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September 19, 2006

Docket No. 50-271
BVY 06-086
TAC No. MC 9670

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

Reference: 1. Letter, Entergy to USNRC, "Vermont Yankee Nuclear Power Station, License No. DPR-28, License Renewal Application," BVY 06-009, dated January 25, 2006.

2. Letter, USNRC to Entergy, "Request for Additional Information Regarding Severe Accident Mitigation Alternatives for the Vermont Yankee Nuclear Power Station, NVY 06-068, dated June 1, 2006.

Subject: Vermont Yankee Nuclear Power Station
License No. DPR-28 (Docket No. 50-271)
License Renewal Application, Amendment 13

On January 25, 2006, Entergy Nuclear Operations, Inc. and Entergy Nuclear Vermont Yankee, LLC (Entergy) submitted the License Renewal Application (LRA) for the Vermont Yankee Nuclear Power Station (VYNPS) as indicated by Reference 1. In Reference 2, the NRC provided a Request for Additional Information (RAIs) pertaining to Severe Accident Mitigation Alternatives (SAMA).

During the development of the recent Mitigating Systems Performance Index (MSPI), changes to the Vermont Yankee Probabilistic Safety Assessment (PSA) model were identified. A sensitivity study was completed to determine the impact of these changes on the SAMA analysis. Based on this, Attachment 1 provides responses to RAIs that were affected by the model changes as Part 2 of 2 to the RAI responses contained in VYNPS Letter BVY 06-071.

This submittal does not contain new regulatory commitments.

Should you have any questions concerning this letter, please contact Mr. James DeVincentis at (802) 258-4236.

I declare under penalty of perjury that the foregoing is true and correct, executed on September 19, 2006.

Sincerely,

Ted A. Sullivan
Site Vice President
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Attachment 1
cc: See next page

A117

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BVY 06-086
Docket No. 50-271

Attachment 1

Vermont Yankee Nuclear Power Station

License Renewal Application

Amendment 13

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

REGARDING THE ANALYSIS OF SEVERE ACCIDENT MITIGATION ALTERNATIVES (SAMAs)

FOR THE VERMONT YANKEE NUCLEAR POWER STATION (VYNPS)

SUBMITTAL 2 OF 2

DOCKET NO. 50-271

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Attachment A

VYNPS SAMA Remaining RAI Responses

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Tables

NRC RAI 1

The SAMA analysis is said to be based on the most recent version of the VYNPS Probabilistic Safety Analysis (PSA) (VY04R1). Provide the following information regarding these PSA models:

a. Table E.1-8 indicates that the core damage frequency (CDF) associated with station blackout sequences (Classes IBE and IBL) is 1.2E-06 per year. This is considerably more than the CDF due to loss of offsite power (LOOP) (7.2E-7 per year in Table E.1-2) and is comparable to the total CDF due to LOOP and loss of alternating current (ac) bus initiating events. Provide the station blackout (SBO) CDF frequency along with its derivation.

b. The VYNPS extended power uprate (EPU) application and response to EPU requests for additional information indicate that the VY02R6 model had a CDF of 7.77E-06 per year and that this increased to 8.1E-06 for EPU conditions. This is different from the current value of 5E-06. Provide a summary of the major Levels 1 and 2 PSA versions and their CDFs from the individual plant examination (IPE) to the present, including the version reviewed by the Boiling Water Reactors Owners Group (BWROG). Also, indicate the major changes to each version from the prior version and the major reasons for changes in the CDF.

c. Discuss the overall conclusion of the BWROG peer review relative to the use of the VYNPS PSA.

d. Internal flooding initiating events are the dominant contributors to CDF at VYNPS. Briefly describe the internal flooding analysis and its evolution, including internal and external peer reviews, the results of these reviews, and any subsequent model updates. It is noted that the BWROG A and B facts and observations did not include internal flooding. Clarify whether the internal flooding analysis was covered in the BWROG peer review.

Response to RAI 1a

Classes IBE and IBL from Table E.1-8 are not directly comparable with LOOP in Table E.1-2. Table E.1-2, "VYNPS PSA Model CDF Results by Major Initiators" provides CDF results for each type of initiating event. However, Table E.1-8, "Summary of Vermont Yankee Core Damage Accident Sequence Functional Classes", provides CDF for each type of accident sequence.

In Table E.1-8, there are several "bins" which refer to SBO "type" accident sequences. The term "station blackout" (SBO) refers to the complete loss of alternating current electric power to the essential and nonessential switchgear buses in a nuclear power plant. Obviously, the core damage endstate will only result when these accident sequences contain additional equipment failures. The revised PSA model makes no distinction between failure of HPCI and RCIC before or after battery depletion (see revised Table E.1-8 in Attachment C). Therefore, Class IBL bin (which previously contained accident sequences in which HPCI and RCIC failure occurred following battery depletion) was not used. Thus, the following bins were created to assist in evaluation of SBO "type" of accident sequences:

Class IBE bin contains those accident sequences where, regardless of the initiating event,

- AC power from essential bus 3 is not available, and
- AC power from essential bus 4 is not available, and
- High pressure coolant injection (HPCI) fails to start and run, and
- Reactor core isolation cooling (RCIC) fails to start and run.

Class IED bin contains those accident sequences where, regardless of the initiating event,

- AC power from essential bus 3 is not available, and
- AC power from essential bus 4 is not available, and
- 125VDC bus 1 is failed, and
- 125VDC bus 2 is failed.

Table RAI.1-1 lists the accident sequence initiating events representing the CDF contribution from the Class IBE bin, and Table RAI.1-2 lists the accident sequence initiating events representing the CDF contribution from the Class IED bin.

Approximately 57% of Class IBE sequences are initiated by a LOOP event, and approximately 3.0% of Class IED sequences are initiated by a LOOP event.

Response to RAI 1b

Table RAI.1-3 provides a summary of the major PSA model versions from the IPE to the present. Model VY118 was used in support of the BWROG peer review. Model VY118 was used for evaluating transients and LOCA initiating events analysis, and the original IPEEE model was used for evaluating internal flood initiating events analysis. The original IPE model was used in support of the BWROG peer review of the PRA Level 2 modeling elements.

The EPU project was reviewed to determine the potential impact risk profile. Risk impacts due to internal events were assessed using sensitivity studies based upon the VY02R6 Model. This review included identification of principal elements of the risk assessment that may be affected by the EPU and associated plant changes. For example, the change in normal full power configuration to require all three feedwater pumps could be postulated to increase the frequency of a plant trip. This potential increase in trip frequency was explicitly addressed in this EPU risk assessment. Thus the result reported that there was a potential increase to 8.1 E-06 for EPU conditions, assuming that future adverse events might occur due to operation at the increased power level. The "EPU Sensitivity Model" was not an actual revision of the PSA model and is not included in Table RAI.1-3.

1998 PSA Model Update (VY118)

- The model was revised to correct modeling limitations found subsequent to the IPE (1993 original issue). These limitations had a minor effect on the results; however they were resolved to improve the accuracy of the model. Specific revisions included (1) remodeling of the logic rules for the emergency core cooling system (ECCS) low pressure injection actuation signal for transient events, (2) recalculation of the low pressure coolant injection (LPCI) system interfacing system loss of coolant accident (ISLOCA) initiating event frequency, (3) revising the LPCI fault tree model to include the recirculation loop discharge valves, and (4) simplifying the long term DC power model by taking no credit for the spare battery charger.
- Three design changes required revision to the model.
    - New instrumentation was installed to satisfy anticipated transient without scram (ATWS) rule equipment diversity requirements. The diverse equipment installed by this design change included new reactor level and reactor pressure transmitters,

alarm relay modules and relays and modification of two existing water level transmitter loops.

- o The normal standby position of the LPCI / residual heat removal (RHR) minimum flow valves was changed from closed to open. This was done to eliminate a "single failure" design basis vulnerability relating to loss of minimum flow protection and subsequent failure of the associated loop LPCI / RHR pumps (which are cross-train powered).
- o The standby position of the torus vent valve was changed from "normally open" to "normally closed". With a normally closed valve, venting success requires plant operators to take manual action to open the valve to align the hard-piped torus vent path. The human error probability (HEP) for opening the valve was also included within this update.

<u>2000 PSA Model Update (VY00R0)</u>

- ▫ Individual RISKMAN models for transients, LOCAs, internal flooding, ISLOCA, LOCA outside of containment, and Level 2 were integrated into a single larger model.
- ▫ The component failure database was updated. A component failure data evaluation was performed in 1999 which reviewed maintenance rule component failure rate data for the time period from January 1, 1992 to June 31, 1998. This failure rate data was combined with the existing failure rate data for these components using a Bayesian updating process.
- ▫ Minor modifications were performed to enhance the integrated model. These modifications and enhancements were part of the RISKMAN version 2.0 Software Implementation Plan. Specifically, conversion of the existing PSA models from the DOS based RISKMAN version 9.1 to the WINDOWS based RISKMAN version 2.0.

<u>2002 PSA Model Updates</u>

<u>VY02R0</u>

- ▫ Major plant design changes were incorporated.
  - o The long term 125 VDC model was updated to reflect the addition of a fourth battery charger, resulting in each 125 VDC bus having two battery chargers, one aligned, and one in standby or maintenance. In addition, the load shed feature resulting from a loss of normal power event was removed to reflect this design modification.
  - o The 24VDC ECCS system model was modified to reflect the replacement of the 24 VDC batteries with 125VDC to 24VDC converters to power busses DC-1 and DC-2.
  - o The containment nitrogen system model was updated to include new additional seismic piping and N2 supply.
- ▫ Failure rate and unavailability data were updated.
  - o Plant-specific failure frequency values were updated with recent data using a Bayesian updating process.
  - o Maintenance unavailability values were updated. The updated unavailability values were derived from a weighted average of the unavailability observed for the time 1992 to 1998 with that of the most recent time period form 1998 to 2002.

- Facts and Observations (F&Os) related to data analysis from the BWROG peer review were resolved.

- Initiating event frequencies were updated.
  - Data for all relevant initiating events were updated based on plant-specific and industry data.
  - F&Os related to initiating event frequencies from the BWROG peer review were resolved.
- Internal flood events model was updated.
  - Initiating event modeling for the large service water (SW) discharge pipe break in the torus room was replaced with two separate initiators. Procedure ON 3148, "Loss of Service Water", was significantly revised to address large breaks in the SW, including large discharge line breaks in the reactor building. The upgraded procedure distinguishes whether the SW discharge pipe break is located on the reactor building side of SW manual valve SW-18 or the turbine building side of SW-18.
  - The HEP for the "initial" operator response for flood mitigation was revised for many of the flooding events, based on the joint-HEP, time dependent, lower bound curve from the THERP methodology for time window >30 minutes.
  - The "FLOODS" frontline event tree was revised to include additional credit for the control rod drive (CRD) system as a reactor vessel injection system.
  - The pipe break initiating event frequency for piping associated with the condensate storage system was reduced to better account for the relatively mild internal operating conditions for this pipe.

<u>VY02R1</u>

- Revised model to successfully convey previously unaccounted for FLOODS Level 1 information to the containment event tree, resulting in the capture of all FLOODS sequences in the Level 2 end states.

<u>VY02R2</u>

- Corrected an error in the original quantification of the service water recovery factor used in top event AW (recovery of SW system or initiation of alternate cooling system). The probability for failure "to recover SW was changed from 0.2 to 0.8.
- The probability of non-recovery of offsite power for the loss of offsite initiator (TLP) was updated from 8.8E-2 to 9.7E-2.

<u>VY02R3</u>

- The model was revised to include separate initiators for inadvertent opening of a relief valve (IORV) and stuck-open relief valve (SORV). Transient event tree sequences in which a safety relief valve (SRV) fails to re-close were summed to obtain the frequency for the SORV initiator. The value for the IORV initiating event was derived from industry data obtained from NUREG/CR-5750.

VY02R4

- Removed CRD as a potential source of injection early in the event sequence. CRD is still credited as a potential 'late' alternate injection source when early injection has been accomplished by LPCI, core spray or condensate systems. Results of updated MAAP calculations indicated that early CRD injection would not be successful in preventing core damage.
- Expanded use of the diesel driven fire pump as a potential source of alternate injection for all accident sequences when random failures or support system failures prevent alternate injection by either the CRD or condensate transfer systems.

VY02R5

- Minor changes were made to the containment event tree (CET):
  - The split fraction rule for guaranteed successful depressurization was modified to account for transient events that result in an SRV opening and subsequently failing to close.
  - Split fraction rule for heat removal were modified to remove RHR system dependence on room coolers RRU-7 and RRU-8.

VY02R6

- Revised model to reflect re-quantification of three fault trees previously improperly quantified: CG (containment N2), S1/S2 (alternate shutdown DC-1AS and DC-2AS) and AICD (alternate injection using the CRD system). Examination of the fault trees showed the model and basic events to be current, but these fault trees apparently were not properly re-quantified using the new values during execution of previous model update. The overall impact of these changes was a slight reduction in calculated CDF.

VY02R7

- Minor changes were made to support use of an updated version of the risk analysis software program, RISKMAN Version 6.5 (RM6.5). Minor improvements incorporated into the fault tree quantification module resulted in slight changes in the split fraction values stored in the master frequency file. The overall impact of these code changes was a slight reduction in calculated CDF.

VY02R8

- The split fraction assignment rule for CRD injection in the FLOODS event tree to reflect the fact that failure of either the LPCI pumps or injection valve will fail the CRD injection function. Correction of this error resulted in an increase in the CDF calculated for internal flooding initiating events.

2004 PSA Model Updates

VY04R0

- Model was revised to account for effects associated with the EPU. The EPU was reviewed to determine the impact on the risk profile associated with operation at an increased power level of 1912 MWt.

- o An additional spring safety valve (SSV) was installed to provide additional overpressure capacity to satisfy ASME code requirements at 120% power. Also, the capacity of the SSVs was increased. This required revision of the following top events:
  - Top event PR, which evaluates use of the Safety Relief Valves (SRVs) and SSVs to accomplish pressure relief of the reactor coolant system during ATWS event sequences.
  - Top event SO, which evaluates use of the safety relief valves (SRVs) and SSVs to accomplish reactor pressure control during transients following a main steam isolation valve (MSIV) closure event or random failure of the turbine bypass valves.
- o Review of MAAP cases indicated that the number of SRV cycles increases for the EPU power level versus the pre-EPU power level. Therefore, the stuck-open relief valve probability given a transient initiator was increased to represent the EPU configuration.
- o The higher power level associated with EPU results in reduced times available for some operator actions. Success of these actions is dependent on a number of performance shaping factors. The performance shaping factor that was principally influenced by EPU is the time available within which to detect, diagnose, and perform required actions. To quantify the potential impact of this performance shaping factor, deterministic thermal hydraulic calculations using the MAAP computer code were used. HEPs for twelve (12) operator actions were adjusted accordingly.

- ▫ The SW recovery model was improved. Changes were made to the top event fault tree to include an improved SW recovery model in place of the estimated recovery factor that was being used. The recovery model reflects operator response to a variety of system failure modes. The SW recovery model was based upon loss of SW initiating event fault tree analysis.
- ▫ Flooding on reactor building elevation 280' was re-evaluated. This re-evaluation was performed to correct assumptions made in regard to the impact of a possible major break in the SW system 18" diameter supply piping on El. 280'.
- ▫ Loss of vital DC bus initiating event frequencies was updated.
- ▫ Instrument failure rate distributions models were updated using more recent industry data.
- ▫ Reactor protection system (RPS) fault tree model was updated. Scram failure probabilities were updated using NUREG/CR-5500. This report documents an analysis of the safety-related performance of the RPS at U.S. General Electric commercial reactors during the period 1984 through 1995.
- ▫ Asymmetries in top event fault trees were removed. Asymmetries generally make risk importance indications (such as risk reduction and risk achievement worth) lower-than-actual for one train, while making it higher-than-actual for its redundant train. This specifically affects the appropriateness of the model for use in applications such as configuration risk monitoring (e.g., ORAM-Sentinel Online Risk Monitor). To support this application, it was necessary to remove asymmetries from the underlying PSA model.
- ▫ The macro rules for front-line event trees used in the Level 2 analysis were changed to obtain a closer match with the binning rules used in the Level 1 analysis. Additional macro rules were introduced for completeness even though they had no impact on the result.

VY04R1

- A new offsite power recovery model was developed which reflects the a revised understanding on the use of the Vernon Dam Hydro Station to supply power to either vital bus via the Vernon Tie within four hours following a grid-related SBO event. The 1992 SBO recovery model assumed that the time to restore AC power from the hydro station was no more than 10 minutes, regardless of the type of SBO event.

2005 PSA Model Update

See Attachment C.

Response to RAI 1c

Response has been previously submitted via letter BVY 06-071.

Response to RAI 1d

Response has been previously submitted via letter BVY 06-071.

Table RAI.1-1 Top Initiating Events Contributing to Class IBE Accident Sequences

Sequence Initiator Bin IBE	IE Description	CDF Contribution	% Bin IBE
TWRLP	TRANSIENT WITH WEATHER - RELATED LOSS OF OFFSITE POWER	1.73E-06	43.61%
TA3	TRANSIENT WITH LOSS OF AC BUS 3	6.92E-07	17.47%
TA4	TRANSIENT WITH LOSS OF AC BUS 4	6.80E-07	17.19%
TGRLP	TRANSIENT WITH GRID-RELATED LOSS OF OFFSITE POWER	4.44E-07	11.22%
TPCLP	TRANSIENT WITH PLANT-CENTERED LOSS OF OFFSITE POWER	1.01E-07	2.55%
T	TRANSIENT	5.80E-08	1.47%
TBCWF	FLOOD EVENT TURBINE BUILDING DUE TO CIRC. WATER PIPE BREAK	4.96E-08	1.25%
TD1	TRANSIENT WITH LOSS OF DC BUS 1	4.25E-08	1.07%
TD2	TRANSIENT WITH LOSS OF DC BUS 2	4.25E-08	1.07%
TMS	TRANSIENT WITH MSIV CLOSURE	1.90E-08	0.48%
DGBF2	AUX STEAM, POTABLE WATER PIPE BREAK IN DG B ROOM	1.80E-08	0.46%
DGAF2	AUX STEAM, POTABLE WATER PIPE BREAK IN DG A ROOM	1.77E-08	0.45%
DGAF1	FLOOD EVENT IN DG-A ROOM DUE TO SERVICE WATER PIPE BREAK	1.66E-08	0.42%
DGBF1	FLOOD EVENT IN DG-B ROOM DUE TO SERVICE WATER PIPE BREAK	1.28E-08	0.32%
TFWMS	TRANSIENT WITH LOSS OF FW, MSIV CLOSURE	1.16E-08	0.29%
TBSWF	FLOOD EVENT TURBINE BUILDING DUE TO SERVICE WATER AND FIRE WATER PIPE BREAKS	7.35E-09	0.19%
TBHVF	FLOOD EVENT TB-HVAC ROOM AND FRONT OFFICE BLDG DUE TO SERVICE WATER PIPE BREAK	5.32E-09	0.13%
R280F2	SPRAY EVENT REACTOR BLDG EL 280 NORTH SIDE DUE TO CORE SPRAY PIPE BREAK	4.27E-09	0.11%
IORV	INADVERTENT/STUCK OPEN RELIEF VALVE	2.84E-09	0.07%
SLOCA	SMALL LOCA	1.20E-09	0.03%
Others	(sum total of 35 initiating events consisting of the SORV, MLOCA, LLOCA, and 32 internal flooding events)	5.56E-09	0.14%
	Total	3.96E-06	100.00%

Table RAI.1-2 Top Initiating Events Contributing to Class IED Accident Sequences

Sequence Initiator Bin IED	IE Description	CDF Contribution	% Bin IED
T	TRANSIENT	2.13E-08	37.84%
TD1	TRANSIENT WITH LOSS OF DC BUS 1	1.10E-08	19.54%
TD2	TRANSIENT WITH LOSS OF DC BUS 2	9.79E-09	17.38%
TMS	TRANSIENT WITH MSIV CLOSURE	6.98E-09	12.38%
TFWMS	TRANSIENT WITH LOSS OF FW, MSIV CLOSURE	4.26E-09	7.57%
TPCLP	TRANSIENT WITH PLANT-CENTERED LOSS OF OFFSITE POWER	1.40E-09	2.48%
IORV	INADVERTENT/STUCK OPEN RELIEF VALVE	5.54E-10	0.98%
SLOCA	SMALL LOCA	2.35E-10	0.42%
TWRLP	TRANSIENT WITH WEATHER - RELATED LOSS OF OFFSITE POWER	2.01E-10	0.36%
TA3	TRANSIENT WITH LOSS OF AC BUS 3	1.66E-10	0.30%
TA4	TRANSIENT WITH LOSS OF AC BUS 4	1.66E-10	0.30%
SORV	Stuck-Open Relief Valve	1.53E-10	0.27%
TGRLP	TRANSIENT WITH GRID-RELATED LOSS OF OFFSITE POWER	7.34E-11	0.13%
TSW	TRANSIENT WITH LOSS OF SERVICE WATER	3.04E-11	0.05%
	Total	5.63E-08	100.00%

Table RAI.1-3 Summary of Major PSA Model Versions

Model	CDF[1]	LERF
IPE (transients & LOCAs)	4.3 E-06	9.4 E-07
VY118 (transients & LOCAs)	4.9 E-06	n/a
IPEEE (internal floods)	9.0 E-06	n/a
VY00R0	1.78E-05	9.33E-07
VY02R0	4.28E-06	1.05E-06
VY02R1	4.28E-06	1.12E-06
VY02R2	4.62E-06	n/a
VY02R3	4.89E-06	n/a
VY02R4	7.81E-06	n/a
VY02R5	7.81E-06	2.29E-06
VY02R6	7.77E-06	2.29E-06
VY02R7	7.63E-06	2.23E-06
VY02R8	8.73E-06	2.61E-06
VY04R0	4.91E-06	1.50E-06
VY04R1	5.03E-06	1.56E-06
VY05R0	7.98E-06	2.50 E-6

[1] With the exception of the original IPE, IPEEE, and version VY118 CDF and LERF values, subsequent VYNPS model version updated CDF and LERF values include the combine contributions from transients, LOCAs and internal floods initiators.

NRC RAI 2

Provide the following information relative to the Level 2 analysis:

a. Section E.1.2.2.5 implies that the binning of Level 1 results into plant damage states (PDSs) is the principal means of ensuring the proper Level 1 to Level 2 interface. Section 4.3 of the IPE states that binning is only used to summarize and report the results. Clarify the use of PDSs, including whether the containment event tree is directly linked to the Level 1 models (such that Level 1 failures are recognized by the Level 2 analysis).

b. Provide the fission product release characteristics for each release category, including fission product release fractions, release times and duration, warning time, release elevation, and energy of release.

c. Briefly describe the approach used to determine the source terms for each release category. Clarify whether new modular accident analysis program (MAAP) analyses were performed as part of the development of the current model and how the MAAP cases were selected to represent each release category (i.e., based on the frequency-dominant sequence in each category or on a conservative, bounding sequence).

d. Clarify whether the Level 2 model was included in the BWROG peer review. If so, describe the conclusion relative to this element. If not, describe the internal and external reviews of the Level 2 analysis that have been performed, the results of these reviews, and any subsequent model updates.

e. Approximately 75 percent of the CDF results in an "early" release. Explain this relatively high percentage and describe the containment failures/release modes that lead to these releases.

Response to RAI 2a

Response has been previously submitted via letter BVY 06-071.

Response to RAI 2b

Values for the release category parameters used in the SAMAs evaluations are listed in Attachment C (Table RAI.2.b).

Response to RAI 2c

The MAAP computer code is used to generate the radionuclide release magnitude for the MACCS2 consequence analysis. The MAAP calculations are representative deterministic thermal hydraulic calculations that portray dominant CET scenarios. Sixty-four accident progression scenarios were analyzed.

The source terms presented in Table RAI.2.b (Attachment C) and used in the consequence analysis are determined as follows:

1. The appropriate MAAP case source terms are selected and assigned to a particular CET accident progression endstate.

2. Based on the source terms from Step 1, the source terms for each plant damage state CET accident progression endstate are determined.

3. The mean frequency of each release category is determined by summing the individual plant damage state CET accident progression endstates contained in the particular release category (i.e., no containment failure, early high release, etc.).

4. The release category individual fractional contributions for each CET accident progression are determined by dividing the result from Step 3 by the individual PDSs frequencies.

5. Each PDS accident progression CET endpoint source terms, release timing, release energy and release elevation by the value determine in Step 4.

6. Sum the individual results of Step 5 to arrive at the total final values contained in Table RAI.2.b (Attachment C).

Response to RAI 2d

Response has been previously submitted via letter BVY 06-071.

Response to RAI 2e

Response has been previously submitted via letter BVY 06-071.

NRC RAI 3

With regard to the treatment and inclusion of external events in the SAMA analysis:

a. The environmental report (ER) uses the staff's conclusions from a prior SAMA evaluation to justify that the VYNPS fire CDF is conservative by a factor of three. Provide a description of the conservatism in the dominant VYNPS fire CDF sequences (e.g., related to fire initiating event frequencies, severity factors, or recovery actions that were not credited) that would support this factor of three.

b. The seismic CDF at VYNPS is not mentioned in the ER or included within in the multiplier used to account for additional SAMA benefits in external events. Provide the estimated seismic CDF at VYNPS, and an assessment of the impact on the external event multiplier, and on the SAMA analysis results if the seismic CDF is included.

c. Entergy's baseline evaluation of SAMA benefits considers only the risk reduction associated with internal events, and neglects the additional risk reduction that a SAMA could have in external events. Entergy does consider the potential for additional risk reduction in external events, but this is done in the context of an upper bound assessment in which the internal event benefits are increased by a factor of ten to account for the combined effect of external events and analysis uncertainties. The impact of external events should be reflected in the baseline evaluation, rather than combining the impact of external events with the uncertainty assessment. In this regard, provide a revised baseline evaluation (using a 7 percent discount rate) that accounts for risk reduction in both internal and external events, and an alternate case using a 3 percent discount rate. (Note that the CDF for external events after Entergy's adjustment in the ER is 3.7 times higher than the internal events CDF. This would justify a multiplier of 4.7 or 5, rather than a multiplier of 4 as stated in the ER.)

d. Provide an assessment of the impact on the baseline evaluation results (i.e., the revised baseline evaluation, which accounts for external events) if risk reduction estimates are increased to account for uncertainties in the analysis.

Response to RAI 3a

Response has been previously submitted via letter BVY 06-071.

Response to RAI 3b

Response has been previously submitted via letter BVY 06-071.

Response to RAI 3c

The SAMA analyses have been redone and presented in the requested format in Attachment B, Revised Table E.2-1. As noted in the Attachment B revised multiplier discussion, the appropriate multiplier is 3.33 on the averted cost risk estimates to represent the total SAMA benefits, accounting for both internal and external events.

Response to RAI 3d

The SAMA analyses have been redone and presented in the requested format in Attachment B, Revised Table E.2-1.

NRC RAI 4

Provide the following information concerning the MACCS analyses:

a. Annual meteorology data from the year 2002 were used in the MACCS2 analyses. Provide a brief statement regarding the acceptability of use of this year's data rather than a different year's data.

b. For the emergency response assumptions, indicate what percentage of the population was assumed to evacuate.

c. The MACCS2 analysis for VYNPS is based on a core inventory from a mid-1980 analysis, scaled by the power level for VYNPS. Current boiling water reactor BWR fuel management practices use longer fuel cycles (time between refueling) and result in significantly higher fuel burnups. The use of the older BWR core inventory, instead of a plant specific cycle, could significantly underestimate the inventory of long-lived radionuclides important to population dose (such as Sr-90, Cs-134 and Cs-137), and thus impact the SAMA evaluation. Justify the adequacy of the SAMA cost benefit evaluation, given the fuel enrichment and burnup expected at VYNPS.

Response to RAI 4a

Response has been previously submitted via letter BVY 06-071.

Response to RAI 4b

Response has been previously submitted via letter BVY 06-071.

Response to RAI 4c

Response has been previously submitted via letter BVY 06-071.

NRC RAI 5

Provide the following with regard to the SAMA identification and screening processes:

a. Section E.1.3.1 indicates that no simple cost-effective enhancements have been identified that will significantly improve the high confidence in low probability of failure (HCLPF) for the condensate storage tank (CST) of 0.25. Provide a cost benefit analysis for the seismic improvement of the CST similar to that for the other SAMAs.

b. The individual plant examination of external events (IPEEE) found that the diesel fuel oil storage tank had a HCLPF of 0.29. The ER states that all improvements identified in NUREG-1742 (which include the diesel fuel oil storage tank) have been implemented. Describe the actions taken for the diesel fuel oil storage tank.

c. The VYNPS IPEEE lists a number of seismic improvement opportunities that are not specifically included in NUREG-1742 (specifically, seismic items 3 (ii) and 7 of IPEEE Section 7.2.2). Confirm that these have been implemented.

d. Describe any further efforts made to determine if any SAMA candidates exist to address seismic risk beyond those already identified in the IPEEE.

e. The listing of "risk significant terms," provided in Table E.1-3, includes numerous different internal flooding initiators, and the SAMAs considered to address these initiators. For most of these initiators, various Phase I SAMAs are identified as having been implemented, and Phase II SAMA 47 was evaluated to further reduce the internal flooding contribution.

   I. For each of the previously implemented changes, clarify whether the change is credited in the current PSA. If not, provide an assessment of the impact of the change on the internal flood CDF. If the change has already been credited, it would not appear to have been completely effective (as evidenced by the high residual risk of the initiating event) and additional SAMAs specific to the flooding event listed in the table could be cost-beneficial.

   II. Phase II SAMA 47 does not appear to address any of the specific internal flooding events listed in the table. Clarify which specific flooding scenario is addressed by SAMA 47.

f. Provide the current status of the 14 opportunities for improvement identified in the IPEEE for internal flooding, indicating if they have been implemented and if credit is taken for them in the current PSA. For those not implemented, indicate their importance and why they should not be considered as SAMA candidates.

g. The fire CDF, even after the reduction factor of three, is almost four times the internal events CDF. While the ER states that the improvements that address fire risk at VYNPS recommended in NUREG-1742 have all been implemented, the fire CDF is still substantial. SAMA candidates based on internal risk contributors will not necessarily address the fire risk. For each fire area or dominant fire sequence, explain what measures were taken to further reduce risk, and explain why the fire CDFs can not be further reduced in a cost-effective manner.

h. In Table E.1-3, the entry for "Transient with [power conversion system] available - initiating event" (risk reduction worth (RRW) of 1.0287) cites SAMA 046 to improve main steam isolation valve (MSIV) design. Explain how this impacts the initiator which must have the MSIV open.

i. As an alternative to Phase II SAMA 2, consider operating procedure revisions to provide additional space cooling via the use of portable equipment or blocking doors open.

j. Phase II SAMA 59 considers installing instruments for opening safety/relief valves (SRVs) for medium loss of coolant accidents (LOCAs). Explain why the benefits of this SAMA in small LOCAs and transients are not included in the benefit assessment.

k. Table E.1-3 indicates that failure of torus venting components has a RRW of 1.0948. Describe the failures considered in this assessment. Provide an assessment of the costs and benefits associated with: 1) adding redundant components, and 2) converting the vent system to a passive design.

l. The Table E.1-3 entry for "Operator Action: Operator fails to start a [turbine building closed cooling water] (TBCCW) pump" indicates that no Phase II SAMAs were recommended. Provide an assessment of the costs and benefits of starting a TBCCW pump automatically.

Response to RAI 5a

As stated in Section E.1.3.1, evaluations determined no simple cost effective modification was possible that would raise the condensate storage tank (CST) HCLPF from .25g to .3g.

Short of replacing the entire tank, a combination of strengthening the lower portion of the shell and additional anchorage would be required to gain additional HCLPF margin. There are currently forty-eight 1-3/4" diameter embedded anchor bolts spaced around the perimeter of the tank base. Up to double the amount of bolts may be required to positively affect the HCLPF. If conceptual studies found that additional anchorages actually decreased the overall capacity due to decrease in spacing around the perimeter of the tank within the existing bolt circle, then the foundation would need to be expanded. Also, additional lower tank wall reinforcement lateral stiffeners would be needed.

The estimate cost of strengthening the lower shell portion of the CST and providing additional anchorage is $995,839. To asses the benefit of this improvement on CDF, operator failure to switchover from CST suction for HPCI/RCIC to torus suction was eliminated. The revised baseline with uncertainty benefit was found to be $17,094. Since the cost of improving the CST HCLPF is larger than the benefit, this improvement is considered not cost effective.

Response to RAI 5b

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5c

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5d

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5e

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5f

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5g

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5h

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5i

Phase II SAMA 2 evaluated the cost-benefit of providing a redundant train of EDG room ventilation. The CDF contribution from EDG failures was eliminated to conservatively assess the benefit of this SAMA. The revised baseline with uncertainty benefit for this SAMA is $1,612,960. The cost of implementing this SAMA was estimated to be $2,202,725; therefore, this SAMA was not considered cost effective.

In response to this RAI, a new SAMA similar to Phase II SAMA 2 was evaluated by substituting operator procedure revisions to provide additional space cooling via the use of portable equipment. The estimated cost for procedure changes and operator training is $35,000, and the estimated cost for providing additional space cooling via the use of portable equipment is $15,000. Since the cost of this alternative appears to be less than the benefit, this SAMA is potentially cost beneficial.

Response to RAI 5j

Response has been previously submitted via letter BVY 06-071.

Response to RAI 5k

The failures considered in the torus vent path included random failures associated with torus vent motor-operated valve TVS-86 failing to open when required and torus vent rupture disk failing to open on demand.

To assess the potential costs and benefits associated with: 1) adding redundant components, and 2) converting the vent system to a passive design, a RISKMAN case was run to evaluate the bounded benefit of a passive torus venting system. Success of this passive system only required the closure of two isolation check valves and sufficient containment pressure to cause torus vent rupture disk to fail. Although the venting process is passive in this model, subsequent operator action is still required to control the venting in

order to maintain the required net positive suction head for LPCI pumps taking suction from the torus.

Conversion of the existing torus vent to a passive torus vent resulted in a CDF reduction of 4.5 percent and a revised baseline with uncertainty benefit of approximately $367,237.

The cost of providing an alternate power source to torus vent valve V16-19-86 is $720,153, while the cost of providing a redundant vent path is $1,504,616. The cost of changing the harden torus vent to a passive design is estimated to be $983,356. Therefore, proposed enhancements to the current torus vent system are not cost effective.

Response to RAI 5l

During a loss-of-offsite-power initiated event, the operating turbine building closed cooling water (TBCCW) pump trips off and the signal to start the pump on low discharge pressure is blocked. Therefore, a pump does not automatically start when power is restored and must be restarted manually from the control room. To conservatively evaluate the benefit of providing an auto-start feature for this event, a RISKMAN model was created with the operator action to start a TBCCW pump set to guaranteed success. These changes resulted in a CDF reduction of 1.4% and a revised baseline with uncertainty benefit of approximately $48,503. Since hardware modifications cost more than $100,000 (ER Section E.2.3), a modification to auto-start a TBCCW pump is not cost effective.

NRC RAI 6

Provide the following with regard to the Phase II cost-benefit evaluations:

a. For a number of the Phase II SAMAs listed in Table E.2-1, the information provided does not sufficiently describe the associated modifications and what is included in the cost estimate. Provide a more detailed description of the modifications for Phase II SAMAs 6, 9, 10, 13, 23, 24, 33, 41, 52, 56, and 63.

b. Several of the cost estimates provided were drawn from previous SAMA analyses for a dual-unit site (e.g., Peach Bottom). As such, many of those cost estimates reflect the cost for implementation in two units. Since VYNPS is a single-unit site, some of the cost estimates should be one-half of what has been cited (i.e., Phase II SAMAs 29, 35, 40, 49, 50, 51, 52, 53, and 54) while others are specific to a plant's design, such as the number of valves or batteries that need to be replaced or added (i.e., Phase II SAMAs 46, 55, and 60). For these cases, provide appropriate (specific to VYNPS) cost estimates. (Note that Phase II SAMAs 49, 50, 51, 53, and 54 are close to being potentially cost-beneficial when a 3 percent real discount rate is used.)

c. Phase II SAMA 27 uses the same analysis case (Strengthen Containment) as Phase II SAMAs 13, 18, and 19 to evaluate the benefit. Yet, Table E.2-1 lists SAMA 27 as having a CDF reduction of 0.0 percent, while all other SAMAs for this analysis case list a CDF reduction of 7.36 percent. Explain this discrepancy.

d. For Phase II SAMA 28 and 29 (and others) a 3 percent reduction in CDF was estimated by changing the time available to recover off-site power before high pressure coolant injection/reactor core isolation coolant (RCIC) are lost from 4 hours to 24 hours. According to Table E.1-8, late SBO sequences (Class IBL) contribute about 17 percent of the total CDF. Explain why only a 3 percent reduction in CDF was estimated for this SAMA.

e. For Phase II SAMA 42, a 1.3 percent reduction in offsite dose was estimated by reassigning the interfacing systems loss of coolant accident (ISLOCA) sequences to the same end states as medium LOCAs. For Phase II SAMA 43, a 1.2 percent reduction in offsite dose was obtained by eliminating the CDF contribution due to ISLOCA. One would expect the dose reduction for SAMA 43 to be greater than that for SAMA 42. Also, the CDF contribution from ISLOCA is given in Table E.1-2 as 0.32 percent, while the CDF reduction from SAMA 43 is given as 0.83 percent. Explain these apparent discrepancies.

f. Phase II SAMA 57 is stated to include items which reduce the contribution of anticipated transient without scram. Indicate which items are included.

g. Phase II SAMA 59 involves providing instrument signals to open SRVs for medium LOCA. Discuss whether the signals already exist in the automatic depressurization system.

h. Phase II SAMA 63, Control Containment Venting within a Narrow Band of Pressure, is intended to eliminate failures associated with successful venting. The benefit of this SAMA was determined by reducing the operator failure to vent by a factor of three. It is not clear that reducing the failure to vent probability is related to the actual benefit from this SAMA. Also, the cost of $250,000 appears high for what appears to be a procedure and training issue. Justify the benefit and cost for this SAMA.

i. Phase II SAMA 64, Provide Cross Tie from the residual heat removal service water (RHRSW) System to residual heat removal Loop B, has an estimated CDF reduction of 0.2 percent. The

description given in Table E.1-3 for term diesel fire pump and John Deere Diesel for Alternate Injection, though, indicates that this term involves a cross tie for fire protection to RHRSW and has a RRW of 1.0584. Describe this SAMA more completely and indicate why the reduction in CDF is so small relative to the RRW.

j. In Table E.2-1, the percent change in CDF and population dose is reported for each analysis case. However, the change in the offsite economic cost risk (OECR) is not reported. Provide the change in the OECR for each analysis case.

Response to RAI 6a

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6b

Since VYNPS is a single-unit site, the cost estimates for Phase II SAMAs 29, and 40 are now one-half of what was previously cited (see Attachment B, Revised Table E.2-1). Revision of these cost estimates had no impact on the original conclusions.

SAMA 35 (Provide an alternate pump power source for feedwater or condensate pumps) would eliminate the feedwater or condensate pumps dependency on offsite power by providing a dedicated diesel or gas turbine. The proposed design modification includes engineering analysis and design, testing, and hardware modification to install a dedicated diesel or gas turbine. The total cost estimate to implement this SAMA is $5,047,488.

Redundant MSIVs are designed to isolate on severe accidents that could lead to radionuclide release and containment bypass. The MSIVs are leak tested each operating cycle to ensure their adequacy. The maintenance rule program monitors the performance of the MSIVs providing early feedback on degradation. In addition, the PSA has determined that the contribution from MSIV isolation failure is insignificant and results in low benefit from implementing this SAMA. The cost estimates for SAMA 46 (Improve MSIV design) is expected to be greater than $1 million.

SAMA 49 (Provide an additional high pressure injection pump with independent diesel) would reduce core melt frequency from small LOCA and SBO sequences by providing an additional high pressure injection pump with independent diesel. The proposed design modification includes engineering analysis and design, testing, and hardware modification to install a high pressure injection pump with independent diesel. Therefore, the total cost estimate to implement this SAMA is $4,956,814.

SAMA 50 (Install independent AC high pressure injection system) would improve high pressure injection capability and reduce core melt frequency from SBO sequences by installing an independent AC high pressure injection system. The proposed design modification includes engineering analysis and design, testing, and hardware modification to install an independent AC high pressure injection system. Therefore, the total cost estimate to implement this SAMA is $4,956,814.

SAMA 51 (Install passive high pressure system) would improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat. The proposed design modification includes engineering analysis and design, and hardware modification to install a passive high pressure system. Therefore, the total cost estimate to implement this SAMA is $28,306,224.

SAMA 52 (Improved high pressure systems) would improve prevention of core melt sequences by improving reliability of high pressure capability to remove decay heat. The proposed design modification replaces one CRD pump with a flow capacity equal to the RCIC system (400 gpm). This includes engineering analysis and design, testing, and hardware modification to replace one CRD pump with larger flow rate. Therefore, the total cost estimate to implement this SAMA is $3,957,037.

SAMA 53 (Install independent active high pressure injection system) would improve reliability of high pressure capability to remove decay heat. The proposed design modification includes engineering analysis and design, testing, and hardware modification to install an active high pressure injection system. Therefore, the total cost estimate to implement this SAMA is $4,373,610.

SAMA 54 (Add a diverse injection system) would reduce core melt frequency from transient and LOCA sequences by installing a diverse injection system. The proposed design modification includes engineering analysis and design, testing, and hardware modification to install a diverse injection system. Therefore, the total cost estimate to implement this SAMA is $3,957,037.

SAMA 55 (Increase SRV reseat reliability) replaces 4 ADS/SRV and 3 RVs with more reliable SRVs. The cost estimate includes engineering analysis and design, and hardware modification. The total cost estimate to implement this SAMA is $4,560,415.

SAMA 60 (Improve SRV design) cost estimate includes engineering analysis and design, and hardware modification. The total cost estimate to implement this SAMA is $2,769,419.

Response to RAI 6c

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6d

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6e

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6f

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6g

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6h

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6i

Response has been previously submitted via letter BVY 06-071.

Response to RAI 6j

The reduction in the OECR for each analysis case in Table E.2-1 of the ER is given in Attachment B, Revised Table E.2-1.

NRC RAI 7

For certain SAMAs considered in the ER, there may be lower-cost alternatives that could achieve much of the risk reduction at a lower cost. In this regard, discuss whether any lower cost alternatives to those Phase II SAMAs considered in the ER would be viable and potentially cost beneficial. Evaluate the following SAMAs (previously found to be potentially cost-beneficial at other plants), or indicate if the particular SAMA has already been considered. If the latter, indicate whether the SAMA has been implemented or has been determined to not be cost-beneficial at VYNPS:

a. Use portable generator to extend the coping time in loss of ac power events (to power battery chargers).

b. Enhance direct current (dc) power availability (provide cables from diesel generator or another source to directly power battery chargers).

c. Provide alternate dc feeds (using a portable generator) to panels supplied only by dc bus.

d. Modify procedures and training to allow operators to cross tie emergency ac buses under emergency conditions which require operation of critical equipment.

e. Develop guidance/procedures for local, manual control of RCIC following loss of dc power.

Response to RAI 7a

Upon a complete SBO, a portable generator could be used to extend the life of both 125-Vdc batteries. This allows maintaining HPCI/RCIC and SRVs availability. Plant procedural changes would be required to implement this SAMA.

Assuming manual DC load shedding and operation of HPCI/RCIC until battery depletion occurs, core boil off times in excess of eight-hours can be reached. To assess the impact of prolonging battery life using a portable diesel generator to power the battery chargers, the probability of non-recovery of offsite power for 4 hours was changed to 24 hours for SBO scenarios. This resulted in a revised baseline with uncertainty benefit of approximately $723,007. The estimated cost of implementing and using the portable generator is $712,347. Therefore, this SAMA is potentially cost effective for VYNPS.

Response to RAI 7b

Response has been previously submitted via letter BVY 06-071.

Response to RAI 7c

See response to RAI 7a.

Response to RAI 7d

Response has been previously submitted via letter BVY 06-071.

Response to RAI 7e

Response has been previously submitted via letter BVY 06-071.

Attachment B

Revised SAMA Results

Table of Contents

Revised List of Tables

Introduction

This attachment contains revised SAMA results based on the current VYNPS PSA model (version VY05R0). Specially, the following:

- Revised multiplier discussion,
- Revised Table 4-4, Estimated Present Dollar Value Equivalent of Internal Events CDF at VYNPS,
- Revised Table E.1-23, Base Case Mean PDR and OECR Values for Postulated Internal Events and,
- Revised Table E.2-1, Summary of Phase II SAMA Analysis, and
- Revised conclusion section 4.21.6.

Revised Multiplier Discussion

ER Section 4.21.5.4, "Final Screening and Cost Benefit Evaluation (Phase II)," describes use of an upper bound estimated benefit for comparison with cost estimates to determine whether a SAMA is cost beneficial. The upper bound estimated benefit used a multiplier to account for external events and uncertainties. However, in the revised analysis, the impact of uncertainty was removed from the baseline evaluation in response to RAI 3c (Attachment A). Also, the core inventory changed as described in response to RAI 4c[2]. Finally, the model revision described in Attachment C necessitated recalculation of the multiplier to account for external events as well as the uncertainty factor.

The external event multiplier was derived by comparing a reduced fire CDF with the internal events CDF. The reduced fire CDF is 1.86 E-05 per year, which is 2.33 times higher than the revised internal events CDF of 7.98 E-06 per year from Revised Table E.1-2. Therefore, a multiplier of 3.33 is used on the averted cost estimates (for internal events) to represent the SAMA benefits from both internal and external events.

The revised baseline benefit values in Revised Table E.2-1, "Revised Summary of Phase II SAMA Analysis," use the model described in Attachment C, account for the revised core inventory from response to RAI 4c, account for both internal and external events conservatively using a multiplier of 3.33, and use a 7% discount rate. The 3% discount rate alternate case benefit values in Revised Table E.2-1 use the model described in Attachment C, account for the revised core inventory from response to RAI 4c, account for both internal and external events conservatively using a multiplier of 3.33, and use a 3% discount rate.

CDF uncertainty calculations for the revised model show that the ratio of the 95th percentile to the mean is 2.15 (Revised Table E.1-1). Therefore, a factor of 2.15 is reasonable to account for uncertainties.

The revised baseline with uncertainty benefit values in Revised Table E.2-1 use the model described in Attachment C, account for revised core inventory from response to RAI 4c, account for both internal and external events using a multiplier of 3.33, use a 7% discount rate, and account for uncertainty via a 2.15 uncertainty factor. Thus, a factor of 7.16 is used to account for the combination of the multiplier to account for both internal and external events (3.33) and the uncertainty factor (2.15).

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[2] Letter, Entergy to USNRC, "Vermont Yankee Nuclear Power Station, License No. DPR-28, License Renewal Application, Amendment 7," BVY 06-071, dated August 1, 2006.

Revised Conclusions

This analysis addressed 302 SAMA candidates for mitigating severe accident impacts. Phase I screening eliminated 236 SAMA candidates from further consideration, based on either inapplicability to VYNPS's design or features that had already been incorporated into VYNPS's current design, procedures and/or programs. No new SAMA candidates were identified in the revised analysis because the risk reduction worth (RRW) importance ranking for the revised PSA model (VY05R0) did not identify risk significant terms with a RRW > 1.005 that were not already included in ER Table E.1-3.

During the Phase II cost-benefit evaluation of the remaining 66 SAMA candidates, an additional 64 SAMA candidates were eliminated because their cost was expected to exceed their benefit and were therefore determined not to be cost-beneficial. As described in Section 4.21.5 of the ER, detailed cost estimates were often not required to make informed decisions regarding the economic viability of a potential plant enhancement when compared to attainable benefit; rather costs were conceptually estimated to the point where conclusions regarding the economic viability of the proposed modifications could be adequately gauged. Since benefit estimates changed in the revised analysis, more refined cost estimates were required to assess the economic viability of some SAMA candidates (2, 3, 16, 28, 32, 33, and 41).

Two Phase II SAMA candidates (i.e., 65 and 66) were found to be potentially cost-beneficial for mitigating the consequences of a severe accident for VYNPS.

- A plant procedural enhancement was recommended to defeat the low-pressure permissive signal of the core spray and LPCI injection valves for reactor pressure vessel (RPV) injection during transients and LOCAs (SAMA candidate 65).
- A plant modification was recommended to install a key lock bypass switch on core spray and LPCI injection valves to bypass the low pressure permissive signal for RPV injection during transients and LOCAs (SAMA candidate 66).

These SAMA candidates do not relate to adequately managing the effects of aging during the period of extended operation. In addition, since the SAMA analysis is conservative and is not a complete engineering project cost-benefit analysis, it does not estimate all of the benefits or all of the costs of a SAMA. For instance, it does not consider increases or decreases in maintenance or operation costs following SAMA implementation. Also, it does not consider the possible adverse consequences of procedure changes, such as additional personnel dose. Therefore, the above potentially cost-beneficial SAMAs have been submitted for engineering project cost-benefit analysis.

Although the procedural change and associated training recommended under SAMA candidate 65 would achieve the same benefit for transients and LOCAs as the modification recommended under SAMA 66, implementation of SAMA candidate 66 would greatly increase the probability of success and thus also reduce plant risk due to fire.

The MACCS2 sensitivity studies indicated that the results of the analysis would not change for the conditions analyzed.

In Section 4.21.6 of the ER, SAMA 47, "Shield injection system electrical equipment from potential water spray," was listed as potentially cost beneficial. In the revised analysis (Revised Table E.2-1), the benefits of this SAMA are smaller and, therefore, it is not potentially cost beneficial.

Revised Table 4-4 Estimated Present Dollar Value Equivalent of Internal Events CDF at VYNPS

Parameter	Present Dollar Value ($)
Off-site population dose	$325,040
Off-site economic costs	$393,922
On-site dose	$3,038
On-site economic costs	$155,723
Total	$877,723

Revised Table E.1-23 Base Case Mean PDR and OECR Values for Postulated Internal Events

Release Mode	Frequency (/yr)	Population Dose (person-sv)*	Offsite Economic Cost ($)	Population Dose Risk (PDR) (person-rem/yr)	Offsite Economic Cost Risk (OECR) ($/yr)
NCF	7.37E-07	1.52E+01	1.93E+06	1.12E-03**	1.42E+00
E/ HI	2.42E-06	2.80E+04	6.66E+09	6.77E+00	1.61E+04
E/MED	3.88E-06	1.54E+04	3.78E+09	5.98E+00	1.47E+04
E/ LO	8.23E-08	2.50E+03	1.03E+08	2.06E-02	8.47E+00
E/ LL	4.29E-09	7.40E+02	1.44E+07	3.17E-04	6.18E-02
V	7.20E-08	3.14E+04	6.31E+09	2.26E-01	4.54E+02
I/HI	1.18E-11	2.80E+04	6.67E+09	3.31E-05	7.90E-02
I/MED	2.84E-10	1.90E+04	4.09E+09	5.40E-04	1.16E+00
I/LO	1.08E-08	3.27E+03	1.33E+08	3.53E-03	1.44E+00
I/LL	0.00E+00	3.37E+02	4.24E+06	0.00E+00	0.00E+00
L/HI	7.52E-07	2.82E+04	7.06E+09	2.12E+00	5.31E+03
L/MED	1.96E-08	1.24E+04	2.14E+09	2.43E-02	4.19E+01
			Totals	1.51E+01	3.66E+04

* 1 sv = 100 rem
** 1.12E-03 (person-rem/yr) = 7.37E-07 (/yr) x 1.52E+01 (person-sv) x 100 (rem/sv)

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
1	Add a service water pump.	0.65%	0.66%	1.09%	$24,817	$5,900,000	Not cost effective	$53,360	$33,777
2	Provide a redundant train of EDG room ventilation.	23.95%	25.83%	26.23%	$750,162	$2,202,725	Not cost effective	$1,612,960	$1,013,815
3	Add a diesel building high temperature alarm, or redundant louver and thermostat.	17.98%	19.21%	19.67%	$561,326	$1,304,700	Not cost effective	$1,206,935	$758,416
4	Install an independent method of suppression pool cooling.	5.76%	7.95%	8.47%	$227,598	$5,800,000	Not cost effective	$489,369	$309,743
5	Install a filtered containment vent to provide fission product scrubbing. Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber	0.00%	0.03%	0.01%	$359	$3,000,000	Not cost effective	$771	$500
6	Install a containment vent large enough to remove ATWS decay heat.	0.01%	0.00%	0.00%	$0	>$2,000,000	Not cost effective	$0	$0
7	Create a large concrete crucible with heat removal potential under the base mat to contain molten core debris.	0.00%	10.60%	12.57%	$279,556	>$100 million	Not cost effective	$601,086	$390,693

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
8	Create a water-cooled rubble bed on the pedestal.	0.00%	10.60%	12.57%	$279,556	$19,000,000	Not cost effective	$601,086	$390,693
9	Provide modification for flooding the drywell head.	0.00%	0.00%	0.00%	$0	>$1,000,000	Not cost effective	$0	$0
10	Enhance fire protection system and standby gas treatment system hardware and procedures.	0.00%	38.68%	39.89%	$941,887	>$2,500,000	Not cost effective	$2,025,199	$1,316,153
11	Create a core melt source reduction system.	0.00%	10.60%	12.57%	$279,556	>$1,000,000	Not cost effective	$601,086	$390,693
12	Install a passive containment spray system.	5.76%	7.95%	8.47%	$227,598	$5,800,000	Not cost effective	$489,369	$309,743
13	Strengthen primary and secondary containment.	6.09%	8.61%	9.02%	$243,921	$12,000,000	Not cost effective	$524,467	$332,013
14	Increase the depth of the concrete base mat or use an alternative concrete material to ensure melt-through does not occur.	0.00%	10.60%	12.57%	$279,556	>$5,000,000	Not cost effective	$601,086	$390,693
15	Provide a reactor vessel exterior cooling system.	0.00%	10.60%	12.57%	$279,556	$2,500,000	Not cost effective	$601,086	$390,693
16	Construct a building connected to primary containment that is maintained at a vacuum.	0.00%	38.68%	39.89%	$941,887	>$2,100,000	Not cost effective	$2,025,199	$1,316,153
17	Add dedicated suppression pool cooling.	5.76%	7.95%	8.47%	$227,598	$5,800,000	Not cost effective	$489,369	$309,743

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
18	Create a larger volume in containment.	6.09%	8.61%	9.02%	$243,921	$8,000,000	Not cost effective	$524,467	$332,013
19	Increase containment pressure capability (sufficient pressure to withstand severe accidents).	6.09%	8.61%	9.02%	$243,921	$12,000,000	Not cost effective	$524,467	$332,013
20	Install improved vacuum breakers (redundant valves in each line).	0.02%	0.00%	0.27%	$3,584	>$1,000,000	Not cost effective	$7,706	$5,008
21	Increase the temperature margin for seals.	0.00%	0.00%	0.00%	$0	$12,000,000	Not cost effective	$0	$0
22	Install a filtered vent	0.14%	0.03%	0.01%	$359	$3,000,000	Not cost effective	$771	$500
23	Provide a method of drywell head flooding.	0.00%	0.00%	0.00%	$0	>$1,000,000	Not cost effective	$0	$0
24	Use alternate method of reactor building spray.	0.00%	38.68%	39.89%	$941,887	>$2,500,000	Not cost effective	$2,025,199	$1,316,153
25	Provide a means of flooding the rubble bed.	0.00%	10.60%	12.57%	$279,556	$2,500,000	Not cost effective	$601,086	$390,693
26	Install a reactor cavity flooding system.	0.00%	10.60%	12.57%	$279,556	$8,750,000	Not cost effective	$601,086	$390,693
27	Add ribbing to the containment shell.	6.09%	8.61%	9.02%	$243,921	$12,000,000	Not cost effective	$524,467	$332,013
28	Provide additional DC battery capacity.	11.39%	11.26%	11.75%	$336,259	$1,726,895	Not cost effective	$723,007	$453,471

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
29	Use fuel cells instead of lead-acid batteries.	11.39%	11.26%	11.75%	$336,259	>$1,000,000[3]	Not cost effective	$723,007	$453,471
30	Provide auto-transfer of AC bus control power to a standby DC power source upon loss of the normal DC source.	3.47%	3.31%	3.83%	$104,567	>500,000	Not cost effective	$224,835	$141,070
31	Install a gas turbine generator.	29.40%	31.79%	31.97%	$919,089	>$2,000,000	Not cost effective	$1,976,180	$1,241,936
32	Change procedure to bypass diesel generator trips, or change trip set-points.	17.98%	19.21%	19.67%	$561,326	>$1,259,940	Not cost effective	$1,206,935	$758,416
33	Provide 16 hour station blackout injection.	11.39%	11.26%	11.75%	$336,259	$1,726,895	Not cost effective	$723,007	$453,471
34	Install a steam driven turbine generator.	29.40%	31.79%	31.97%	$919,089	>$2,000,000	Not cost effective	$1,976,180	$1,241,936
35	Provide an alternate pump power source.	29.40%	31.79%	31.97%	$919,089	>$5,047,488[3]	Not cost effective	$1,976,180	$1,241,936
36	Install a gas turbine.	29.40%	31.79%	31.97%	$919,089	>$2,000,000	Not cost effective	$1,976,180	$1,241,936
37	Install a dedicated RHR (bunkered) power supply.	6.21%	8.61%	9.02%	$244,584	>$2,000,000	Not cost effective	$525,892	$332,758
38	Add a dedicated DC power supply.	5.67%	5.96%	6.56%	$180,342	$3,000,000	Not cost effective	$387,763	$243,891

[3] The estimated cost reflects the revised values in response to RAI 6b.

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
39	Install additional batteries or divisions.	5.67%	5.96%	6.56%	$180,342	$3,000,000	Not cost effective	$387,763	$243,891
40	Install fuel cells.	11.39%	11.26%	11.75%	$336,259	>$1,000,000[3]	Not cost effective	$723,007	$453,471
41	Extended station blackout provisions.	11.39%	11.26%	11.75%	$336,259	$1,726,895	Not cost effective	$723,007	$453,471
42	Locate residual heat removal (RHR) inside containment.	0.48%	0.66%	0.82%	$20,570[4]	>$500,000	Not cost effective	$44,229	$28,023
43	Increase frequency of valve leak testing.	0.48%	0.66%	0.82%	$20,570	$100,000	Not cost effective	$44,229	$28,023
44	Ensure all ISLOCA releases are scrubbed.	0.00%	1.32%	1.37%	$32,256	>$2,500,000	Not cost effective	$69,356	$45,074
45	Add redundant and diverse limit switches to each containment isolation valve.	0.48%	0.66%	0.82%	$20,570	>$1,000,000	Not cost effective	$44,229	$28,023
46	Improve MSIV design.	0.01%	0.00%	0.00%	$0	>$1,000,000[3]	Not cost effective	$0	$0
47	Shield injection system electrical equipment from potential water spray.	2.67%	1.99%	2.46%	$67,673	$250,000	Not cost effective	$145,508	$90,778
48	Install an independent diesel for the condensate storage tank makeup pumps.	1.51%	0.00%	0.00%	$7,950	$135,000	Not cost effective	$17,094	$8,946

4 The estimated benefit reflects the revised values in response to RAI 6e.

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
49	Provide an additional high pressure injection pump with independent diesel.	28.19%	24.50%	25.14%	$744,014	$4,956,814[3]	Not cost effective	$1,599,742	$999,096
50	Install independent AC high pressure injection system.	28.19%	24.50%	25.14%	$744,014	$4,956,814[3]	Not cost effective	$1,599,742	$999,096
51	Install a passive high pressure system.	28.19%	24.50%	25.14%	$744,014	$28,306,224[3]	Not cost effective	$1,599,742	$999,096
52	Improved high pressure systems	18.81%	16.56%	16.67%	$497,204	$3,957,037[3]	Not cost effective	$1,069,064	$667,734
53	Install an additional active high pressure system.	28.19%	24.50%	25.14%	$744,014	$4,373,610[3]	Not cost effective	$1,599,742	$999,096
54	Add a diverse injection system.	28.19%	24.50%	25.14%	$744,014	$3,957,037[3]	Not cost effective	$1,599,742	$999,096
55	Increase safety relief valve (SRV) reseat reliability.	0.80%	37.02%	38.80%	$914,268	$4,560,415[3]	Not cost effective	$1,965,814	$1,276,297
56	Install an ATWS sized vent.	0.01%	0.00%	0.00%	$0	>$2,000,000	Not cost effective	$0	$0
57	Improve ATWS coping capability.	1.84%	0.66%	0.82%	$27,858	>$500,000	Not cost effective	$59,898	$36,223
58	Diversify explosive valve operation.	0.00%	0.00%	0.00%	$0	>$200,000	Not cost effective	$0	$0
59	Increase the reliability of safety relief valves by adding signals to open them automatically.	2.42%	0.66%	1.09%	$34,754	>$1,500,000	Not cost effective	$74,727	$44,959

Revised Table E.2-1 Revised Summary of Phase II SAMA Analysis

Phase II SAMA ID	SAMA	CDF Reduction	Off-Site Dose Reduction	OECR Reduction	Revised Baseline Benefit	Estimated Cost	Conclusion	Revised Baseline With Uncertainty	3% Discount Rate Alternate Case
60	Improve SRV design.	13.49%	7.95%	7.92%	$261,504	2,769,419[3]	Not cost effective	$562,274	$345,948
61	Provide self-cooled ECCS pump seals.	0.38%	0.00%	0.55%	$9,156	>$200,000	Not cost effective	$19,686	$12,253
62	Provide digital large break LOCA protection.	0.33%	0.00%	0.55%	$9,156	>$100,000	Not cost effective	$19,686	$12,253
63	Control containment venting within a narrow band of pressure.	2.80%	3.31%	3.83%	$101,255	$250,000	Not cost effective	$217,713	$137,343
64	Provide a crosstie from the RHRSW system to RHR loop B.	0.47%	0.00%	0.55%	$9,818	>$500,000	Not cost effective	$21,110	$12,998
65	Improve operator action: Defeat low reactor pressure interlocks to open LPCI or core spray injection valves during transients with stuck open SRVs or LOCAs in which random failures prevent all low pressure injection valves from opening.	16.25%	17.22%	17.21%	$498,290	$50,000	Potentially cost effective	$1,071,399	$672,856
66	Install a bypass switch to bypass the low reactor pressure interlocks of LPCI or core spray injection valves.	16.25%	17.22%	17.21%	$498,290	$1,000,000	Not cost effective	$1,071,399	$672,856

Attachment C

PSA Model Revision

Table of Contents

Revised List of Tables

Introduction

This attachment contains information on the current VYNPS PSA model (version VY05R0). Specifically, the following:

- Brief description of the model changes between VY04R1 and VY05R0,
- Revised Table E.1-1, CDF Uncertainty.
- Revised Table E.1-2, VYNPS PSA Model CDF Results by Major Initiators,
- Revised Table E.1-8, Summary of Core Damage Accident Sequence Functional Classes, and
- Revised Table RAI.2-1 (instead of Table E.1-9), VYNPS Release Categories and Characteristics.

2005 PSA Model Update

VY05R0

In order to make the PSA model more consistent with standard industry modeling practices and to improve risk assessment applications, the following model changes were made.

- Changed mission time for the emergency diesel generators (EDGs) to 24 hours. The mission time for the EDGs was assumed to be 8 hours, based on the likelihood that power will be restored from off-site sources within this time frame. However, current industry practice is to use the single most conservative mission time for an EDG irrespective of when off-site power is expected to be restored. A general mission time of 24 hours has been used extensively in PSAs for full power operations because,
    - after 24 hours, accident progression is slow and there is a high probability that repair will be successful or means for replacing equipment function will be improvised in 24 hours, and
    - after 24 hours, there is a high probability that a sufficient number of systems and staff will be available to maintain stable conditions.
- Updated loss of off-site power (LOSP) initiating event frequencies to include weather-related LOSP, based on information from NUREG/CR-5496, "Evaluation of Loss of Offsite Power Events at Nuclear Power Plants: 1980-1996". This resulted in a significant increase in calculated CDF.
- Created a new fault tree (top event JDDG) to credit use of the John Deere diesel generator as an alternate power supply for the station battery chargers in addition to its use for remote operation of the residual heat removal (RHR) service water to RHR cross-tie valves.

The following changes were incorporated to enhance modeling of accident sequences in which ECCS success may rely upon containment overpressure.

- Created a new fault tree (top event IP, "Primary Containment Integrity"). Primary containment must remain intact in order to credit containment overpressure when necessary to maintain sufficient NPSH margin for LPCI and core spray pump operation. This dependency is now explicitly evaluated in the event tree quantification.
- MAAP (Modular Accident Analysis Program) computer runs predicted that the available NPSH for the ECCS pumps would be below the required NPSH following opening of the torus vent path. Therefore, operator action AINPSH, "Operator Fails to Control Vent and LP Fails due to Loss of NPSH" was added to model the potential that the operator fails to adequately control the torus vent, leading to NPSH loss and ECCS pump failure.

Revised Table E.1-1 Core Damage Frequency Uncertainty

Confidence	CDF(/ry)
Mean value	8.42E-6
5th percentile	3.81E-6
50th percentile	6.78E-6
95th percentile	1.81E-5

Revised Table E.1-2 VYNPS PSA Model CDF Results by Major Initiators

IE Type	IE Description	CDF (/RY)	Percentage of CDF
LOOP	Loss of offsite power	2.81E-06	35.22%
FLOOD	Internal flooding	1.40E-06	17.49%
TPCS	Transients without power conversion systems (PCS)	8.38E-07	10.51%
LOACBUS	Loss of AC bus 3	7.94E-07	9.95%
LOACBUS	Loss of AC bus 4	7.29E-07	9.14%
LODCBUS	Loss of DC bus 2	2.82E-07	3.54%
LODCBUS	Loss of DC bus 1	2.77E-07	3.47%
IORV	Inadvertently -opened relief valve	2.72E-07	3.40%
TRANS	Reactor trip	1.73E-07	2.16%
ATWS	Anticipated transient without scram	1.48E-07	1.85%
SORV	Stuck-open relief valve	6.46E-08	0.81%
TSW	Total loss of service water	5.18E-08	0.65%
ISLOCA	Interfacing system LOCA	3.85E-08	0.48%
LOCAOC	LOCA outside containment	3.35E-08	0.42%
LLOCA	Large LOCA	2.62E-08	0.33%
MLOCA	Medium LOCA	2.48E-08	0.31%
SLOCA	Small LOCA	2.16E-08	0.27%
	Total	**7.98E-06**	**100%**

Revised Table E.1-8 Summary of Vermont Yankee Core Damage Accident Sequence Functional Classes

Class	Sub-Class	Class Description	Point Estimate	% of Total CDF
I	A	Transient sequences with loss of all high-pressure injection and failure to depressurize. Core damage occurs with the reactor at high pressure.	1.15E-06	14.45%
	BE[5]	'Early' SBO sequences. Core damage occurs due to early failure of HPCI and RCIC.	3.96E-06	49.61%
	C	ATWS sequences where core damage is caused by loss of injection during level/power control.	1.66E-08	0.21%
	D	Transient sequences with loss of all injection. Core damage occurs with the reactor at low-pressure.	1.41E-06	17.65%
	EC	Transient sequences with delayed loss of DC power due to failure of battery chargers.	2.73E-09	0.03%
	ED	'Early' SBO sequences caused by failure of DC-1 and DC-2.	5.63E-08	0.71%
II	A	Transient sequence with loss of all containment heat removal. Core damage is caused by containment failure.	4.86E-07	6.10%
	L	Loss of containment heat removal with RPV breach but no initial core damage; core damage after containment failure.	4.79E-08	0.60%
	V	Transient sequences where the main condenser and RHR fail, and the torus vent opens for containment pressure relief. Core damage occurs when ECCS systems fail NPSH, due to failure to reclose the vent.	2.56E-07	3.21%
III	A	RPV ruptures due to failure of all over-pressure protection systems.	4.46E-09	0.06%
	B	Small or Medium LOCA sequences for which the reactor cannot be depressurized prior to core damage occurring.	2.06E-07	2.58%
	C	LOCA sequences with loss of injection. Core damage occurs with the reactor at low pressure.	1.32E-07	1.66%
	D	LOCA sequences where core damage is caused by containment failure. Containment fails due to failure of vapor suppression (stuck-open vacuum breaker).	6.35E-09	0.08%
IV	A	ATWS sequences where core damage is caused by containment failure.	1.19E-07	1.49%
	L	ATWS sequences where core damage occurs due to overpressure failure of the Reactor Coolant System.	5.31E-08	0.67%
V	-	Containment Bypass sequences. (Interfacing systems LOCA and LOCA outside of containment.)	7.20E-08	0.90%
		Total	**7.98E-06**	**100%**

[5] Late SBO bin (IBL) is binned into IBE bin for VY05R0.

Table RAI.2.b VYNPS Release Categories

Release Category	Frequency (/year)	Warning Time (sec)	Elevation (m)	Release Start (sec)	Release Duration (sec)	Release Energy (W)
NCF	6.17E-07	0.0E+00	3.00E+01	0.00E+00	1.30E+05	2.50E+05
E/HIGH	2.42E-06	3.96E+03	3.00E+01	3.60E+03	1.80E+04	1.30E+07
E/MEDIUM	3.88E-06	3.97E+03	3.00E+01	3.61E+03	1.80E+04	1.30E+07
E/LOW	8.23E-08	3.96E+03	3.00E+01	3.60E+03	1.80E+04	1.30E+07
E/LOW-LOW	4.29E-09	3.96E+03	3.00E+01	3.60E+03	1.80E+04	1.30E+07
V	7.20E-08	0.00E+00	3.00E+01	0.00E+00	1.80E+04	2.50E+05
I/HIGH	1.18E-11	1.44E+04	3.00E+01	2.16E+04	6.48E+04	7.70E+06
I/MEDIUM	2.84E-10	1.44E+04	3.00E+01	2.16E+04	6.48E+04	7.70E+06
I/LOW	1.08E-08	1.44E+04	3.00E+01	2.16E+04	6.48E+04	7.70E+06
I/LOW-LOW	0.00E+00	1.44E+04	3.00E+01	2.16E+04	6.48E+04	7.70E+06
L/HIGH	7.52E-07	2.88E+04	3.00E+01	8.64E+04	4.32E+04	2.50E+05
L/MEDIUM	1.96E-08	2.88E+04	3.00E+01	8.64E+04	4.32E+04	2.50E+05
L/LOW	0.00E+00	2.88E+04	3.00E+01	8.64E+04	4.32E+04	2.50E+05
L/LOW-LOW	0.00E+00	2.88E+04	3.00E+01	8.64E+04	4.32E+04	2.50E+05

Release Fractions

	NG	I	Cs	Te	Sr	Ru	La	Ce	Ba
NCF	2.08E-01	8.59E-06	8.59E-06	5.11E-06	1.21E-08	8.46E-08	2.69E-09	3.26E-09	9.66E-08
E/HIGH	7.89E-01	2.42E-01	2.42E-01	5.20E-02	6.63E-03	1.76E-03	5.48E-04	3.21E-03	4.65E-03
E/MEDIUM	9.95E-01	7.43E-02	7.43E-02	3.03E-02	1.19E-03	5.73E-04	4.37E-05	3.70E-04	1.74E-03
E/LOW	6.78E-01	2.37E-03	2.37E-03	1.13E-03	1.41E-05	2.35E-04	1.98E-06	4.82E-06	6.16E-05
E/LOW-LOW	9.82E-01	5.22E-04	5.22E-04	2.88E-04	1.01E-06	1.18E-05	2.51E-07	9.18E-07	3.88E-06
V	9.99E-01	3.09E-01	3.09E-01	2.29E-01	4.31E-03	9.02E-03	4.96E-04	1.45E-03	9.83E-03
I/HIGH	1.00E+00	1.88E-01	1.88E-01	7.29E-02	4.44E-04	6.93E-04	3.20E-05	1.28E-04	1.04E-03
I/MEDIUM	1.00E+00	7.30E-02	7.30E-02	3.18E-02	1.28E-03	4.43E-03	4.54E-04	9.31E-04	5.12E-03
I/LOW	9.82E-01	3.44E-03	3.44E-03	1.45E-04	5.39E-08	7.53E-08	7.28E-09	1.44E-08	1.32E-07
I/LOW-LOW	9.77E-01	2.23E-04	2.23E-04	5.38E-05	1.79E-07	1.85E-06	4.14E-08	1.46E-07	6.82E-07
L/HIGH	7.89E-01	2.94E-01	2.94E-01	6.88E-02	6.86E-03	2.49E-03	5.41E-04	3.62E-03	6.00E-03
L/MEDIUM	9.07E-01	4.43E-02	4.43E-02	1.50E-02	2.00E-04	5.40E-03	2.27E-05	7.69E-05	8.41E-04
L/LOW	7.54E-01	7.38E-03	7.38E-03	2.23E-03	1.61E-05	7.07E-05	8.41E-07	4.58E-06	2.85E-05
L/LOW-LOW	9.25E-01	2.52E-04	2.52E-04	8.67E-05	3.89E-07	1.09E-05	4.96E-08	1.78E-07	2.36E-06

NCF No containment failure
E Early
I Intermediate
L Late
V LOCA outside containment or Interfacing System LOCA (containment bypass)