2 CDF is 6.2E-5 per year. The contributors to Unit 2 risk are presented in a similar fashion as for Unit 1. The figures below provide the Unit 2 high level results, showing how safety functions and initiating event categories contribute to CDF.

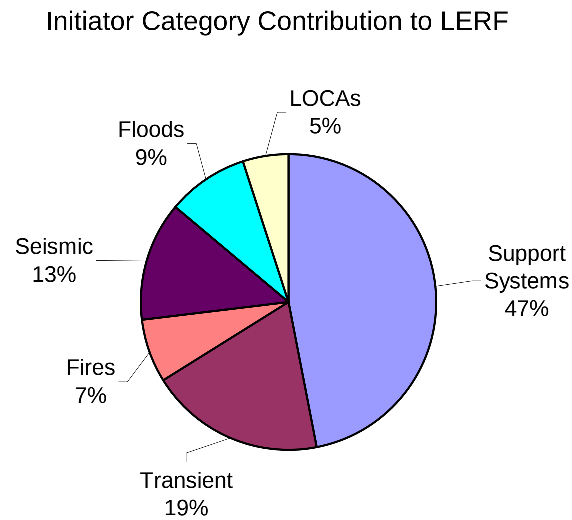




Station blackout (59 percent of functional contribution) and support systems failures (75 percent of initiator category contribution) are the dominant initiating events. As expected, they are also important contributors to the loss of injection and heat removal functions. Typical of more recently designed plants like Unit 2, external hazards do not contribute in a significant way, rather support systems tend to dominate. LOOP is the most important support systems initiating event (approximately 59 percent of CDF). Station blackout sequences dominate.

The Level 2 analysis investigates the sequences that comprise the contributors to CDF and determines their potential impact on containment performance. The results of the Level 2 analysis define the release frequencies. LERF is a key indicator of containment performance from the Level 2 results. The Unit 2 LERF is approximately 1.2E-6 per year. The following figures summarize the Level 2 results.





As shown above, LERF represents a small fraction (i.e., two percent) of all release end states. Similar to CDF, support systems failures are important contributors (47 percent) to LERF. ISLOCA only contributes approximately 0.15 percent to LERF.

IMPORTANCE ANALYSIS RESULTS

Utilizing the RRW methodology, the following two tables provide the rankings of the top five (5) risk-significant systems or functions, and operator actions for Unit 2 CDF and LERF.

System or Function	RRW Rank	
	CDF	LERF
AC Power	1	1
RCIC	2	2
HPCS	3	3
RHR A & B	4	
Containment Failure	5	
Containment Isolation		4
Seismic Fragility		5

Operator Action	RRW Rank	
	CDF	LERF
SBO – align HPCS bus to Div I or II	1	2
Emergency Depressurize RPV	2	3
Vent Containment	3	
RCIC – prevent high temperature trips	4	
Manual initiation of ECCS	5	
Containment Isolation during SBO		1
Flood in Control Bldg – mitigation		4
ATWS – restore feedwater		5

F.1.5 SAMA DEVELOPMENT AS A FUNCTION OF THE RISK PROFILE

A discussion of the Unit features and how they affect the risk profile and the selection of SAMAs is included in the following two sections.

F.1.5.1 UNIT 1 SAMA Development from the Risk Profile

The following summarizes the risk profile review to identify plant-specific SAMAs for Unit 1:

Initiating Events

Fires are the most important contributors to CDF. The following initiating events contribute 10 percent or more to CDF:

- FT3B1 (14 percent) – Fire, Turbine Building, Elevation 261, South due to a dry transformer. A potential alternative to reduce this risk is postulated for detailed analysis (retained for SAMA evaluation). The transformer could be moved or protection provided. Also, see improved operator actions below.
- FT3B3 (10 percent) – Fire, Turbine Building, Elevation 261, South due to a panel. A potential alternative to reduce this risk is postulated for detailed analysis (retained for SAMA evaluation). The panel could be moved or protection provided. Also, see improved operator actions below.

Ways to reduce the above risk are retained as SAMA U1-210 in Section F.3.1.

Seismic events are important contributors to radionuclide release (32 percent of LERF). While important to LERF, it is judged to not warrant further evaluation because seismic events are relatively low contributors to CDF and because several components were screened close to the 0.3g HCLPF screening value. Since the plant screening fragility (0.3g HCLPF) dominates seismic risk (assumed to cause core damage), it would be costly to improve the fragility of the plant. In addition, significant new costly analysis would be required to determine whether and where seismic capacity could be improved and cost of modifications are projected to be very high. Therefore, this was not pursued further.

Functional Importance

Station blackout is an important contributor to risk (19 percent of CDF); therefore, the availability and reliability of offsite power and emergency diesels is known to be important. This risk is managed as part of the online risk management process (a requirement of the Maintenance Rule, i.e., 10 CFR 50.65). As a result of the implementation of this requirement, NMPNS has successfully obtained approval from the NRC for a risk-informed Unit 1 technical specification change to extend the allowed outage time for emergency diesels to 14 days. This application was successful with risk management actions (compensating measures) and without the need for plant improvements (no cost-effective improvements were identified beyond the online risk management process). Still, SAMAs U1-209, -211, and -215, which would reduce station blackout risk, were identified for further evaluation.

Equipment Importance

The following equipment contributes five percent or more to CDF:

- Diesel firewater pump, PMP-100-02 (21 percent) – a crosstie to the Unit 2 fire water supply is not credited in the Unit 1 PRA, but is in present procedures and credited as a compensating measure during online maintenance. Thus, additional measures to reduce this risk can be assumed to be already in place.
- Reactor recirculation pump seals, ZZNSL (16 percent) – this risk is from the probability of a pump seal LOCA, which prevents the emergency condensers from providing successful safe shutdown. However, Unit 1 has installed improved seals, there is sufficient monitoring capability, and no further cost-effective modifications have been identified. Additional training on loss of reactor building closed loop cooling (RBCLC) is being retained for SAMA evaluation (SAMA U1-4).

Human Actions

The following human actions contribute five percent or more to CDF:

- Use of East/West Instrument Room and SOP-14, ZHRA1 (26 percent), during fire scenarios (see important fire initiators above). Feedwater and the main condenser are available or emergency condensers are available with long-term makeup (either is a success path). However, emergency AC power is lost and instrumentation is lost when the direct current (DC) batteries discharge, which requires use of the instrument room. Improved training and procedures is retained for SAMA evaluation (SAMA U1-209).
- Manage AC Loads to Protect Emergency AC Transformer (4kV to 600V), ZAA01 (17 percent), given loss of normal AC power (power board 11 or 12). Potential modifications to improve training and procedures or provide new transformers are retained for SAMA evaluation (SAMA U1-220).

- Late Injection after Containment Failure, ZCF01 (six percent). These scenarios occur very late with RPV inventory control initially successful; injection fails when containment fails due to overpressure. The more recent severe accident procedures (SAP, Revision 2 for Unit 1; SAP, Revision 0 for Unit 2) are judged to have added improvements since the IPE (operator reliability has not been re-evaluated in the PRA).
- Emergency Depressurize RPV, ZOD01 (six percent), given that RPV inventory level cannot be maintained without depressurization. This operator action is recognized as important; it is clear in the emergency operating procedures (EOPs), and is included in training. No further improvements are deemed cost-beneficial.
- Use of East/West Instrument Room and SOP-14, ZHRA4 (six percent), during fire scenarios (see important fire initiators above) and station blackout. This is similar to ZHRA1 above except, in this case, inventory control is successful but heat removal is not available at least in the long term. A modification to improve training and procedures is retained for SAMA evaluation (SAMA U1-209).
- Align CST makeup to main condenser to support feedwater, ZFW01 (five percent), given loss of instrument air. A modification to improve training and procedures is retained for SAMA evaluation (SAMA U1-222).

F.1.5.2 Unit 2 SAMA Development from the Risk Profile

The following summarizes the risk profile review to identify plant-specific SAMAs for Unit 2:

Initiating Events

LOOP is the most important contributor to CDF (59 percent). Reviews conducted to identify means to reduce this risk are described under the Functional Importance discussions below.

Functional Importance

Station blackout is the most important contributor to CDF (59 percent). The following potentially cost-effective improvements have been identified as part of a draft evaluation in support of an emergency diesel generator (EDG) allowed outage time risk informed technical specification application and are retained for SAMA evaluation (SAMAs U2-215 through -217):

- A piping modification that provides an opportunity to align fire water to the RPV through RHR within 30 minutes of a station blackout is retained for SAMA evaluation (SAMA U2-216). This capability and the operator action are modeled in PRA top event S1. The equipment, including fire water pumps from both Units 1 and 2, is modeled in PRA top event FPW and is unchanged.

- An electrical modification that includes a portable charger with the following capabilities is retained for SAMA evaluation (SAMA U2-215):
  - Supply either Division I or II DC switchgear and charge its battery. This allows the plant to cope without AC power beyond eight hours. The most important and immediate action would be to supply DC to safety relief valves (SRVs) allowing diesel fire pump to provide makeup and availability of instrumentation. This includes PRA top events PCH (portable charger equipment) and OPCH (operator action to align portable charger more than two hours after station blackout).
  - Supply 120V AC to 2IAS*SOV164 (165) to allow opening nitrogen supply from 2IAS*TK4 (5) to the SRVs. This allows use of SRVs and diesel fire water beyond 12 hours. This is credited for station blackout and non-station blackout scenarios. PRA top event OSVL (operator recovers tanks 4/5 to SRVs) models this operator action in the station blackout model. PRA top event SVLR (recovery of long term nitrogen to SRVs) models this action in the non-station blackout model. These are long-term actions required after event OPCH success.
  - Supply 120V AC to 2CPS*SOV109 and 2CPS*SOV133. This allows operators to open 2CPS*AOV109 inside the drywell and align containment venting, further extending the coping time beyond 24 hours. This is credited for station blackout and non-station blackout scenarios. PRA top event OCV (operator manually vents containment) models this operator action in the station blackout model. PRA top event R1 models this action in the non-station blackout model. These are long-term actions required after OPCH and OSVL success.

Equipment Importance

The following equipment contribute five percent or more to CDF:

- AC power recovery (>50 percent) – this is based on data rather than equipment reliability. However, the proposed modifications for station blackout will also reduce the importance of recovery.
- Division I EDG (approximately 40 percent) including unit coolers. The following summarizes the key basic events:

Basic Event	Fraction of CDF
HVPHCZXUC1AXXXL5 Div I EDG	0.25
HVPFFZXUC1AOMXRD Div I EDG	0.06
[EGSGAZXEG1XXXXS1] Div I EDG	0.05

About 25 percent of the CDF is associated with unit cooler plugging as a result of testing flow every five years by procedure. Reduction of this contribution is retained for SAMA evaluation (SAMA U2-221).

- Division II EDG (approximately 40 percent) including unit coolers.

Basic Event	Fraction of CDF
HVPHCZXUC1BXXXLC Div II EDG	0.15
HVPFFZXUC1BOMXRD Div II EDG	0.09
[EGSGAZXEG3XXXXS1] Div II EDG	0.07
[EGSGAZXEG3XXXXR2] Div II EDG	0.06

About 15 percent of the CDF is associated with unit cooler plugging as a result of testing flow every cycle by procedure. Reducing this contribution is retained for SAMA evaluation (SAMA U2-221).

- Reactor Core Isolation Cooling (RCIC) (>30 percent).

Basic Event	Fraction of CDF
ICSPT1XP1XXXXXRD RCIC	0.09
ICSPT1XP1XXXXXS2 RCIC	0.07
ICSPT1XP1XXXXXS3 RCIC	0.07
ICSPT1XP1XXXXXS1 RCIC	0.07

RCIC unavailability is partly the result of equipment failures in Unit 2 (plant-specific experience). NMPNS has been working to improve the reliability of RCIC as a function of Maintenance Rule requirements relative to those events. In addition, the three start failures shown to contribute to RCIC unreliability are the result of system modeling. It is assumed the system will cycle a few times to Level 8 (system trips on high level) and Level 2 (system restarts on low level). However, if starts 2 and 3 were removed from the model, manual control operator actions would have to be added to the model. If the operator action failure probability is lower than the start failures, risk could be reduced. Additional training on this aspect of plant operation is not judged risk important. Implementing the diesel firewater piping modification (SAMA U1-216) would reduce RCIC importance.

One basic equipment-related event was identified that contributes more than five percent to LERF but was not identified as a significant contributor to CDF. Mechanical failure of control rods to scram contributes approximately 14 percent to LERF. No additional improvements were identified to improve this reliability.

Human Actions

The following human actions contribute five percent or more to CDF:

- AC Power recovery (>50 percent) – this is based on data rather than equipment reliability. However, the proposed modification for station blackout will also reduce the importance of recovery (SAMA U2-214).

- High Pressure Core Spray (HPCS) Crosstie to Div I or II (47 percent) – ways to improve this capability were identified as part of the EDG allowed outage time evaluations and discussed previously under functional importance. This procedure takes a significant amount of time and the likelihood of success is not high in scenarios where RCIC is unavailable. Rather than pursue this improvement, the proposed modifications described above were identified as a more viable approach (SAMA U2-218 is considered to evaluate potential benefit of improving this capability and to ensure the cost effectiveness of a modification is considered).
- Emergency Depressurization (10 percent), given that RPV inventory level cannot be maintained without depressurization. This operator action is recognized as important; it is clear in the EOPs, and is included in training. No further improvements are deemed cost-beneficial.

An additional operator action was identified for mitigation of an event that contributes more than five percent to LERF yet was not identified as a significant contributor to CDF. This event is flooding of the control building, which contributes more than eight percent to LERF. Reducing this contribution is retained for SAMA evaluation (SAMA U2-223).

F.1.6 PRA MODEL UNCERTAINTY PROFILE

Although an uncertainty distribution has not been created for CDF and LERF, uncertainty is considered in the model development and risk applications. As discussed in Regulatory Guide 1.174, PRA analyses must consider three types of uncertainty: parametric, model, and completeness.

Parametric uncertainty deals with the statistical variance of data used as input to the PRA model. This variance is included as distributions for inputs (e.g., basic events) in the model database. Since these distributions are included in the model, with some effort, uncertainty in individual inputs can be propagated through the model to obtain a distribution for CDF, LERF, or any sequence. This has not been done because:

- The greatest value is obtained by using the uncertainty thought process in establishing basic event distributions before settling on the mean value. This has been accomplished and provides the basis for the baseline models and point estimates of risk. This parametric uncertainty provides the basis for propagation uncertainty in CDF and LERF. The value associated with propagating these uncertainties for CDF and LERF has not been established (see below).
- Most applications to date have utilized a delta risk calculation that involves the comparison of a base model and a model that includes specific changes. Propagating uncertainty, particularly for a delta risk evaluation, has even more limited value and is not necessary. It is reasonable to assume that the variance in the base quantification of the models is unchanged for most change in risk applications. For example, comparison of the mean values of a base model with a change altered model results in a specific change in risk value. A similar comparison between the 95 percent values of the quantified models is not expected

to affect the conclusion unless a major change aimed at reducing uncertainty is proposed. In this case, uncertainty and/or sensitivity analyses would have to be considered to support risk management decision-making.

- Sensitivity analysis and changes in importance are used to investigate uncertainty.

Model uncertainty can be more difficult to deal with in a quantitative manner because it involves the completeness of the state of knowledge used to build the model. Modeling assumptions are best addressed with sensitivity analyses, which are a common part of risk management decision-making. In addition, compensating measures and conservatism are used many times when dealing with modeling issues.

Completeness uncertainty is another difficult area to deal with quantitatively. This issue deals with aspects of plant design or operation that have not been included in the model. The NMP models have evolved over several years, incorporating insights from outside reviews (e.g., NRC and BWROG). There are no known issues of completeness relative to identified plant failure modes.

F.2 MELCOR ACCIDENT CONSEQUENCES CODE SYSTEM MODELING

This section of Appendix F describes the assumptions made and the results of modeling performed to assess the risks and consequences of severe accidents (U.S. Nuclear Regulatory Commission, Class 9).

The Level 3 analysis was performed using the Melcor Accident Consequences Code System (MACCS) 2 code (Ref. F.2-1). MACCS2 simulates the impacts of severe accidents at nuclear power plants upon the surrounding environment. The principal phenomena considered in MACCS2 are atmospheric transport, mitigative actions based on dose projections, dose accumulation by a number of pathways including food and water ingestion, early and latent health effects, and economic costs. Input for the Level 3 analysis includes the reactor core radionuclide inventory, source terms from NUREG/CR-4467, site meteorological data, projected population distribution (within a 50-mile radius), emergency response evacuation modeling, and economic data. These inputs are described in the following section.

F.2.1 INPUT DATA

The input data required by MACCS2 are outlined below.

F.2.1.1 Core Inventory

NMPNS calculated the core inventory activity for fission products and actinides for the purpose of developing sources for use in dose calculations. Only the nuclides considered important to offsite dose were assumed to be those included in the core inventory. Any daughter product not so listed was considered a psuedo-stable nuclide and the decay chains were truncated. It was also assumed that the reactor would be shut down at accident initiation for all releases; therefore, NMPNS used end of cycle shutdown core activity levels.

The core inventory for each Unit was based upon values in Table A-1 of NUREG/CR-4467 for a 3,578 megawatts-thermal (MWt) boiling water reactor and scaled to 1,850 MWt for Unit 1 and 3,467 MWt for Unit 2 (Ref. F.2-2, page 17). The reference core inventory data are presented in Table F.2-1.

This assumes that the activity level to thermal power relationship is linear. A 10 percent activity increase was assumed in a sensitivity case (see Section F.2.3) to bound any uncertainties associated with the non-linear characteristics related to this assumption.

F.2.1.2 Meteorological Data

The meteorological data input file consists of 8,760 weather data sets representing one year of hourly recordings of wind direction, wind speed, atmospheric stability, and accumulated precipitation. Multiple years (1985-2001) of NMP meteorological data

TABLE F.2-1

REFERENCE CORE INVENTORY FOR A 3,578 MWT BOILING WATER REACTOR

Nuclide	Activity (bqs)	Nuclide	Activity (bqs)
Co-58	2.02E+16	Ru-103	4.88E+18
Co-60	2.42E+16	Ru-105	3.25E+18
Kr-85	3.32E+16	Ru-106	1.33E+18
Kr-85m	1.21E+18	Rh-105	2.43E+18
Kr-87	2.19E+18	Sb-127	3.08E+17
Kr-88	2.96E+18	Sb-129	1.07E+18
Xe-133	7.18E+18	Te-127	2.98E+17
Xe-135	1.71E+18	Te-127m	4.01E+16
I-131	3.42E+18	Te-129	1.00E+18
I-132	5.02E+18	Te-129m	2.63E+17
I-133	7.17E+18	Te-131m	5.06E+17
I-134	7.85E+18	Te-132	4.94E+18
I-135	6.75E+18	Ba-139	6.62E+18
Rb-86	1.86E+15	Ba-140	6.52E+18
Cs-134	5.59E+17	La-140	6.66E+18
Cs-136	1.50E+17	La-141	6.14E+18
Cs-137	3.35E+17	La-142	5.92E+18
Sr-89	3.67E+18	Ce-141	5.92E+18
Sr-90	2.60E+17	Ce-143	5.76E+18
Sr-91	4.77E+18	Ce-144	3.84E+18
Sr-92	5.00E+18	Pr-143	5.64E+18
Y-90	2.78E+17	Nd-147	2.52E+18
Y-91	4.48E+18	Pu-238	5.23E+15
Y-92	5.00E+18	Pu-239	1.32E+15
Y-93	5.70E+18	Pu-240	1.66E+15
Nb-95	5.58E+18	Pu-241	2.86E+17
Zr-95	5.90E+18	Np-239	7.52E+19
Zr-97	6.08E+18	Am-241	2.90E+14
Mo-99	6.44E+18	Cm-242	7.67E+16
Tc-99m	5.55E+18	Cm-244	4.14E+15

bqs = becquerels (1bqs = 2.7E-11 curies) were summarized and reviewed to determine a representative year. The 1994 data set was chosen with the 2001 data set as an alternate. Both years were "average" for items of interest with no extremes in the annual averages or joint frequency distributions. However, some observations were missing due to natural events, broken sensors, etc. The missing data were filled using various techniques including substitution of alternate data (e.g., data from backup meteorological tower, data from alternate measurement levels, interpolation between data points).

F.2.1.3 Emergency Response

To determine the appropriate emergency response assumptions, NMPNS reviewed Evacuation Travel Time Estimates for the James A. Fitzpatrick/Nine Mile Point Emergency Planning Zone (Ref. F.2-3) and the New York State Radiological Emergency Preparedness Plan (Ref. F.2-4) coupled with local geographic and demographic characteristics. NMPNS chose evacuation routes to move traffic generally in a radial direction away from the NMP site in accordance with NUREG-0654 criteria, so the appropriate MACCS2 evacuation model is a uniform radial evacuation out to 10 miles to the reception centers or shelters (Ref. F.2-3, page III-1; Ref. F.2-5). NMPNS determined that a 7,200-second evacuation delay time and a 1.8 meters per second evacuation speed were appropriate. NMPNS also assumed that 95 percent of the population surrounding the plant would evacuate in an emergency.

F.2.1.4 Population Distribution

To generate the population input data, NMPNS used the RSICC code SECPOP90: Sector Population, Land Fraction, and Economic Estimation Program (Ref. F.2-6) as the baseline population distribution for estimating the projected population used in the analysis. The analysis area is the 50-mile region around NMP and includes 10 counties that are completely or partially within the 50-mile radius. The Syracuse metropolitan area is within the 50-mile radius and the Utica-Rome and Rochester metropolitan areas are partially within the analysis area. SECPOP90 provides the population distribution by sectional rosette centered on NMP and divided into nine radial intervals out to 50 miles. The rosette consists of 16 standard compass directions, the first of which is centered on due north, the second on 22.5 degrees east of north, and so on. The total 1990 population residing in the 50-mile radius region was estimated to be 911,816 persons.

SECPOP90 uses year 1990 block level census data to calculate the population within each rosette section; therefore, year 2030 population estimates were calculated using the 2030 county-level estimates to develop a weighted average population projection for each rosette section. County-specific population projections for year 2030 were obtained from Cornell University. Notably, the Cornell data predict a decline in the population in the surrounding counties within the next thirty years.

Specifically, the 1990 rosette populations generated by SECPOP90 were extrapolated to year 2030 by using the ratio of 1990/2030 county populations multiplied by the estimated fraction of each county comprising the rosette section, creating an area weighted average. The percentage of each county that comprises each rosette section was estimated by overlaying the rosette onto county maps. For example, if a rosette section lies completely within Oswego County, the population factor is equal to the fractional change in the Oswego County population, or 1.001. If land area of the section is split with 70 percent in Oswego County and 30 percent in Jefferson County, the factor would be [(.7)(1.001) + (.3)(1.007)] or 1.0028. The resulting factors for each section were multiplied as a matrix by the 1990 data to calculate a county weighted projection from 1990 to 2030. The SECPOP90 site data file was manually updated with these new numbers. The total 2030 population for the 50-mile region is estimated to be 834,332. Table F.2-2 presents the 2030 population by sector. A 10 percent population multiplier was applied as an additional conservatism to account for non-linear population change (see Section F.2.3).

F.2.1.5 Land Fractions

Land fractions represent the portions of the total surface area that are land for each sector, and they are calculated using an algorithm that weights the county-level land fraction data. This is possible because the code contains a county level database with the land fractions for each county, and every record in the block level database includes the area of the block and a code to indicate in which U.S. county the block resides.

NMPNS used the values generated by the SECPOP90 code for each rosette section directly in the analysis.

F.2.1.6 Regional Economic Data

Agricultural economic data required for MACCS2 include (Tables F.2-3 and F.2-4):

1) the fraction of land devoted to farming;

2) the farmland property values;

3) the total annual farm sales; and

4) the fraction of farm sales resulting from dairy production.

The SECPOP90 database includes county economic data derived from the year 1990 census and various other government documents dated 1992 to 1995. For preparation of the NMP Level 3 models, the SECPOP90 site input file was manually updated to circa 2000 for the 10 counties within 50 miles of NMP. Therefore, the Level 3 input files contain updated values for each economic region and, hence, for each sector. The agricultural economic data were updated using available data from the 1997 Census of Agriculture (Ref. F.2-7) supplemented by data available through other federal agencies (Ref. F.2-8; Ref. F.2-9; Ref. F.2-10; Ref. F.2-11).

TABLE F.2-2

1990 50-MILE RADIUS POPULATION PROJECTED TO 2030

Compass Direction	Distance in Miles								
	1	2	5	10	15	20	30	40	50
N	0	0	0	0	0	0	0	222	1,273
NNE	0	0	0	0	0	76	1,639	8,500	5,885
NE	0	0	0	0	357	1,030	6,239	28,002	36,812
ENE	1	0	0	0	3,086	3,102	1,165	240	5,777
E	28	44	37	620	1,798	2,120	1,773	579	2,526
ESE	0	54	527	2,840	1,831	2,291	2,720	7,473	16,021
SE	0	122	365	1,240	1,744	4,831	13,861	14,288	36,519
SSE	0	47	486	913	2,472	3,986	80,286	242,166	23,049
S	35	17	454	1,208	15,527	5,752	19,509	28,124	20,044
SSW	0	12	981	3,091	3,297	4,061	4,635	10,842	39,745
SW	0	0	948	21,910	3,184	1,507	8,100	11,457	27,725
WSW	0	18	143	3,623	132	0	75	5,944	19,166
W	3	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0

TABLE F.2-3

MACCS2 AGRICULTURAL DATA

County	Fraction of Land Devoted to Farming	Fraction of Farm Sales Resulting from Dairy Production	Average Annual Farm Sales ($/hectare)	Farmland Property Values ($/hectare)
Cayuga	0.567551	0.548727	1,133	3,270
Jefferson	0.357494	0.780905	654	2,216
Lewis	0.220116	0.879097	848	2,180
Madison	0.442930	0.769904	873	2,771
Oneida	0.278413	0.680080	847	3,115
Onondaga	0.294566	0.528181	1,192	3,753
Ontario	0.450810	0.421387	1,036	4,333
Oswego	0.168057	0.348064	758	3,468
Seneca	0.564681	0.362439	864	3,245
Wayne	0.432344	0.140398	1,590	4,777

TABLE F.2-4

PER CAPITA REGIONAL ECONOMIC DATA

County	Non-Farm Wealth Value ($/person)
Cayuga	100,317
Jefferson	102,292
Lewis	83,888
Madison	112,161
Oneida	110,227
Onondaga	129,254
Ontario	128,273
Oswego	101,637
Seneca	104,222
Wayne	110,002

Additional regional economic data factored into the NMP risk analyses include the value of farm wealth, the fraction of farm wealth in the region due to improvements, and the value of non-farm wealth. The value of farm wealth and non-farm wealth by county are presented in Table F.2-4. The fraction of farm wealth in the region due to improvements was calculated to be 0.02 using the average farm wealth (Table F.2-4) and the average value of farm real estate (Ref. F.2-8).

F.2.1.7 Food Pathway Assumptions

The MACCS2 ingestion model preprocessor, COMIDA2, was used to model the ingestion pathway. Crop season and share data were not used, since the ingestion model uses diet assumptions versus agricultural production to define food intake. However, the COMIDA2 code does require input for waterborne nuclides of concern for the water ingestion model, as well as food. NMPNS identified four nuclides, Sr-89, Sr-90, Cs-134, and Cs-137, as input to the ingestion model.

Based on its size, Lake Ontario could be treated as an ocean watershed with zero uptake. However, NMPNS conservatively treated the Lake as a lake watershed since, unlike an ocean, it is a source of drinking and irrigation water.

F.2.1.8 Deposition Velocities

Particulate nuclides in the plume are subject to wet and dry deposition and then, subsequently, to runoff and washoff. NUREG/CR-4551 developed values and assumptions for deposition by treating all the nuclides subject to water washout as a single group. NMPNS calculated a NMP-specific dry deposition velocity value of 0.2 meters per second for the predominately countryside terrain around NMP. Since the site-specific value compared favorably with the “base value” given in NUREG/CR-4551, it was used for this analysis. Runoff and washoff are calculated as part of the COMIDA2 ingestion model.

F.2.2 RESULTS

The result of the Level 3 models is a matrix of offsite exposure and offsite property costs associated with a postulated severe accident in each release category. This matrix was combined with the results of the Level 2 model to yield the probabilistic offsite dose and probabilistic offsite property damage resulting from the analyzed plant configuration. The final result of a Level 3 evaluation of a SAMA is a value of the cumulative dose expected to be received by offsite individuals and a value of the expected offsite property losses due to severe accidents given the plant configuration under evaluation. The following discussion presents Unit-specific results.

Nine Mile Point Unit 1

The offsite exposure risk for Nine Mile Point Unit 1 is 22.5 person-rem per year. Table F.2-5 provides the baseline exposures associated with each release category.

TABLE F.2-5

SUMMARY OF NINE MILE POINT UNIT 1 OFFSITE CONSEQUENCES

Release Category	Frequency (per year)	Offsite Dose (person-rem)	Offsite Dose Risk (person-rem/yr)	Offsite Economic Costs ($)	Offsite Economic Risk ($/yr)
EHGH	2.18E-06	1.47E+06	3.20	4.47E+09	9,750
IHGH	3.09E-06	1.46E+06	4.51	4.47E+09	13,800
LHGH	8.17E-07	8.46E+05	0.69	3.60E+09	2,940
EMED	2.09E-06	8.47E+05	1.77	3.55E+09	7,420
IMED	6.39E-06	8.42E+05	5.38	3.55E+09	22,700
LMED	7.78E-06	8.46E+05	6.58	3.60E+09	28,000
ELO	1.00E-08	3.30E+05	0.003	1.48E+09	15
ILO	1.72E-07	3.32E+05	0.057	1.50E+09	258
LLO	7.92E-07	3.32E+05	0.26	1.50E+09	1,190
NOREL	3.60E-06	2.12E+03	0.008	2.53E+06	9
Total	2.69E-05		22.5		86,000

EHGH = early high
IHGH = intermediate high
LHGH = late high
EMED = early medium
IMED = intermediate medium
LMED = late medium
ELO = early low
ILO = intermediate low
LLO = late low
NOREL = no release

The offsite exposure risk was calculated by multiplying the frequency of the release by the dose. The base case offsite economic risk is $86,000 per year. Table F.2-5 also provides the Nine Mile Point Unit 1 base case offsite economic costs associated with each release category. The economic risk for each release category was calculated by multiplying its frequency by the corresponding economic costs.

Nine Mile Point Unit 2

The offsite exposure risk for Nine Mile Point Unit 2 is 50.9 person-rem per year. Table F.2-6 provides the baseline exposures associated with each release category. Similar to Unit 1, the offsite exposure and economic risks were calculated by multiplying the frequency of the release by the dose. The base case offsite economic risk is $125,000 per year. Table F.2-6 also provides the Nine Mile Point Unit 2 base case offsite economic costs associated with each release category.

TABLE F.2-6

SUMMARY OF NINE MILE POINT UNIT 2 OFFSITE CONSEQUENCES

Release Category	Frequency (per year)	Offsite Dose (person-rem)	Offsite Dose Risk (person-rem/yr)	Offsite Economic Costs ($)	Offsite Economic Risk ($/yr)
EHGH	1.23E-06	2.43E+06	2.99	6.02E+09	7,400
IHGH	8.22E-06	1.41E+06	11.6	4.47E+09	36,700
LHGH	6.82E-06	4.41E+06	30.1	8.05E+09	54,900
EMED	8.90E-07	1.42E+06	1.26	4.58E+09	4,080
IMED	3.00E-07	1.41E+06	0.423	4.47E+09	1,340
LMED	7.81E-07	1.38E+06	1.08	4.49E+09	3,510
ELO	3.66E-06	4.49E+05	1.64	2.25E+09	8,240
ILO	3.51E-07	4.54E+05	0.159	2.28E+09	800
LLO	3.34E-06	4.48E+05	1.50	2.28E+09	7,620
NOREL	3.61E-05	3.71E+03	0.134	4.34E+06	157
Total	6.17E-05		50.9		125,000

EHGH = early high
IHGH = intermediate high
LHGH = late high
EMED = early medium
IMED = intermediate medium
LMED = late medium
ELO = early low
ILO = intermediate low
LLO = late low
NOREL = no release

F.2.3 SENSITIVITY ANALYSIS

Sensitivity analyses were performed to assess variations in certain input factors, which included population projections, fission product release, and evacuation speed.

F.2.3.1 Population Projection

The values used to generate the Level 3 results were projected population estimates for the year 2030. It is well known that population trends can be non-linear and difficult to predict, especially 30 years into the future. In order to bound any uncertainties that would underestimate the actual population during the license renewal period, a population sensitivity case assumed that the population was 10 percent greater than predicted. The 1.1 population increase factor was applied uniformly to all sectors of the analysis area rosette.

F.2.3.2 Fission Product Release

An assumption for the core inventory used in the Level 2 model was that the activity levels are directly proportional to thermal power. A sensitivity case that assumed that core activity levels were 110 percent above the linearly calculated values was performed to bound the uncertainties in this approach.

F.2.3.3 Evacuation Speed

A sensitivity analysis performed on evacuation speed demonstrated that the total dose and economic cost results are insensitive to this parameter. This is primarily due to the low population of the NMP emergency planning zone.

F.2.3.4 Results

The results of the sensitivity analyses for population and fission product release are summarized in the Table F.2-7. As noted above, offsite dose and economic cost are not affected by evacuation speed. The sensitivity analyses indicate increases in population and core activity levels both have a linear impact on the dose risk; whereas, economic risk is more sensitive to population increases (approximately linear) than to core activity level increases.

These sensitivity cases are also reflected in the cost-benefit analysis results presented in Section 4.17 of the main environmental report.

TABLE F.2-7

SUMMARY OF THE LEVEL 3 SENSITIVITY ANALYSIS

	Unit 1		Unit 2	
	Offsite Dose Risk (person-rem/yr)	Offsite Economic Risk ($/yr)	Offsite Dose Risk (person-rem/yr)	Offsite Economic Risk ($/yr)
Base Case	22.5	86,100	50.9	125,000
10 Percent Population Increase	24.2	94,500	54.5	137,000
10 Percent Power Increase	24.2	89,300	55.3	129,000

F.3 SAMA ASSESSMENTS

This section includes the evaluation summaries for the SAMAs NMPNS evaluated in the cost-benefit analysis. Each summary includes a Unit-specific description of the candidate SAMA, a discussion of the potential benefits, a summary of the evaluation and resulting benefits, and a discussion of the associated implementation costs.

F.3.1 UNIT 1 SAMA ASSESSMENTS

SAMA No. U1-4
TITLE: Training on Loss of Reactor Building Closed Loop Cooling

Description:

This SAMA involves a procedure revision to direct operators to quickly reduce RPV pressure to a 500 pounds per square inch gage (psig) to 700 psig pressure band and allow complete recirculation isolation and reliance on the fuel zone level indicators given a four or five recirculation loop seal LOCA. The objective is to investigate reducing the risk from reactor recirculation pump seal LOCAs due to loss of seal cooling [reactor building closed loop cooling (RBCLC)]. Loss of RBCLC results in loss of feedwater and the potential for recirculation pump seal LOCAs. Feedwater is lost almost immediately due to loss of pump cooling. A recirculation pump seal LOCA becomes more likely since pump seal cooling is lost. A pressure band of 500 psig to 700 psig would reduce the challenge to the seals and would also maintain the 100°F/hr cooldown limit for the RPV. The benefit of reduced RPV pressure is illustrated by testing performed by the seal vendor. This report showed a significant reduction in seal failure at the lower pressure range.

SAMA Benefits:

For those cases where normal AC power is available, the PRA includes an operator action to isolate the pump seal LOCA, should it occur. However, the current PRA includes a relatively high failure probability for this action due to uncertainty regarding operator priorities. Additional guidance, training, and/or clarification could reduce failure probability as modeled in the PRA.

Evaluation:

To quantify the benefit of this change, the operator action failure probability is improved from 0.1 to 1E-3 (system top event NSL) to simulate the modification. The total reduction in CDF is approximately 1.8E-7/year. The population dose would decrease by 0.085 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U1-21
TITLE: Provide firewater to the shutdown cooling heat exchanger

Description:

The objective of this SAMA is to improve the shutdown cooling function by providing an additional heat sink for the system. This modification would include a piping modification to connect firewater directly to the shutdown cooling (SDC) heat exchanger. The Unit 1 SDC system operates by circulating water from the reactor recirculation loops through a set of heat exchangers and back to another recirculation loop. The heat sink for the system is RBCLC, which in turn uses service water as its heat sink. Unit 1 has four service water pumps of which two are classified as emergency service water pumps. These pumps are provided with onsite emergency AC power. Should all service water loops fail, Unit 1 has the capability to align the firewater system to cool the RBCLC heat exchangers; however, SDC still depends on RBCLC. Guidance for this process is included in operating procedure N1-SOP-7, “Service Water Failure/Low Intake Level.”

SAMA Benefits:

Severing the complete reliance of SDC on RBCLC would provide additional benefit, which is evaluated here as a piping modification connecting firewater directly to the SDC system.

Evaluation:

The SDC system model (top event SD) is modified to allow firewater to cool the SDC heat exchangers, redundant to RBCLC. Split fraction SDF (guaranteed failure) is modified to change the RW=F portion to RW=F*FP=F. FP allows firewater to provide cooling redundant to RBCLC (RW). This change is made in event trees AT3, TRSL2, and LOCA event trees.

This change does not create a new operator action, which essentially assumes a high reliability for operators in such sequences. This slightly overestimates the benefit of such a modification. The total reduction in CDF is approximately 6.1E-7/year. The population dose would decrease by 0.458 person-rem per year.

Cost of Implementation:

The proposed modification would require extensive piping to connect the firewater system to the RBCLC and to install an effluent line to a monitored discharge location. Two connection points would have to be installed in the RBCLC header with spool pieces in the emergency firewater line to be installed via operator action in the event cooling is required. Engineering to support implementation would include design for piping, seismic pipe supports, and RBCLC pipe modifications; RBCLC cooling capacity and flow requirement evaluation; and capacity limitation evaluation and flow balancing for the firewater system to ensure that it can adequately perform its other functions. The design effort alone would cost in excess of $150,000. With procedure modifications, training, material, and craft installation, the total cost of the modification would be in excess of $500,000.

SAMA No. U1-24
TITLE: Improve procedures for loss of HVAC

Description:

The objective of this SAMA is to improve the procedure for loss of control room heating, ventilation, and air conditioning (HVAC). The Control and Auxiliary Control Rooms (i.e., the control area) are cooled by a common HVAC system. The system consists of normal and emergency trains. The emergency trains include filtration equipment to maintain control room habitability given the presence of ambient radionuclides. In addition to the filtration equipment, the system is designed to keep the Control Room at a slightly positive pressure to reduce the potential for influx of hazardous airborne material.

SAMA Benefits:

Given failure of the normal control area ventilation system, annunciator L1-4-1, “Control Room Ventilation System Trouble,” will alarm. The alarm response procedure (ARP) for this alarm guides operators to start the emergency ventilation system. It also refers to operating procedure N1-OP-49. This operating procedure provides direction on system operation and includes a precaution and limitation notation that inoperability of control room ventilation may require alternate cooling to be established to protect computer equipment.

Evaluation:

Loss of control area ventilation was screened from the PRA as non-risk significant. The notation above regarding “precaution and limitation notation that inoperability of control room ventilation may require alternate cooling to be established in order to protect computer equipment” is viewed as a cue for operators to open doors and/or establish cooling using fans or other portable devices. While more formal guidance could be created, the PRA team views this as providing a minor benefit over operator skill of the trade and guidance currently in place. Thus, the change in CDF is judged to be essentially 0.0 for this analysis, consistent with the PRA. The population dose would decrease by 0.0 person-rem per year.

Cost of Implementation:

Since further evaluation after the initial screening has determined that there is no benefit to be gained from this SAMA, a cost of implementation has not been determined.

SAMA No. U1-112
TITLE: Modify RWCU for decay heat removal

Description:

This SAMA involves installing a bypass line to improve the heat removal capability of the reactor water cleanup (RWCU) system after shutdown (decay heat removal).

SAMA Benefits:

Unit 1 has no capability to bypass the regenerative heat exchanger in the RCWU system. With the installation of a regenerative heat exchanger bypass, the flow rate to the non-regenerative heat exchanger would be increased, thus potentially increasing the amount of heat that the non-regenerative heat exchanger can remove from the system.

Evaluation:

The Unit 1 Shutdown PRA is not completed, but the Unit 2 PRA can be used to estimate the safety benefit and derive insights. The following changes were made to the model (no significant maintenance is modeled) to obtain an approximation of potential benefits to CDF:

- Top event RWCU (reactor water cleanup) is set to failure if its support systems are not available (RWCUF if NA=F + NB=F + RW=F).
- Split fraction RWCU1 (screening failure probability of 0.1) is added to allow credit for RWCU.

The greatest change in conditional CDF (assumes plant is in this configuration all year) was determined to be approximately 5E-8/year. If one assumes that the plant is always in this configuration when shut down and the plant is shut down 10% of the year, the unconditional CDF is approximately 5E-9/year. This is considered insignificant. Also, radionuclide decay during shutdown reduces the source term over time. Thus, the change in CDF is judged to be essentially 0.0 for this analysis. The population dose would decrease by 0.0 person-rem per year.

Cost of Implementation:

Since there is no safety benefit for this SAMA and it is expected that the cost of this modification would exceed $1 million, a detailed cost of implementation was not calculated.

SAMA No. U1-113
TITLE: Use CRD for alternate boron injection

Description:

The objective of this SAMA is to utilize the control rod drive (CRD) system to pump liquid poison into the reactor during an ATWS event.

SAMA Benefits:

This modification would improve the reliability of boron injection by providing an alternative to RWCU and the hydro pump for performing this function.

Evaluation:

The PRA presently does not model alternate injection because of the time it takes to implement (PRA evaluates a full power ATWS). Thus, another alternate boron injection capability would have no benefit unless it was hard piped to the liquid poison tank. Such a change would improve the reliability of top event SL in the PRA. Thus, to simulate this modification, all SL top event failure probabilities were reduced by two orders of magnitude. The total reduction in CDF is approximately 6.3E-8/year. The population dose would decrease by 0.076 person-rem per year.

Cost of Implementation:

Because this SAMA entails an extensive piping modification and the benefit is so low, it has been judged that the cost would be at least an order of magnitude higher than the benefit such that a detailed cost estimate is not required.

SAMA No. U1-208
TITLE: Improve drywell head bolts

Description:

This SAMA involves replacing the drywell head bolts with stronger bolts.

SAMA Benefits:

The perception was that this would reduce the risk of releases from the drywell head.

Evaluation:

The drywell head failure mode is an insignificant contributor to containment failure at low temperatures (200°F), but its contribution increases, and becomes more significant, as a function of temperature increases to 800°F. Other important failure modes at these temperatures are also via the drywell; however, they do not attain the same order of benefit as a wetwell air space failure where the source term is scrubbed. Thus, the benefit, if any, would be minor if stronger head bolts were installed. A very conservative bounding analysis was performed to check the potential benefits of eliminating all drywell failure modes in the Level 2 model by setting top events DI/DC (drywell intact) to guarantee to success. There was no reduction in CDF for this modification; however, there is some reduction in certain release categories. The population dose would decrease by 0.013 person-rem per year.

Cost of Implementation:

Replacing the drywell head bolts with stronger head bolts will provide a small benefit in Unit 1. Replacing the bolting assemblies (stud, nut, and washer) will cost in excess of $150,000 for materials alone (based on an estimated cost of $1,600 per assembly). Additional costs include labor; however, due to minimal benefit, only the material costs were identified.

SAMA No. U1-209
TITLE: Improve SOP-14 and Training

Description:

The intent of this SAMA is to improve procedure SOP-14 for the scenarios where vital AC power is lost to both divisions. Adding the dominant scenarios to simulator and in-plant exercises that are included in the regular training rotation could improve reliability of the operator actions as modeled in the PRA.

SAMA Benefits:

The Unit 1 PRA model quantification results in a number of significant sequences where vital AC power is lost to both divisions. Such a loss of power results in the loss of important equipment, including supply to the125V DC chargers. This causes an eventual loss of DC power, which in turn causes a loss of RPV instrumentation. The plant can cope during this time until instrumentation is lost because other equipment—such as the emergency condensers, diesel fire pump, and feedwater—is available if normal AC power is available. NMPNS determined that a procedure revision could be implemented to prevent the loss of power if operators were able to maintain control of the plant, which, in this case, requires operators to be cognizant of critical parameters such as RPV inventory level.

Evaluation:

PRA top event HRA models the operator action (use of SOP-14 for instrumentation when DC power runs out in the long term). Split fractions HRA1 and HRA4 are the most risk-significant actions. The following is a summary of HRA scenarios:

- HRA1 - operators have access to the main control room, main feedwater is initially successful, and there is no LOCA condition (e.g., no stuck open emergency relief valve). This is also used for control room fires that do not force evacuation concurrent with availability of ECs. The following are dominant scenarios:
    - Fire (FT3B1 or FT3B3, see SAMA U1-210) initiating event that causes loss of PB102, PB103, PB101, PB12, and BB12.

  - o Loss of PB102 initiating event and subsequent loss of RPS Bus 12.
  - o Loss of PB103 initiating event and subsequent loss of RPS Bus 11.

- HRA2 - similar to HRA1 except the Control Room is unavailable (control room fire and evacuation).
- HRA3 - control room fires that do not force evacuation concurrent with unavailability of ECs.
- HRA4 - similar to HRA1 fire scenarios; except there is a stuck-open emergency relief valve. Station blackout scenarios are also important.

The range of failure probabilities for these types of actions is currently 0.1 to 0.02. Since the actions are taken exclusively outside the Control Room, it is difficult to calculate a significantly low failure probability. However, with regular training on such sequences, coupled with the fact that there is ample time available to diagnose these types of sequences, a 0.1 improvement factor is viewed as attainable. Thus, the PRA is quantified with HRA1 reduced from 2E-2 to 2E-3, HRA2 reduced from 0.1 to 1E-2, HRA3 reduced from 0.1 to 1E-2, and HRA4 reduced from 5E-2 to 5E-3. With these reductions, the total reduction in CDF is approximately 6E-6/year. The population dose would decrease by 5.37 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U1-210
TITLE: Protect critical fire targets

Description:

The purpose of this SAMA is to protect critical fire targets from dominant fire sources by either moving some of the critical fire targets or sources to improve separation and/or providing cable tray protection (e.g., barrier board).

SAMA Benefits:

Protecting fire targets from dominant fire sources (initiators FT3B1 and FT3B3 in the PRA) would result in a major reduction in risk.

Evaluation:

Protecting fire targets from dominant fire sources (initiators FT3B1 and FT3B3 in the PRA) would result in a major reduction in risk. The following is proposed to reduce the dominant fire initiating events described in Section 6.1:

- Revisit the original fire hazards analysis - evaluate the combustible load realistically within the two fire sources (dry transformer and electrical panel) on Elevation 261’ of the Turbine Building. Based on this realistic heat load, update fire model and determine whether fire will impact cable tray targets. If the subject cable trays can still be damaged, continue to next option. If the trays cannot be damaged, update the PRA by removing or reducing the frequency of these initiating events.

- Perform a more detailed risk analysis of scenarios, including timing, procedures, training, and operator performance (include assessment of damage repair procedures and SOP-8). Based on this evaluation, update risk significance and determine costs and benefits of improved procedures, training, and/or modifications such as moving these sources or providing protection to the critical cable trays.

For the purposes of this analysis, it is assumed that the fire hazards analysis realistically defines the combustible load for these two fire sources. The frequency of initiating events FT3B1 and FT3B3 is set to 0.0 to simulate the benefits of this modification. The total reduction in CDF is approximately 6.1E-6/year. The population dose would decrease by 5.45 person-rem per year.

Cost of Implementation:

Two locations on Elevation 261’ in the south end of the Turbine Building require fire barriers. The electrical panel in question exposes 15 to 20 feet of cable tray to a fire source. Providing cable tray protection in the form of barrier board or an established alternative can be installed for less than $10,000. The other source is a dry transformer that is mounted close to the cable tray. Moving the transformer 5 to 10 feet away from the cable tray would cost less than $20,000. Installation of fire barrier board or alternative protection on the trays would be an additional $10,000. The total cost of this modification would be less than $40,000.

SAMA No. U1-211
TITLE: Reduce offsite power dependency on DC 11

Description:

This SAMA would provide for manual operation of the 115kV offsite power supply breakers.

SAMA Benefits:

Currently, Unit 1 has no capability to operate 115kV offsite power supply breakers R10 and R40 without 125V DC battery board 11. This makes the plant completely reliant on one battery board for offsite power recovery given an LOOP. A modification and formalized recovery action to allow battery boards 12 and/or 14 to support R10 and R40 closure almost immediately to support early recovery would provide the greatest potential benefit. Alternately, establishing a formalized procedure to locally close the breaker would likely require the line to be de-energized, and therefore recovery during the first hour would not be likely.

Evaluation:

The model modifications necessary to consider this potential plant change involve split fraction rules for top events OGR (offsite power recovery within 1 hour) and OSP (offsite power recovery after 1 hour). To estimate the benefit of crediting battery board 14 in the present PRA model, it is assumed that battery board 12 can close the appropriate breakers. A screening value of 0.1 is applied to this operator action to close the breakers. In order to capture this potentially new support state, new split fractions OGRZ, OSP2Z, OSP4Z, and OSP8Z were developed. Split fraction OGRZ represents the boundary condition where offsite power and battery board 11 are failed and battery board 12 is available. It was calculated as OGR1+0.1 to reflect the additional operator action failure mode with battery board 11 unavailable. OSP split fractions were calculated similarly (i.e., OSP2Z=OSP2+0.1, etc.).

OGR split fraction rules were then changed from:

OGRF	OG=F*DA=F + COMP3=F + COMP4=F
OGRS	OG=S
OGRF	Several Rules
OGR1	1

To:

OGRF	OG=F*DA=F*DB=F + COMP3=F + COMP4=F
OGRZ	OG=F*DA=F*DB=S
OGRS	OG=S
OGRF	Several Rules
OGR1	1

Split fraction rules for OSP were changed from:

OSPF	-BB11 + OGR=S + CD1
OSP2	CD2*OG=F*BB11
OSP4	CD4*OG=F*BB11
OSP8	CD8*OG=F*BB11
OSPF	1

To:

OSPF	-BB11*-BB12 + OGR=S + CD1
OSP2Z	CD2*OG=F*-BB11*BB12
OSP4Z	CD4*OG=F*-BB11*BB12
OSP8Z	CD8*OG=F*-BB11*BB12
OSP2	CD2*OG=F*BB11
OSP4	CD4*OG=F*BB11
OSP8	CD8*OG=F*BB11
OSPF	1

The total reduction in CDF for these changes is approximately 2.2E-7/year. The population dose would decrease by 0.363 person-rem per year.

Cost of Implementation:

To allow offsite power breakers to be re-powered from either battery board 12 or 14, control circuitry would need to be installed or a portable diesel-driven battery charger made available with the associated procedure changes and training. The control circuitry option will require $25,000 for equipment as well as, $100,000 for engineering, procedure changes, and training. The total cost of the project is more than three times the benefit and therefore is not considered further.

An alternative to provide a battery charger, including procedure changes and training, is estimated to cost approximately $50,000.

SAMA No. U1-212
TITLE: Add capability to manually operate containment venting

Description:

This SAMA involves adding the capability to manually operate (hand wheel or local air tank) valve 201-16, which vents the primary containment.

SAMA Benefits:

Should instrument air or battery board 11 become unavailable when required, this modification would provide for the capability to manually initiate containment venting.

Evaluation:

Local manual operation of valve 201-16 is modeled by modifying the following containment venting (top event CV) split fraction CVF and CV2 rules in the event trees AT3, LOCA, and TRSL2 as follows:

CVF	-(BB11*AS=S) + LS102F*LS103F
CV3	SD=F*-SDF + OH=F*TC=S
CV2	-PB167
CV1	PB167

These were modified to reflect the postulated modification to allow local manual operation of valve 201-16. Note that downstream valve 201-17 is a motor-operated valve supplied with AC power from power board 167. This valve has a hand wheel, and local manual operation of the valve is included in the model (split fraction CV2). Since local manual action was previously modeled, the postulated improvement for valve 201-16 can be modeled as part of split fraction CV2. Thus, split fraction rules for CV are modified as follows to reflect the benefit of a hand wheel or local air tank for valve 201-16:

CVF	LS102F*LS103F
CV3	SD=F*-SDF + OH=F*TC=S
CV2	-PB167 + -BB11 + -AS=S
CV1	PB167

The total reduction in CDF is approximately 8E-8/year. The population dose would decrease by 0.550 person-rem per year.

Cost of Implementation:

This modification would require "test tees" to be installed in the air tubing on the valve actuator to allow installation of a temporary motive force, such as nitrogen bottles. The cost of the tubing modification would be less than $10,000. The cost of the associated training and procedure changes is estimated to be approximately $30,000. The total cost of the modification is $40,000.

SAMA No. U1-215
TITLE: Add portable battery charger

Description:

This SAMA involves the use of a portable charger for charging the batteries to extend the coping time when AC power has been lost.

SAMA Benefits:

A review of the PRA indicates that the key scenarios to be improved are the same as identified above in SAMA U1-209. A portable charger would allow operators to cope from the Control Room rather than use the East and West Instrument Rooms.

Evaluation

A review of the PRA indicates that the key scenarios to be improved are the same as identified for SAMA U1-209; therefore, the SAMA U1-209 quantification is used. The total reduction in CDF is approximately 6E-6/year. The population dose would decrease by 5.37 person-rem per year.

Cost of Implementation:

NMPNS has initiated an Engineering Action Request for Unit 2 (02-02829) to provide an alternative to supply charging capability to the 125V battery. The cost of a portable diesel-driven charger is estimated to be $20,000. An additional cost of $30,000 to perform procedure changes and training will also be incurred. The total cost of this modification, including any fieldwork necessary to support any installation or storage needs, is estimated to be $50,000.

One common battery charger can be procured for use by both Units. Economic gains are also realized due to procedure preparation and training activities required for both units, resulting in a combined cost of $70,000 for both units.

SAMA No. U1-220
TITLE: Improve AC power load management

Description:

This SAMA involves an upgrade of the 4160V to 600V transformers in the emergency AC divisions. Procedural or training improvements are judged unlikely, since the current procedures appear to be adequate.

SAMA Benefits:

A modification to upgrade these components could greatly reduce the potential for overload.

Evaluation:

The operator action (basic event AA_OPERSHEDZAA01) is removed from the model (system top event AA) to simulate the modification. This assumes the operator is perfectly reliable (slightly overestimates benefit since HRA is already 6.4E-3) or that new transformers are provided. The total reduction in CDF is approximately 3.7E-6/year. The population dose would decrease by 3.79 person-rem per year.

Cost of Implementation:

This modification will replace and upgrade the two 4160V to 600V transformers in the emergency AC divisions. The transformers and the associated cabling, taps, relays, and other equipment will cost $200,000. Engineering, pedestal modification, and equipment installation will bring the cost of the modification to $600,000.

SAMA No. U1-222
TITLE: Improve procedures for loss of instrument air

Description:

A key operator action when instrument air is lost is the operator action to open an air-operated valve (AOV) (59-07 or -08) from the CST to the main condenser hot well, ensuring makeup to the feedwater system. The improvement of the procedure (N1-SOP-06) and the provision of training on the change, which were thought to be possible at first screening of this SAMA, are judged now to be not possible since both appear to be adequate. An alternative modification involves either (1) a fully automatic feedwater control system independent of instrument air or (2) capability to control feedwater operation from the main Control Room independent of instrument air.

SAMA Benefits:

Eliminating the operator action required to manually open the valve would eliminate the risk associated with that operation.

Evaluation:

The operator action (basic event FW_OPER_ZFW01) is removed from the model (system top event FW) to simulate the modification. This assumes the operator is perfectly reliable (overestimates benefit since HRA is already 1.9E-2) or that new automatic valves are provided. The total reduction in CDF is approximately 1.1E-6/year. The population dose would decrease by 1.05 person-rem per year.

Cost of Implementation:

A more elaborate means than providing additional procedures and training is necessary to increase operator reliability. A modification might include either a fully automatic electric feedwater control system or at least minimum capabilities to control feedwater operation from the Control Room independent of instrument air. Replacing air-operated controls with electric controls will require $200,000 for engineering. Equipment costs, installation costs, acceptance testing, and training will bring the cost of the modification to more than $600,000. This modification is not cost beneficial.

F.3.2 UNIT 2 SAMA ASSESSMENTS

SAMA No. U2-21
TITLE: Provide firewater to the Residual Heat Removal

Description:

The objective of this SAMA is to improve the SDC function by providing an additional heat sink for the system in the form of a piping modification to connect firewater directly to the residual heat removal (RHR) heat exchangers and thereby establish a source of cooling water redundant to service water.

SAMA Benefits:

The Unit 2 SDC system operates by using the RHR system to circulate water from a reactor recirculation loop through the RHR heat exchangers and then back to another recirculation loop. The heat sink for the system is service water. Unit 2 has six service water pumps and these pumps are provided with onsite emergency AC power. Should all service water loops fail, SDC would be unavailable.

Severing the complete reliance of SDC on service water would provide additional benefit for other modes of RHR, such as suppression pool cooling.

Evaluation:

The benefit of this modification can be quantified by removing RHR heat exchanger (top events HA and HB) dependency on service water (top events SA and SB); the dependency is now on both service water and firewater (top event FPW). Event trees AT1, LL2, ML2, SL2, and TR2 split fraction rules for HAF are modified to change the SA=F portion to become SA=F*FPW=F. This allows the fire protection top event (FPW) to provide cooling redundant to service water division 1. A similar change was made in the same event trees for Division 2 RHR top event HB. This sensitivity does not create a new operator action, which essentially assumes a high reliability for operators in such sequences. This is conservative, thus supporting the proposed modification.

The total reduction in CDF is approximately 0.0. This is due to the coincident dependency of RHR pump room cooling on service water. Adding redundant heat removal to the heat exchangers does not provide any significant benefit because the RHR pumps would still fail due to room over-temperature, given the loss of service water. This issue is discussed further in SAMAs U2-23a, b, and c. The population dose would decrease by 0.0 person-rem per year.

Cost of Implementation:

The cost of implementation for this modification has been roughly estimated to be >$100,000. After further review of this modification, NMPNS determined that no benefit could be achieved; therefore, a detailed cost estimate was not calculated.

SAMA No. U2-23a
TITLE: Provide redundant train of ventilation for RHR Pump Rooms

Description:

This SAMA involves a revision of the operating procedure to provide additional space cooling via the use of portable equipment or the blocking open of doors.

Note that loss of service water is a key contributor to loss of ventilation in the PRA. Therefore, any procedural changes or improvements should be considered for both incorporation into loss of ventilation and loss of service water procedures (see SAMA U2-213).

SAMA Benefits:

For RHR Pump Rooms A and B, calculations show that the limiting room (RHR Pump Room B) is marginal. The following two options should be considered, in order:

- Reconsider opening doors as a procedural action (may provide success)
- Consider use of a portable fan with associated procedural changes

The provision of additional cooling provides a significant benefit.

Evaluation:

Room cooling dependency for RHR pump trains A and B (top events LA and LB) was removed from the model (deleted MA and MB portions of split fraction rules) in event trees AT1, ISLOCA, LL1, ML1, SL1, and TR1. The corresponding reduction in CDF is approximately 1.8E-6/yr. The population dose would decrease by 3.48 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-23b
TITLE: Provide redundant train of ventilation for the HPCS Pump Room

Description:

The change associated with this SAMA is the revision of the operating procedure to provide additional space cooling via the use of portable equipment or the blocking open of doors.

Note that loss of service water is a key contributor to loss of ventilation in the PRA. Therefore, any procedural changes or improvements should be considered for both incorporation into loss of ventilation and loss of service water procedures (see SAMA U2-213).

SAMA Benefits:

For the HPCS Pump Room, calculations have been performed to determine whether opening the door would reduce temperatures sufficiently to protect the pump motor. This was not successful. Either an additional elevated opening in the Room or a portable fan would be required with the associated procedure changes to generate a significant benefit.

Evaluation:

Room cooling dependency for the HPCS Pump Room (top event HS) was removed from the model (deleted SA and SB portions of split fraction rules) in event trees ISLOCA, LL1, ML1, SL1, and TR1. Split fractions HSF, HS1, HS2, HS7, HS8, HS14, and HS15 were retained without SA and SB in the rules and other split fractions were deleted. The resultant reduction in CDF was approximately 2.5E-6/yr. The population dose would decrease by 4.00 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-23c
TITLE: Provide redundant train of ventilation for the RCIC Pump Room

Description:

The change associated with this SAMA is a revision of the operating procedure to provide additional space cooling via blocking open of doors.

Note that loss of service water is a key contributor to loss of ventilation in the PRA. Therefore, any procedural changes or improvements should be considered for both incorporation into loss of ventilation and loss of service water procedures (see SAMA U2-213).

SAMA Benefits:

For the RCIC Pump Room, opening the door is addressed as a means for providing successful room cooling in the current station blackout procedures. The proposed modification includes this procedural action during non-station blackout events with loss of room cooling (e.g., loss of service water).

The provision of additional cooling provides a significant benefit.

Evaluation:

Room cooling dependency on service water for the RCIC Pump Room (top event IC) was removed from the model (deleted SA, SB, MA, MB portions and macros for MCC102A and 302B) in event trees TR1, SL1, and ML1. Split fractions were revised by removing SA, SB, MA, MB, MCC102A, and MCC302B. Also, split fractions IC6, IC7, IC8, and IC10 were deleted as well as the second IC1, IC2, and IC3, as they become unnecessary. The resultant reduction in CDF was approximately 8.6E-7/yr. The population dose would decrease by 1.01 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-24
TITLE: Enhance procedures for loss of HVAC to the Control Room

Description:

This SAMA involves the enhancement of procedures for operation of control room ventilation.

SAMA Benefits:

It was postulated that the procedures could be enhanced to reduce the risk associated with a loss of ventilation.

Evaluation:

Upon further review, it was determined that loss of control room ventilation was screened from the PRA as non-risk significant. Loss of safety related and redundant air conditioning to the Control Room would be detected early since the operators are in the Control Room and there are both trouble and inoperability alarms associated with the systems. Other cooling possibilities include forcing air through the Control Room with the special filter trains and/or smoke removal fans and/or opening doors and allowing air conditioning from the lower elevations to provide some cooling. Even if the Control Room became very hot and started to impact electrical equipment and systems, the operators still have the option of taking control at the remote shutdown rooms at elevation 261’. These rooms have their own safety related air conditioners. Given these capabilities and the presence of operators, the likelihood of ventilation failures leading to core damage is judged unlikely and is not modeled in the PRA. Thus, the change in CDF is judged to be essentially 0.0 for this analysis, consistent with the PRA. The population dose would decrease by 0.0 person-rem per year.

Cost of Implementation:

Since the evaluation revealed that there was no benefit provided for this SAMA, a cost estimate was not performed.

SAMA No. U2-56
TITLE: Provide an additional source of onsite emergency AC power

Description:

This SAMA involves installation of a new diesel to provide an additional source of onsite emergency AC power.

SAMA Benefits:

Unit 2 has three EDGs, but the third, which is dedicated to HPCS, is reliant on the other EDGs to provide support for service water. The addition of another EDG that is not reliant on any existing system for support would allow for recovery of AC power within 30 minutes.

Evaluation:

The benefit of an additional EDG is modeled by changing split fraction rule:

BDF 1

to:

BDF A1BUSNR*A2BUSNR + INIT=BFA88B + INIT=CBF88B
BD1 1

Split fraction BD1 (failure probability is 1E-2) in event tree SBO1 basically “turns on” the logic to allow a fourth plant diesel, which had been modeled in the PRA but set to failure to indicate no such equipment is currently available at Unit 2. The first new rule sets the new diesel to failure if non-recoverable bus failures occur on the emergency buses or if a fire occurs in the emergency switchgear area of Fire Area 88 (Control Building, El. 261’). The total reduction in CDF is approximately 3.3E-5/year. The population dose would decrease by 2.47 person-rem per year.

Cost of Implementation:

The cost of implementation for this modification has been estimated to be >$10 million, making it non-cost beneficial. Because the benefit is so high, however, it was retained for evaluation.

SAMA No. U2-73
TITLE: Provide firewater backup for emergency diesel generator cooling

Description:

The objective of this SAMA is to provide an additional heat sink for the EDGs, redundant to service water. The addition of piping and associated valves and fittings would allow firewater to cool the EDGs. This modification requires either automatic alignment of firewater on loss of service water or operator instructions to trip the EDG on high temperature and manually align firewater (investigate feasibility of fire hose connection), as well as ensuring diesel room cooling.

SAMA Benefits:

With the redundant water supply, the loss of service water does not adversely affect the operation of the EDGs.

Evaluation:

The benefit of firewater cooling to the EDGs is modeled by changing the split fraction macro rules for the ACA and ACB macros in event tree SUP4. These modifications added *FPW=F to the macros. This requires firewater to be failed in addition to service water. A similar change was made to macros A1DGNR and A2DGNR in event tree SBO1. Also, to avoid circular logic, top event FPW was moved to earlier in Event Tree SUP4 with no change to the event tree or top event logic. No operator action has been added to this PRA modification. It is assumed the operator would be reliable to the level of equipment modeled, which would make the action have a small impact. This is conservative with regard to estimating the benefit. The total reduction in CDF is approximately 1.6E-6/year. The population dose would decrease by 2.29 person-rem per year.

Cost of Implementation:

The cost for this modification has been estimated to be $500,000.

SAMA No. U2-112
TITLE: Modify RWCU for decay heat removal

Refer to U1-112. The description, benefits, and evaluation are the same as those described for Unit 1.

SAMA No. U2-113
TITLE: Use of CRD for alternate boron injection

Description:

The objective of this SAMA is to utilize the CRD system to pump liquid poison into the reactor during an ATWS event. Piping modifications would be required to support use of CRD.

SAMA Benefits:

This modification would improve the reliability of boron injection by providing another alternative for boron injection in addition to RWCU and the hydro pump.

Evaluation:

The PRA presently does not model alternate injection because of the time it takes to implement (PRA evaluates a full power ATWS). Thus, another alternate boron injection capability would have no benefit unless it was hard piped to the liquid poison tank. Such a change would improve the reliability of top event SL in the PRA. Thus, to simulate this modification, the following changes were made to SL top event failure probabilities and rules:

From:

SLF MCC102C + MCC302D
SL1 C1=S*C2=S
SL2 C1=F*C2=S
SL3 C1=S*C2=F
SLF 1

To:

SL1 -MCC102C*-MCC302D*NA=S*NB=S (decreased from 5.7E-2 to 5.7E-4)
SL2 -MCC102C*-MCC302D*(NA=F + NB=F) (5.7E-2 for SLC)
SL3 (MCC102C + MCC302D)*NA=S*NB=S (1E-2 used for CRD)
SLF 1

The total reduction in CDF is approximately 4.4E-7/year. The population dose would decrease by 0.683 person-rem per year.

Cost of Implementation:

The proposed modification requires piping to be run across multiple levels and rooms of the Reactor Building. The design effort involved with this modification would include pipe layout and seismic support design, penetrations, and transport design that would cost at least $50,000. Considering the design cost and cost associated with installation, material purchase, procedure modification, and operator training, the total cost of this modification would be well in excess of $150,000.

SAMA No. U2-208
TITLE: Improve drywell head bolts

Description:

The modification associated with this SAMA is the replacement of the drywell head bolts with stronger bolts.

SAMA Benefits:

This modification would provide the benefit of reducing the risk of releases from the drywell head.

Evaluation:

It has been determined that the drywell head failure mode is an insignificant contributor to containment failure. Thus, the benefit, if any, would be minor if stronger head bolts were installed. A very conservative bounding analysis was performed to check the potential benefits of eliminating all drywell failure modes in the Level 2 model by setting top events DI/DC (drywell in tact) to guarantee to success. There was no reduction in CDF for this modification; however, there is some reduction in certain release categories. The population dose would decrease by 0.760 person-rem per year.

Cost of Implementation:

Replacing the drywell head bolts with stronger head bolts will provide a small benefit in Unit 2. Replacing the bolting assemblies (stud, nut, and washer) will cost in excess of $150,000 for materials alone (based on an estimated cost of $1,600 per assembly). Additional costs include labor; however, due to minimal benefit, only the material costs were identified.

SAMA No. U2-213
TITLE: Enhance loss of service water procedure

Description:

The change associated with this SAMA is the enhancement of the Unit 2 loss of service water procedure (SOP-11) to provide more specific guidance, as described below, upon loss of service water.

SAMA Benefits:

Two types of important dependencies in the Unit 2 PRA with respect to loss of service water are described below:

- Loss of ventilation to emerging core cooling system (ECCS) pump rooms (i.e., HPCS, RCIC, RHR A, and RHR B): These are important because of the impact on the core inventory control function. Potential modifications that remove service water dependency from these systems are described for SAMAs U2-23a, b, and c above. The loss of service water procedure should incorporate changes as appropriately identified in SAMAs U2-23a, b, and c.

- Loss of heat removal function: Loss of service water results in loss of main condenser and loss of suppression pool cooling although there is significant time to recover these functions. The remaining containment heat removal function, containment venting, is also not currently performed by the most reliable system since it takes time to make the alignment and it depends on Division II AC. The loss of service water procedure could provide guidance on recovery of heat removal for the dominant scenarios in the PRA and provide a reminder for early alignment of containment venting.

The specific procedural change to achieve benefits would be defined upon further evaluation of this modification.

Evaluation:

The benefits of an enhanced loss of service water procedure can be summarized as follows:

- Loss of ventilation to ECCS pump rooms: SAMAs U2-23a, b, and c analyses can be used.
- Several dominant sequences have already been recovered in the PRA (top event R1) based on the significant time available and availability of key support systems. Additional and more reliable recovery is possible with improved procedures.

The benefits of SAMAs U2-23a, b, and c can be applied here. The reduction in CDF attributed to this SAMA is 2.5E-6/yr. The population dose would decrease by 4.00 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-214
TITLE: Enhance station blackout procedure

Description:

The change associated with this SAMA is the enhancement of the station blackout procedure to provide entry conditions into SOP-3 and SOP-1 for some of the important failure modes during certain electrical configurations.

SAMA Benefits:

This was identified as a potential improvement because during certain electrical configurations (e.g., Line 6 out of service with the Division II EDG powering the emergency bus), it was noted that entry conditions into SOP-03 and SOP-01 do not explicitly cover some important failure modes. This has been addressed with compensating measures during the applicable alignments, but should be permanently corrected.

Evaluation:

Compensatory measures are needed for online maintenance currently performed. Extension of these compensatory measures is viewed as cost beneficial because it will reduce resource requirements for justifying online maintenance activities in the future as well as providing a risk benefit during normal plant operation. Benefits are judged to be in excess of $100K.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-215
TITLE: Provide additional capability for maintaining 125V battery charge

Description:

This SAMA would provide an additional capability for maintaining the 125V DC battery charged given loss of emergency AC power combined with the capability to align the automatic depressurization system (ADS) and containment venting related solenoid-operated valves (SOVs) to DC power [via the uninterruptible power supply (UPS)].

SAMA Benefits:

This would afford operators a success path for inventory control and heat removal for longer-term loss of AC scenarios.

Evaluation:

The basic event failure probability for the portable charger (top event PCH) was reduced from 0.96 to 5E-2. Top events PCH and R1 (Recovery) were requantified and a new master frequency file (MFF) derived. This MFF was requantified through the existing model to produce revised results reflective of a plant condition where alternate battery charging is possible. The total reduction in CDF is approximately 3.1E-6/year. The population dose would decrease by 10.4 person-rem per year.

Cost of Implementation:

NMPNS has initiated an Engineering Action Request (02-02829) to provide an alternative to supply charging capability to the 125V battery. The cost of a portable diesel-driven charger is estimated to be $20,000. An additional cost of $30,000 to perform procedure changes and training will also be incurred. The total cost of this modification, including any fieldwork necessary to support any installation or storage needs, is estimated to be $50,000.

One common battery charger can be procured for use by both Units. Economic gains are also realized due to procedure preparation and training required for both units, resulting in a combined cost of $70,000 for both units.

SAMA No. U2-216
TITLE: Hard pipe diesel fire pump to RPV

Description:

The modification associated with this SAMA is to hard pipe the diesel fire pump to the RPV. Currently, Unit 2 relies on a pathway that depends, in part, on a 2.5-inch fire hose that must be manually connected between a firewater header and the RHR system. This configuration makes the operator action difficult and results in a system flow rate that is inadequate to support successful mitigation of many types of accident scenarios.

SAMA Benefits:

Implementation of this SAMA would improve system flow rate and increase function reliability.

Evaluation:

The basic event failure probability representing the inadequacy of system flow rate was reduced from 0.8 to 1E-5. This value was selected in order to maximize the benefit. Top event S1 (Operators Align diesel fire pump for RPV Injection) was requantified and a new master frequency file (MFF) derived. This MFF was requantified through the existing model to produce revised results reflective of a plant condition where an improved firewater to RPV injection pathway exists. The total reduction in CDF is approximately 2.6E-5/year. The population dose would decrease by 3.95 person-rem per year.

Cost of Implementation:

NMPNS has initiated an Engineering Action Request (02-02829) to provide a 6-inch hard piped line from the diesel fire pump to the RPV. Tie in to both systems will be required, as well as isolation valves and seismic pipe supports. The engineering to support implementation is estimated to be $100,000. Material costs, craft installation, procedure changes, and training will bring the total cost of the project to $200,000.

SAMA No. U2-218
TITLE: Improve HPCS crosstie to Div I or II

Description:

The objective of this SAMA is to provide more reliable means for cross-tying the Div III EDG to the Division I or II switchgear given an LOOP and failure of the divisional EDGs. Currently, Unit 2 has this capability, but the process for aligning the EDG is estimated to take in excess of an hour. This makes operator reliability low for scenarios that involve station blackout with RCIC system failure.

SAMA Benefits:

An improved process for crediting the Div III EDG in station blackout scenarios could provide a risk reduction benefit. The improvement must allow operators to quickly perform the action. Limiting necessary actions to the Control Room would be desirable, but manipulation locally would be adequate as long as the actions were straightforward and limited to a few areas in close proximity. Discussion with operations, including Operations Training, indicates that procedure changes that allow implementation within 30 minutes are apparently not feasible. However, the modeled benefit described below could be achieved by SAMAs U2-215, -216, and/or -221.

Evaluation:

The basic event failure probability representing operator failure in the HPCS EDG crosstie task was reduced from 0.85 to 1E-3 for the SBO-RCIC failure case. The action was also reduced from 5E-2 to 1E-3 for cases where RCIC is successful. Top event HPCS was requantified and a new MFF derived. This MFF was requantified through the existing model to produce revised results reflective of a plant condition where an improved HPCS crosstie capability exists. The total reduction in CDF is approximately 2.5E-5/year. The population dose would decrease by 2.03 person-rem per year.

Cost of Implementation:

After further evaluation and discussions with Operations, NMPNS determined this concept was not feasible for achieving the modeled benefit. Therefore, a cost estimate was not prepared.

SAMA No. U2-219
TITLE: Improve containment venting

Description:

The modification associated with this SAMA involves providing a more reliable means of venting the primary containment by eliminating the use of blind flanges and allowing a direct, remotely operable hard-pipe vent. Currently, plant design requires operators to manually install blind flanges in the standby gas treatment system (SGTS) to bypass the SGTS filter trains (EOP-6, Attachment 21). The procedure also allows operators to vent through the SGTS filter in the event that blank flanges cannot be installed in time. This had been included in training and an emergency planning drill. Thus, significant improvement in operator action is not judged likely.

SAMA Benefits:

This would increase operator reliability by reducing the need for local actions and limiting the potential for confusion.

Evaluation:

The basic event failure probability representing operator failure in top event CV was reduced by a factor of 0.1 for each boundary condition modeled. Top event CV was requantified and a new MFF derived. This MFF was requantified through the existing model to produce revised results reflective of a plant condition where an improved primary containment venting capability exists. The total reduction in CDF is approximately 2.5E-6/year. The population dose would decrease by 5.77 person-rem per year.

Cost of Implementation:

The benefit in this case is derived from a scenario where the need for operator actions is eliminated by automated system functions. Significant regulatory hurdles to circumvent containment closure requirements and deliberate venting procedures would have to be addressed. If a modification to automatically vent containment were approved, it would involve installation of multiple valves and operators, hard piping, valve actuation circuitry, and logic. The engineering alone to evaluate such a modification would cost >$200,000. Equipment, installation, procedure changes, and training would cost >$500,000. The total cost of this work would, therefore, exceed $700,000.

SAMA No. U2-221a and b
TITLE: Reduce unit cooler contribution to EDG unavailability

Description:

The modification associated with this SAMA would provide a more reliable means of cooling the EDG control panel rooms. Two separate plant changes have been identified:

a – The first is to test the unit coolers during every cycle.

b – The second is to eliminate the unit cooler dependency. This could be accomplished by providing guidance for operators to open the EDG control panel room doors. This could also be accomplished by performing additional analysis to demonstrate equipment survivability without unit cooler operation.

SAMA Benefits:

a – This would reduce the exposure time for the standby failure mode and would reduce EDG failure probability.

b – This would provide a redundant means of cooling that would reduce the risk associated with the loss of the unit coolers.

Evaluation:

a – By increasing the testing frequency, the basic event failure probability representing five-year standby failure was reduced consistent with a one-cycle exposure time. Top events A1 and A2 were requantified and a new MFF derived. The total reduction in CDF is approximately 8.7E-6/year. The population dose would decrease by 2.82 person-rem per year.

b – A second requantification was performed based on assuming a once-per-cycle surveillance test and adding a 0.1 reduction factor to each unit cooler to model some alternate means of room cooling. The total reduction in CDF is approximately 1.9E-5/year. The population dose would decrease by 9.27 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000 and anticipates cost of analysis to be approximately $25,000. Therefore, the total cost of this modification would be $55,000. This would be applicable to both options “a” and “b.”

SAMA No. U2-222
TITLE: Improve procedures for loss of instrument air

Description:

This SAMA involves an enhancement of the loss of instrument air procedure (N2-SOP-19) to provide a better means of responding to loss of instrument air. At Unit 2, loss of instrument air causes a number of plant impacts. One that is significant in the PRA involves the failure of feedwater. Relative to feedwater, loss of instrument air causes a number of air-operated valves to transfer to their fail-safe position. This includes the condensate transfer makeup valve to the hotwell, which fails open, and the emergency (gravity) hotwell makeup valve, which fails closed. The ARP for lo-lo hotwell level directs operators to reopen the emergency hotwell makeup valve, which would support long-term feedwater operation even if the main steam isolation valves were closed. However, condensate pump and feedwater pump minimum flow line flow control valves (2CNM-FV38A/B/C and 2FWR-FV2A/B/C) fail open on loss of instrument air. N2-SOP-19 indicates that these valves fail in a way that could cause loss of feedwater and refers to the loss of feedwater procedure (N2-SOP-6) for the response direction. The minimum flow line flow control valves open a pathway back to the main condenser and would greatly limit the flow available to the reactor. While the loss of instrument air procedure mentions these valves and their impact, no specific guidance could be found for operators to manually close these valves in the event that feedwater is required.

SAMA Benefits:

As such, the PRA model fails feedwater if instrument air is unavailable. A change to provide guidance for operators to close these minimum flow line flow control valves would allow credit to be taken for feedwater response in loss of instrument air scenarios.

Evaluation:

The benefit of this modification is modeled in the PRA by changing event tree rules for event trees TR1, SL1, and ML1. For event tree TR1, the AS=F rule logic was removed from the FWF split fraction rule and FW21, FW22, and FW23 were added as rules for cases where instrument air is unavailable. These split fractions include an operator action used normally for small LOCA cases and are used for this loss of instrument air sensitivity case to insure an operator action is asked. The AS=F rule logic was also removed from the FWF rules in the SL1 and ML1 event trees and the model was requantified. The total reduction in CDF is approximately 4.6E-6/year. The population dose would decrease by 3.47 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000.

SAMA No. U2-223
TITLE: Improve Control Building flooding scenarios

Description:

The changes associated with this SAMA involve potential procedural and structural modifications to address a flood source in the Control Building.

SAMA Benefits:

An internal flood initiated in the Control Building is an important contributor to risk because it can flood out both divisions of emergency AC and DC power. These failures are also treated as non-recoverable. The internal flooding scenario contains the following contributions:

- Internal Flood Initiating Event includes contributions from the firewater main in the corridor and service water in the diesel generator rooms.
- Failure to Mitigate assumes failure to open doors to the yard to result in failure of both divisions of AC and DC power. Flood detection and mitigation is based upon direction into procedure N2-ARP-01.

In order to identify and evaluate potential procedure changes, training and/or structural modifications, more detailed analyses of initiating event causes, flooding rates, time to impact, passive component failure modes, etc., is needed. Potential structural modifications such as a door (prevent accumulation of water) or piping modifications (move firewater header) would essentially eliminate this flood source.

Evaluation:

A combination of improved initiating event frequency and/or mitigation could lead to an order of magnitude reduction in risk. To simulate this improvement, the PRA was quantified with initiating event FLCB set to 9.3E-5/yr. The total reduction in CDF is approximately 8.3E-7/year. The population dose would decrease by 1.26 person-rem per year.

Cost of Implementation:

NMPNS estimates the minimum cost of a procedure change to be $30,000; however, NMPNS assumes the most benefit could be achieved by structural modifications to eliminate the flood source. To support this evaluation, NMPNS estimates the minimum cost of a structural change, including materials and design, to be $70,000. This modification would also involve additional analyses estimated at $30,000. Therefore, the total cost would be $100,000.

F.4 REFERENCES

F.1-1 NMP1 IPE (Generic Letter 88-20 submittal, models, and supporting analyses). July 1993.

F.1-2 NMP2 IPE (Generic Letter 88-20 submittal, models, and supporting analyses). July 1992.

F.1-3 NMP1 IPEEE (Generic Letter 88-20 submittal, models, and supporting analyses). June 1996.

F.1-4 NMP2 IPEEE (Generic Letter 88-20 submittal, models, and supporting analyses). June 1995.

F.2-1 Oak Ridge National Laboratory. RSICC Computer Code Collection, MACCS2, Version 1.12, CCC-652 Code Package. Oak Ridge, Tennessee. 1997.

F.2-2 Daniel J. Alpert, David I. Chanin, Lynn T. Ritchie. *Relative Importance of Individual Elements to Reactor Accident Consequences Assuming Equal Release Fractions*. NUREG/CR-4467. Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. March 1986.

F.2-3 Parsons Brinckerhoff Quade & Douglas, Inc. *Evacuation Travel Time Estimates for James A. Fitzpatrick/Nine Mile Point Emergency Planning Zone*. July 1993.

F.2-4 New York State Emergency Management Office. *New York State Radiological Emergency Preparedness Plan*. Available at: http://www.nysemo.state.ny.us/REP/repl.html. Accessed January 30, 2002.

F.2-5 U.S. Nuclear Regulatory Commission, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants*, NUREG-0654, Rev. 1. U.S. Nuclear Regulatory Commission, Washington, D.C. October 1980.

F.2-6 S. L. Humphreys, et al. *SECPOP90: Sector Population, Land Fraction, and Economic Estimation Program*, NUREG/CR-6525. Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. January 1999.

F.2-7 U.S. Department of Agriculture. *1997 Census of Agriculture*, New York State and County Data, "Volume 1, Geographic Area Series Part 32, March 1999." Available at: http://www.nass.usda.gov/census/census97/volume1/ny-32/toc97.htm.

F.2-8 U.S Department of Agriculture, National Agricultural Statistics Service. *Agricultural Land Values, Final Estimates 1994 – 1998*. Statistical Bulletin Number 957. Available at: http://www.usda.gov/nass/pubs/histdata.htm#sb.

F.2-9 U.S. Department of Commerce. *Statistical Abstract of the United States: 2000*. March 2000. Available at: http://www.census.gov/prod/www/statistical-abstract-us.html.

F.2-10 U.S. Department of Labor, Bureau of Labor Statistics. *Consumer Price Index – U.S. City Average*. ftp://ftp.bls.gov/pub/special.requests/cpi/cpiai.txt.

F.2-11 Bureau of Economic Analysis. *Regional Accounts Data, Local Area Personal Income, Per Capita Personal Income*. Available at: http://www.bea.doc.gov/bea/regional/reis.