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Waterford 3

W3F1-2017-0001

February 7, 2017

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

SUBJECT: Responses to Request for Additional Information for the Environmental Review of the Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

REFERENCES:

1. Entergy letter W3F1-2016-0012 "License Renewal Application, Waterford Steam Electric Station, Unit 3" dated March 23, 2016.
2. NRC letter to Entergy "Request for Additional Information for the Environmental Review of the Waterford Steam Electric Station, Unit 3" dated November 22, 2016.

Dear Sir or Madam:

By letter dated March 23, 2016, Entergy Operations, Inc. (Entergy) submitted a license renewal application, which contained the environmental report (Reference 1).

In letter dated November 22, 2016 (Reference 2), the NRC staff made a Request for Additional Information (RAI) as a result of the review of the severe accident mitigation analysis (SAMA) evaluation contained in the environmental report. The additional information is needed for the NRC to complete its review.

As discussed during a conference call between the NRC and Entergy on December 13, 2016, it is acceptable for Entergy to provide the responses to the SAMA RAIs no later than February 7, 2017. Enclosure 1 provides the responses to the SAMA RAIs.

There are no new regulatory commitments contained in this submittal. If you require additional information, please contact the Regulatory Assurance Manager, John Jarrell, at 504-739-6685.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 7, 2017.

Sincerely,

MRC/AJH

Enclosures: 1. SAMA RAI Responses – Waterford 3 License Renewal Application

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Enclosure 1 to

W3F1-2017-0001

SAMA RAI Responses
Waterford 3 License Renewal Application

RAI SAMA 1

1. Provide the following information regarding the Level 1 Probabilistic Risk Assessment (PRA) or Probabilistic Safety Assessment (PSA) used for the Severe Accident Mitigation Alternative (SAMA) analysis. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the Waterford Electric Station, Unit 3 (WF3) SAMA analysis, NRC staff evaluates the applicant’s treatment of internal events and calculation of core damage frequency (CDF) in the Level 1 PRA model. The requested information is needed in order for the NRC staff to reach a conclusion on the sufficiency of the applicant’s Level 1 PRA model for supporting the SAMA evaluation.

1.a. WF3 Environmental Report (ER) Section D.1.4 indicates that there is approximately a factor of 3 increase in CDF and a factor of 3 decrease in large early release frequency (LERF) from PSA 2009 R4 to 2015 PSA R5 used for the SAMA analysis. Discuss the major reasons for these changes.

Waterford 3 Response

Several changes were made in the Revision 5 PSA model update as listed in ER Section D.1.4.4.

The most significant change causing the increase in CDF was the revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. This change had little impact on LERF because the associated sequences are not early sequences. The condensate storage pool (CSP) update, for emergency feedwater to utilize source water from the demineralized water storage tank (utilizing gravity fed supply) feeding the CSP, caused a decrease in CDF. However, that decrease was overshadowed by the increase from the battery depletion modeling.

The decrease in LERF was due to removal of conservatisms in the LERF model. Contributing changes include the following.

- Removal of dependency to refill nitrogen accumulators (extended credited operation time from 10 hours to 24 hours)
- Added containment cooling system fan coil isolation valves into model
- Revision of modeling associated with refill of the CSP to reflect current procedural guidance
- Updated human failure events

1.b. ER Section D.1.4.5 indicates that the 2009 peer review concluded that approximately 9% of the applicable PRA standard’s supporting requirements (SRs) were met at Capability Category I while 10% of the SRs were rated as not met. Discuss any findings from this

review that remain open in the PRA models used for the SAMA analysis and their potential impact on the SAMA analysis.

Waterford 3 Response

Three findings from the 2009 peer review, unrelated to internal flooding, remain open in the PRA models used for the SAMA analysis. These findings and their potential impact on the SAMA analysis are discussed below.

- IE-C12-01: *ISLOCA - low pressure LPSI and HPSI line contain two check valves in series. The failure rate of the check valves need to be treated as conditional, rather than independent. Additionally need to address small ruptures in the LPSI MOVs. At present only large leakage is considered.*

  This finding is associated with the inclusion of State of Knowledge Correlation (SOKC). The increase in probabilities due to SOKC would be minor per WCAP-17154-P. This is insignificant because the conditional failure rate of both check valves would be about 2E-7. Additionally, a review of NUREG/CR-6928 shows that small ruptures are defined as 1 to 50 gpm. Leaks of this size are not considered sufficient to meet the classification for ISLOCA. ISLOCA is not a significant contributor to risk at WF3, with a CDF contribution of 9.44E-10 /rx-yr and a LERF contribution of 4.26E-10 /rx-yr. Therefore, adjusting the failure rates of LPSI and HPSI line check valves to address SOKC would have a negligible impact on the risk profile and no impact on the SAMA cost-benefit conclusions.

- SY-A18a-01: *HPSI system has an installed spare that can be aligned to either system. Coincident unavailability due to maintenance for redundant equipment is possible (spare pump OOS for extended periods and could be OOS with another pump). Need to specifically address this possibility. This may also be true for charging pumps.*

  SR SY-A18 (changed to SY-A20 in latest version of the standard) states: INCLUDE events representing the simultaneous unavailability of redundant equipment when this is a result of planned activity. The Plant Specific Failure Data Development analysis (PSA-WF3-01-DA-01) documents the inclusion of all planned concurrent maintenance (including installed spares). This remains 'not addressed' due to documentation. The coincident unavailability is included in the model; however the documentation does not fully explain the process used to consider/model events.

  This is a documentation finding, with no impact on the SAMA cost-benefit results.

- SY-C2-01: *Need to add a discussion of what the criteria for CCF considerations are (which types of components were looked at, were inter- and intra- system CCFs considered, etc. If the component types were determined based off of a list from a Reference, provide this information and a pointer to the reference document/methodology.*

This finding is a documentation issue only. During the disposition of the F&O for SY-B4, the criteria for CCF considerations were reviewed. Inter-system and Intra-system CCFs considered are documented in the CCF calculation, but not explicitly in each system notebook. This finding has no quantitative impact on the internal events model. This is a documentation finding, with no impact on the SAMA cost-benefit results.

Eight findings from the 2009 peer review, related to internal flooding, remain open in the PRA models used for the SAMA analysis. These eight findings are summarized below. Some of the findings are documentation issues and resolution of others would tend to decrease or have no impact on the internal flooding CDF.

The internal flooding model was not used to analyze individual SAMA candidates. Rather, the internal flooding CDF contribution of 2.48E-06/rx-yr was used, along with external events CDF values, to calculate the internal/external events multiplier for the SAMA analysis. The multiplier was utilized because the current internal flooding model hasn't been integrated with the current internal events model or the Level 2 and 3 models. As noted in the response to question 1.e, the CDF for the 2015 (R5) PSA model used for the SAMA analysis is larger than prior models because that model includes a revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. This modeling increased the CDF from sequences initiated by a loss of offsite power. Since the internal flooding CDF comes from sequences initiated by internal floods, it would not be significantly impacted by this model change. Thus, there is no impact on the SAMA cost-benefit conclusions.

- IF-B2-01: *Although required by this SR, no evaluation of individual component failure modes, human-induced mechanisms, or other events that could release water into the area were identified. The evaluation assumed that using a guillotine rupture was adequate to not require any specific failures or human-induced mechanisms. This does not meet the intent or specifics of this requirement. Other SRs (IF-B3 and IF-D6) are also potentially not met when only the use of a guillotine rupture is used.*

  (IF-B3) Waterford 3 basically characterized all flood sources as catastrophic ruptures but where there are potential spray targets they do evaluate spray impacts. Waterford characterizes the flood in terms of gpm for larger sources or as total flood capacity for smaller flood sources. Waterford does consider pressure of the flood source to a limited extent, primarily when evaluating the potential for spray impacts. However, there is no evidence that Waterford considered the temperature of the flood source beyond stating that HELB is treated elsewhere. Waterford should include some discussion of temperature in PRA-W3-01-002.

  (IF-D6) Section 2.0 of the Internal Flooding analysis specifically states "all causes of flooding were considered except plant-specific maintenance activities. No

mention of inclusion/exclusion of generic maintenance activities was found. While Waterford discusses operator error contributions to flooding at a very high level in section 3.1.2, basically the only floods considered were catastrophic failures. The flood scenario frequencies were then quantified using generic pipe rupture data and plant-specific pipe length. The resulting low frequencies often lead to scenarios being subsumed. While the operator induced floods may be less severe, the frequencies will be higher, so they should be considered explicitly.

- IF-C3c-01: *There do not appear to be any Engineering calculations available to support some of the statements or inherent assumptions made in the Internal Flooding Analysis. In particular, room dimensions and flood rates are not available to justify flood depths stated for various rooms, some zones credit "air tight" doors as being structurally sound up to a depth of 6 inches with no justification of door integrity against a static water load of this depth, "air tight" doors appear to be treated as "flood doors" with no justification as to how this was determined (normally air tight door seals are not designed to prevent water intrusion or extrusion), timing related calculations (time for flood to reach susceptible equipment, flood rates, etc.) were not included or referenced, etc. If these calculations exist, they should be either provided in appendices to the report or referenced in the appropriate sections of the report.*

  If the calculations do not exist, they should be performed, and the statements and inherent assumptions in the analysis re-verified to ensure they reflect the results of the calculations.
  On page 89 of the Internal Flooding Report, within the 2nd paragraph, a statement is made that a particular door is assumed to open out, and that the flood propagation pathway will go through that door. No discussion, or calculation, is provided to justify why that particular door will open versus another of the doors from the room (there are multiple doors associated with the room). If there is no basis behind that particular door failing prior to the other doors, then an evaluation of the flooding impacts from other doors opening should be performed.

  On page 215, there is an un-supported assumption that drain failures have a failure probability of 0.1. Need to provide basis for this assumption.

- IF-C7-01: *The Fire Water pump house has been excluded from evaluation on the basis that the failure of the fire pumps will not precipitate a reactor trip and the fire protection itself is not used to mitigate any accident scenario that might lead to core damage other than those occasioned by fire. This exclusion needs to be re-visited to determine if an internal flood in the fire water pump house has the potential to initiate a flood/spray event elsewhere in the plant due to spurious fire water valve actuations (e.g. look at potential for spray/submergence on a fire water control panel to determine if it could cause spurious signals to fire water equipment in the plant resulting in a plant spray/flood event.), and if this*

inadvertent actuation could result in the need for a plant shutdown. If this impact has been evaluated, document it.

- IF-D5a-01: *Although Waterford calculates the initiating event frequency for each evaluated flood scenario using generic data, and the specific calculations are presented in a footnote for each scenario, a reduction factor has been inappropriately applied to component rupture failure rates. The analysis states that the generic component failure rates are obtained from EGG-SSRE-9639 (see Table 3.2.1.2 in Flood report). However, these failure rates are then reduced by an additional factor to convert them from "spray" failures to "rupture" failures. (The example provided shows a "1/27th" reduction for a 1000 gpm valve failure) The application of the reduction factor is inappropriate since the data are "rupture" rates, not "spray" rates, and the EGG-SSRE-9639 source document has already applied a 1/25 reduction factor to ensure that the rates are applicable as rupture rates. Need to use the "rupture" failure rates without applying the additional reduction factor.*

- IF-D7-01: *The discussion for excluding the condensate polisher building from consideration based on the assumption that the operators would bypass the condensate polisher system in the event of a rupture/leak within the building is inadequate.*

- IF-D7-02: *The Internal Flooding report is inconsistent / incorrect in its use of "subsume" versus "screen". For example, in Section 4.2.1.3, the report states that scenarios are "subsumed" but the justification for subsuming the scenarios is based on the justification for "screening" of scenarios (screening is defined in SR IF-D7).*

- IF-E5a-01: *For operator actions, only actions outside of the Control Room appear to have been reviewed. Also, no analysis could be found to determine if there were any "unique" (i.e. not credited in the base PRA) operator actions that should be added for internal flooding recoveries, or if the operator actions credited were modified to account for the stress level/timing differences associated with internal flooding scenarios. Of the actions credited in the base PRA model, 4 of the operator actions appear to be removed by a recovery rule file as inaccessible. However, no additional analysis was found to justify why these 4 actions were determined to be inappropriate for internal flooding recovery, or why no other human actions were impacted by the internal flooding scenarios.*

- IF-E6-01: *In general, WSES3 used the standard quantification processes from section 4.5.8 of the standard. However, WSES3 did not propagate the numerical uncertainties as part of the quantification. WSES3 needs to redo the Internal Flooding Quantification and include the propagation of the numerical uncertainties and provide the mean and ERF factors for the resultant CDFs.*

1.c. Provide the “freeze date” or the date which corresponds to the WF3 design and operation incorporated into the WF3 PSA used for the SAMA analysis. Identify any design or operational (including fuel cycle) changes that have or, are planned, since this freeze date that might impact the SAMA analysis.

Waterford 3 Response

The PRA model used in the SAMA analysis has a freeze date of 11/1/2015. Since this time some changes have been made to the design and operation of the plant. Three changes that would potentially have an impact on the SAMA analysis are the modifications made for FLEX (diverse and flexible coping strategies, which do not affect the design basis of the plant but primarily operational response to an extended loss of AC power), the temporary emergency diesel, and the proceduralization of local manual control of EFW pump turbine and flow control valves in a more prominent way. These changes would serve to reduce the SBO contribution to core damage and release categories. No fuel cycle changes are planned that might impact the SAMA analysis.

1.d. Confirm that no changes have been made to the WF3 model used in the SAMA analysis since the peer review that would constitute an upgrade as defined by the PRA Standard ASME/ANS RA-Sa-2009, as endorsed by Regulatory Guide (RG) 1.200, Revision 2.

Waterford 3 Response

No changes have been made to the WF3 model used in the SAMA analysis since the peer review that would constitute an upgrade as defined by ASME/ANS RA-Sa-2009, as endorsed by RG 1.200, Revision 2.

1.e. The revised Attachment W to the WF3 National Fire Protection Association (NFPA) 805 License Amendment Request (LAR) gives the internal events CDF and LERF as 6.5E-06 per reactor-year (rx-year) and 8.7E-08 per rx-year respectively. These values are approximately 60% of the results given for the 2015 (R5) PSA used for the SAMA analysis (internal events CDF and LERF as 1.05E-05 per rx-year and 1.36E-07 per rx-year respectively). Identify which of these values best represents WF3 for license renewal purposes, discuss the reasons for these differences and the impact on the SAMA analysis.

Waterford 3 Response

In enclosure 2 of letter W3F1-2015-0025, “Responses to Request for Additional Information Regarding Adoption of National Fire Protection Association Standard NFPA 805 License Amendment Request (LAR) Waterford Steam Electric Station, Unit 3 (Waterford 3),” dated May 14, 2015, the internal events CDF and LERF are given as 6.5E-06/rx-yr and 8.7E-08/rx-yr, respectively.

The CDF value differs from that given for the 2015 (R5) PSA model used for the SAMA analysis because it is from a prior interim model revision which did not include the revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. The prior interim LERF model had a slightly lower value due to the update in the SGTR sequences which are binned as LERF which saw an increase due to the change in values of thermal-induced SGTR and pressure-induced SGTR failure probabilities.

The 2015 (R5) PSA model used for the SAMA analysis best represents WF3 for license renewal purposes. Additional changes to the revision 5 PSA model update can be seen in Section D.1.4.4 of the ER.

1.f. Briefly describe the process and procedures in place to assure the technical adequacy of changes made to the WF3 PSA since the 2009 peer review.

Waterford 3 Response

The PSA Maintenance and Update procedure describes the process for maintaining the PSA models current with the as-built and as-operated plants. It describes the model change request (MCR) database used to track plant changes, procedure revisions, nuclear licensing revisions, and model improvements that impact the PSA models. This procedure is in place for PSA model maintenance in order to ensure that the model remains current with the as-built, as-operated plant and to ensure that industry standards, experience, and technology are appropriately incorporated into the models. This procedure gives specific instructions for identifying model change requests, documenting those requests, and incorporating those requests into the PSA model.

PSA engineers review all plant modifications and procedure revisions with the potential to impact the PSA model and enter them into the MCR database. MCRs that are important and necessary to assure the technical adequacy of the PRA or quality of the PRA result in a condition report within the corrective action system and an interim model update. Those that have a minor impact, but still necessary to address may be deferred until the next PSA update.

The PSA engineers performing model updates are experienced, trained professionals and each change is reviewed by a second, experienced, trained PSA engineer. In addition, expert panel reviews are used to enhance the technical quality of the PSA updates. Changes from the expert panel review for an update are immediately incorporated into that update of the model. Therefore, the WF3 PSA is of sufficient technical quality for use in the SAMA analysis.

1.g. ER Section D.1.1 (p. D-26) states that the CDF uncertainty factor of 1.99 is based on the ratio of the 95th percentile CDF to the mean CDF. Since the PSA results used in the cost-benefit analysis are based on point estimates, the uncertainty factor should be based on the ratio of the 95th percentile CDF to the point estimate CDF. Describe the uncertainty analysis and provide the 95th, mean and point estimate results from this analysis. Discuss the impact of the revised uncertainty factor on the results of the SAMA analysis.

Waterford 3 Response

The parametric uncertainty analysis was performed by defining a probability distribution on the value of each parameter and then propagating this parameter value uncertainty through the result (CDF) using Monte Carlo sampling performed by the UNCERT software. The parameters of interest are those of the probability models for the basic events of the logic model and include failure rates, component unavailabilities, initiating event frequencies and human error probabilities. The 95th, mean, and point estimate are shown in the table below.

	Point Estimate	Mean	95%
CDF (/rx-yr)	1.05E-05	1.086E-05	2.164E-05

The ratio of the 95th percentile CDF to the point estimate CDF is 2.06. The “Internal and External Benefit with Uncert” values in revised Table D.2-2 use an uncertainty factor of 2.06.

1.h. Discuss the scope of the 2009 WF3 internal events peer review and if all applicable elements of the ASME PRA standard were assessed in this review. Discuss the potential impact on the SAMA analysis of any elements that were not assessed.

Waterford 3 Response

The scope of this review was a full scope review of the WF3 PRA with the exception of the Configuration Control requirements and the following High Level Requirements (HLR): HLR-IE-A, HLR-IE-B, HLR-HR-A, HLR-HR-B, HLR-HR-C, HLR-HR-D, HLR-HR-E, and HLR-HR-F. The Configuration Control requirements were not reviewed because Entergy uses a fleet-wide configuration control procedure for all of their plants and this procedure was reviewed as part of the Arkansas Nuclear One Unit 2 (ANO-2) peer review. The Initiating Event (IE) HLRs and the Human Reliability Analysis (HRA) HLRs listed above were covered by an earlier review and did not need to be revisited. The team did do a confirmatory review of HLR-IE-A and HLR-IE-B. The results of the confirmatory review of HLR-IE-A and HLR-IE-B and results of the earlier peer review for the other listed HLRs are provided below.

HLR-IE-A: The confirmatory review concluded, *"WSES-3 PRA has considered initiating events based on a number of sources such as the past PRAs, generic nuclear plant operating data, and WSES-3 specific experience. Therefore, the requirements of this HLR are satisfied."*

HLR-IE-B: The confirmatory review concluded, *"The initiating events have been grouped properly and the review team found these groupings to be consistent with other plant PRAs. Therefore, the requirements of this HLR are satisfied."*

HLR-HR-A: The earlier peer review concluded, *"Pre-initiators were identified by a defined approach. This included system/component alignment issues and instrument miscalibrations. This was completed in the system analyses. One issue that was initially identified related to the lack of the documentation of the review of plant specific information. This issue has been resolved."*

HLR-HR-B: The earlier peer review concluded, *"The screening was completed in an acceptable manner. A process for screening pre-initiators was defined and followed. Activities that could impact multiple trains were not screened. One issue was identified related to the screening out of the pre-initiator Human Failure Events (HFEs) of the running systems."*

HLR-HR-C: The earlier peer review concluded, *"This was completed appropriately. Human failure events were defined and added to the PRA model appropriately."*

HLR-HR-D: The earlier peer review concluded, *"A systematic process was defined and followed for calculating human error probabilities. A detailed assessment was applied to all HFEs, as opposed to using screening values."*

HLR-HR-E: The earlier peer review concluded, *"A systematic approach was followed to identify the operator responses for each accident sequence. Operators were used via talk-throughs to provide the information necessary to fully understand and assess the actions required. (Note that these talk-throughs did not include measurement of sequence timing.) The operator input was well done and documented."*

HLR-HR-F: The earlier peer review concluded, *"HFEs were defined and incorporated in the PRA model appropriately. The definition of the HFEs was completed and input information was well documented in individual operator action worksheets."*

Findings (one each for HLR-IE-A, HLR-IE-B, HLR-HR-A, HLR-HR-B, HLR-HR-D, and HLR-HR-F and none for HLR-HR-C or HLR-HR-E) from the earlier peer review were carried over into the list of findings from the 2009 peer review. These findings have been closed, and no findings related to these HLRs remain open in the PRA models used for the SAMA analysis. Thus, there is no impact on results of the SAMA analysis from this carry-over review.

RAI SAMA 2

2. Provide the following information relative to the Level 2 PRA or PSA analysis. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF-3 SAMA analysis, NRC staff evaluates the applicant's treatment of accident propagation and radionuclide release in the Level 2 PRA model. The requested information is needed in order for the NRC staff to reach a conclusion on the adequacy of the applicant's Level 2 PRA model for supporting the SAMA evaluation.

2.a. The table in ER Section D.1.4 gives LERF for the 2015 (R5) PSA as 1.36E-06 per rx-year, while Section D.1.2.1 (p. D-27) and Table D.1-12 gives 1.88E-06 per rx -year. Explain the difference.

Waterford 3 Response

The LERF value given in Section D.1.4 for the 2015 (R5) PSA (1.36E-07/rx-yr) is the simplified internal events LERF model for WF3. For the SAMA analysis, a detailed Level 2 model was created which includes LERF and provides a value of 1.88E-06/rx-yr as show in Table D.1-12. Additional details of the full level 2 model and its development are described in the response to 2.b.

2.b.1 ER Section D.1.4.4 indicates that a full level 2 model was created for the 2015 (R5) PSA based on the 2015 internal events model. Describe the full level 2 model in comparison with the prior LERF only model reviewed in the 2009 peer review, the changes made to it to obtain the 2015 (R5) level 2 model and the steps taken to insure the technical adequacy of the full Level 2 model.

Waterford 3 Response

The previous simplified LERF-only model following the WCAP-16341-P methodology was used as the starting point for the detailed WF3 Level 2 model. The conversion of the simplified LERF model into a Level 2 analysis for WF3 included the following:

- Restructuring the event trees for addition and consolidation of nodes;
- Execution and incorporation of plant-specific MAAP calculations in the determination the event tree outcomes;
- Development of 12 release categories beyond the LERF, SERF, LATE and INTACT end states;
- Incorporation of the WF3 Emergency Action Levels, evacuation estimates, and MAAP 4.0.6 accident sequence timing;
- Utilization of FP results derived from MAAP analyses in the binning of the release categories; and
- Development and incorporation of detailed ultimate containment capacity into the Level 2 analysis.

The WF3 model is a Level 2 analysis capable of meeting the Category II requirements of Regulatory Guide 1.200 and the ASME PRA Standard. The updated Level 2 analysis uses available technical work from the previous WF3 PRA analyses where appropriate, but applies the most recent accident progression research, current industry practices, and realistic plant-specific analyses. The level 2 analysis was performed by Jensen-Hughes and received in-depth technical reviews within Jensen-Hughes and by a representative of Entergy with level 2 experience and all comments were resolved. Also, an expert panel cutset review of the significant and non-significant cutsets for the level 2 model was performed and all issues addressed.

2.b.2 ER Sections D.1.2.1, “Containment Performance Analysis,” and D.1.2.2.6, “Mapping of Level 1 Results into the Various Release Categories,” both provide discussions regarding the transfer of Level 1 core damage results to the Level 2 fission product release analyses. The ER states:

> For the WF3 Level 2 analysis, no grouping into [Plant Damage States] PDS was performed to group accident sequences with similar safety features and containment failure responses. A more rigorous approach was taken where each Level 2 accident sequence was assessed individually based on the accident-specific containment response.
>
> The WF3 Level 2 accident sequences were named using the two or three letter identification for the CD sequences from the Level 1 core damage event trees (i.e., AX, MU, SB, TQX, TKQ, and RB) and combined with a one-letter code to represent core melt sequences (core damage with containment safeguard systems).

Provide additional information on this process including a description of the Level 1 and Level 2 sequence naming nomenclature and how the Level 2 sequences or Containment Event Tree (CET) endpoints were assigned to the Level 2 release categories.

<u>Waterford 3 Response</u>

The Level 2 accident sequences are derived directly from the WF3 Level 1 core damage sequences. All Level 1 core damage sequences were evaluated following the modification of the Level 2 scenarios for further analysis and incorporation into the Level 2 model. The modifications of the Level 2 scenarios are based on Level 1 core damage sequences that have been extended for a 36-hour duration, 12 hours beyond the 24-hour core damage period used to establish success criteria. In addition, the Level 2 scenarios are evaluated for containment integrity response based on the operational configurations of the WF3 containment safeguard systems. The MAAP results from the analyses performed on the Level 2 scenarios are used to develop the Level 2 model.

As part of the development of the Level 2 model, a detailed evaluation of the WF3 containment capacity was performed to assess the integrity response during Level 2 accident progression. Based on the containment response timings and FP release fractions obtained from the MAAP analyses, the Level 2 scenarios are assigned to the appropriate Release Categories (RC). The parameters used for the RC classification include the timing of occurrence of any containment failure and the maximum FP fraction over the 36-hour MAAP analysis period.

The Level 2 accident sequences are identified and named in accordance the WF3 core damage sequences as establish as part of the Level 1 success criteria. The Level 1 core damage sequence names are based on the performance of the safety function systems in combination with the sequence initiating event. For example, the RC H-E sequence is identified as TQX_H. This scenario is classified as a having a transient initiating event "%T", with a failure of the event "Q" to maintain the RCS pressure boundary and a failure of the event "X" to maintain long-term RCS control during the recirculation phase. This nomenclature is consistent with that used for the WF3 IPE and the Level 1 PRA. In addition, the containment safeguard system configurations are denoted in a manner consistent with the IPE designations for combinations of containment fan and spray failures. A "TQX_H" sequence has no functioning containment fans or sprays. Other containment safeguard combinations of the TQX sequence include: "TQX_B" with both containment fans and sprays operation, "TQX_D" with containment spray failed, and "TQX_F" with containment fan coolers failed.

The WF3 Level 2 accident sequences allow each core damage sequence to be evaluated four times, once for each safeguard configuration, and assigned to a RC uniquely based on both the initial accident sequence and its corresponding containment response. Because the assignment of Level 2 accident sequences is directly assessed for each accident scenario, the establishment of PDS based on core melt conditions as was previously used in the WF3 IPE was not required.

2.c. ER Section D.1.2.1 states that 4 CETs were used to model the core melt progression and radioactive releases. Four trees, Trees B, D, F and H, representing four combinations of containment heat removal, are subsequently discussed. Confirm that these are the four CETs used and describe the use of the four trees considering that the two containment heat removal systems are explicitly represented by CET nodes.

Waterford 3 Response

Yes, these are the four CETs used. To provide a more accurate determination of the Level 2 sequence response, different configurations of Containment Heat Removal (CHR) system performance were applied to each Level 1 sequence and evaluated independently. Each of the four trees represents a different configuration of containment heat removal system performance.

CET-B: Both Containment Sprays and Containment Cooling Fans are available (CHR-B)
CET-D: Only Containment Cooling Fans are available (CHR-D)
CET-F: Only Containment Sprays are available (CHR-F)
CET-H: No Containment Safeguards are available (CHR-H)

ER Sections D.1.2.1.1 and D.1.2.1.2 discuss the CFC (containment fans) and CS (containment sprays) top events, but these are not actual nodes in the CETs. Rather, they define the entry points for each of the trees. Each Level 1 sequence was evaluated using each of the four trees.

2.d. ER Section D.1.2.2.7 indicates that for: Containment Bypass Sequences, Containment Isolation Sequences, Reactor Vessel Rupture Events and Interfacing System Loss of Coolant Accident (LOCA) Events; there was no consideration of fission product (FP) scrubbing, retention, or deposition and all were assigned to the High-Early (H-E) release category (RC). Clarify this statement since with no scrubbing, retention or deposition, 100 percent release of volatile FPs would be expected.

Waterford 3 Response

The discussion in D.1.2.2.7 addressed the characterization of the FP releases for the purpose of binning these release scenarios based on severity. Containment Bypass Sequences, Containment Isolation Sequences, Reactor Vessel Rupture Events, and Interfacing System Loss of Coolant Accidents were classified as High-Early releases. These scenarios are classified as early releases because the initiating event failure leads to an immediate release pathway from the containment structure. In addition, these scenarios are classified as high severity because the containment release pathway precludes the mitigation or retention of fission products due to scrubbing, retention, or deposition mechanisms that occur within the containment structure. MAAP analyses were not performed for these High-Early sequences.

2.e. ER Section D.1.5.2.9 states:

> The representative accident sequences selected for each release category represented both the dominant accident class based on the Level 2 results and the maximum release of fission products from the MAAP analyses.

Provide a more detailed discussion of this process including a description of the Level 2 sequences used to characterize the source terms for each of the significant release categories, the basis for this selection and its appropriateness for use in determining the benefit for the Phase II SAMAs evaluated. Note that using the dominate sequence in each RC to characterize the releases for that category may not necessarily lead to the correct benefit for the individual SAMA cost-benefit analyses.

Waterford 3 Response

The process of selecting a representative accident sequence included a review of the risk importance of the accident sequences in combination with the timing and severity of the release.

A cutset review of the Level 2 model quantification results was used to identify predominant sequences. This review process included an evaluation to identify dominant accident sequences that contribute either to the top cutsets or based on total cutset frequency within each release category.

A review of the MAAP analyses of the accident sequences was conducted to identify sequences based on timing and release magnitude. A review of fission product source terms identified accident sequences with the highest source term based on CsI within their assigned release category. Similarly, the initiation of containment release times was reviewed to identify scenarios with the earliest release timing for their assigned release category. The purpose of the review was to screen the sequences and capture potential accident sequences for additional review for each RC.

Following the process of identifying and screening of potential accident sequences from both the cutset review and the MAAP analysis, an additional review of the candidate sequences was used to select an accident sequence for each release category that is both conservative and representative of WF3.

2.f. The start of release times given in ER Table D.1-10 are not consistent with the RC definitions in Table D.1-8 for a number of release categories. For example: for RC H-E (start of release less than 4 hours after general emergency declaration), the time of the start of release (plume 1) is 13.4 hours while the time of declaration of a general emergency is 15 minutes; and for RC High – Intermediate (H-I) (start of release is greater than 4 hours after general emergency declaration), the time of release is 2.0 hours. Provide a discussion of the reasons for these differences and the impact on the results of the SAMA analysis.

Waterford 3 Response

ER Table D.1-8 provides the grouping of the release categories: early, intermediate and late releases. These releases represent the time duration between the establishment of WF3-specific conditions associated with a General Emergency (GE) and the time that the actual containment failure occurs.

Time to General Emergency Conditions – The MAAP results are used to establish the time to plant conditions used in the recognition and classification of emergencies. Plant criteria used by WF3 to establish plant conditions for a General Emergencies are based on the

WF3 emergency response procedures. Using these plant criteria, the timing to reach these conditions was extracted from the MAAP data to establish a scenario specific timing for General Emergency conditions. The maximum time to meet these conditions defines the time at which the WF3 plant and personnel recognize the plant-specific state of General Emergency.

Plume Release Time – The initiation time for a plume release is established using the MAAP results. Plume release times are determined as the time at which the containment has failed.

The characterization of timings used to determine the Release Categories is a relative measure of time. The duration of time between the declaration of a General Emergency based on plant criteria to the time of the plume release represents the characterization timing. Early releases are classified as having a containment release within 4 hours of plant General Emergency declaration.

The plant-specific General Emergency timings used to classify the Level 2 scenarios are also incorporated in the Level 3 model to support the timing of emergency response action in context with the progress on the accident and plume release. The Level 3 model parameter RDOALARM defines the declaration of GE by Waterford 3 to emergency responders and agencies. The RDOALARM used in the Level 3 model represented the time for the plant to evolve to General Emergency conditions and also included a 15-minute assessment time for Waterford 3. The RDOALARM parameter was incorrectly used to this assessment time in relation to the plant GE conditions rather than in context of the plant scram time. Values of the RDOALARM have been modified as shown in revised Table D.1-10 and reflect the time between the recognition of GE conditions plus the 15-minute assessment time in relation to the initiating event (scram time). Revised Table D.1-10 provides the timings associated with the release plumes used in the Level 3 analysis. The plume release times represent the time at which a release pathway opens (containment failure) and FP releases begin. Plume release times are determined in relation to the start of the initiating event (reactor scram).

The Level 3 model was updated using the correct RDOALARM times. Also, 48hr FP releases were used as described in the response to 2.g and alternate accident sequences were selected to represent the M-I and L-I RC as described in the response to 4.b. The revised Table D.1-12 is shown below. The updated mean values of PDR and OECR for WF3 are 17.1 person-rem/yr and $162,682/yr.

Table D.1-12

Characteristics of Release Scenario		Results – Year 2010M	
Release ID	Frequency (per year)	Population Dose[1] (person-sv)	Offsite Economic Cost ($)
Intact	3.68E-06	1.28E+03	1.25E+08
H-E	1.88E-06	3.20E+04	2.88E+10
H-I	4.75E-06	2.20E+04	2.25E+10
M-E	2.74E-08	1.75E+04	1.56E+10
M-I	1.34E-07	8.94E+03	4.57E+09
M-L	1.84E-08	1.12E+04	8.54E+09
L-I	2.42E-09	5.70E+03	1.75E+09
L-L	5.56E-10	4.15E+03	7.86E+08
LL-L	3.85E-10	6.47E+03	2.74E+09
	Totals	1.71E+01 person-rem/yr	1.63E+05 $/yr

1 Conversion Factor: 1 sv = 100 rem

2.g. ER Section D.1.2.2.6 indicates that level 2 accident sequences were evaluated deterministically using the Modular Accident Analysis Program (MAAP) 4.0.6 code and a 36-hour accident time period, and that this time period was selected to ensure that sufficient time was allotted to allow for late failures and to capture the peak steady-state FP release concentrations. Provide support that the 36 hour accident time period yields the peak FP release over the 48 hour time period beginning at the time of declaration of a general emergency. If the peak FP release does not occur using the 36 hour accident time period, discuss the impact on the SAMA analysis if the analysis is extended to 48 hours after the declaration of a general emergency.

Waterford 3 Response

Each RC representative accident sequence was re-evaluated using the MAAP code over a time period extending for 48 hours following the declaration of the WF3 General Emergency. This re-evaluation was performed to conservatively establish peak FP fractions. The Level 3 model was updated using the extended 48-hour MAAP FP fractions. Also, the RDOALARM times were corrected as described in the response to RAI SAMA 2.f and alternate accident sequences were selected to represent the M-I and L-I RC as described in the response to RAI SAMA 4.b. The revised Table D.1-12 is shown above. The updated mean values of PDR and OECR for WF3 are 17.1 person-rem/yr and $162,682/yr.

2.h. ER Table D.1-9 states that the frequency of the "intact" RC is obtained from the difference between the base CDF and the total of the other release categories. Provide the results for the "intact" RC from the sum of the no containment failure containment event tree end states. Discuss the impact of cut set truncation on the CDF and RC frequencies and the validity of the approach taken to determining the RC frequencies.

Waterford 3 Response

The CDF and RC frequencies were both quantified at a truncation of 1E-11 and convergence studies were performed on both the level 1 and level 2 model results. The level 1 demonstrates CDF convergence (defined as a change of less than 5% per decade) at 1E-11. Also, the level 2 demonstrates a change of less than 5% at a 1E-11 truncation. The highest frequency release categories (H-E and H-I) also demonstrate a change of less than 5% at 1E-11 truncation. Thus no significant change in SAMAs would be expected by providing the results for the "intact" RC from the sum of the no containment failure containment event tree end states vs taking the difference between the base CDF and the total of the other release categories.

RAI SAMA 3

3. Provide the following information with regard to the treatment and inclusion of external events in the SAMA analysis. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF3 SAMA analysis, NRC staff evaluates the applicant's treatment of external events in the PRA models. The requested information is needed in order for the NRC staff to reach a conclusion on the sufficiency of the applicant's PRA models for supporting the SAMA evaluation.

3.a. In response to NRC requests following the accident at the Fukushima Daiichi Nuclear Power Plant, new seismic hazard curves have been developed for each nuclear power plant site. The Entergy response to NRC staff RAIs on the WF3 NFPA 805 transition LAR (Agencywide Documents Access Management System (ADAMs) ML14162A506) provided an assessment of the seismic CDF that is different from that given in the integrated leak rate testing interval extension LAR used in the SAMA analysis. Provide an updated WF3 seismic CDF using the approach of the NFPA 805 assessment but based on the new post Fukushima hazard curves and discuss the impact of using this seismic CDF on the WF3 SAMA analysis.

Waterford 3 Response

In response to NRC staff RAIs on the WF3 NFPA 805 transition LAR (Enclosure 2 to Letter W3F1-2014-0025, dated June 11, 2014) Entergy provided an assessment of the seismic CDF that is different from that used in the SAMA analysis. This seismic CDF, 9.02E-07/rx-yr, was based on the EPRI seismic hazard curves.

Using the new post-Fukushima hazard curves to assess the seismic CDF in the same manner as the NFPA 805 RAI response, would result in a seismic CDF of 6.48E-06/rx-yr. This would change the internal/external events multiplier from 3.02 to 3.57. The "Internal and External Benefit" values in revised Table D.2-2 use a multiplier of 3.57.

3.b. As stated above, the revised Attachment W to the WF3 NFPA 805 LAR gives the internal events CDF and LERF as 6.5E-06 per rx-year and 8.7E-08 per rx-year respectively. These values are approximately 60% of the results given for the 2015 (R5) PSA used for the SAMA analysis. If the 2015 (R5) value is the most appropriate for use in the license renewal applications (LRA), provide an assessment of the impact of this more recent internal events model on the results of the fire PSA used in the SAMA analysis and the resulting impact on the SAMA analysis.

Waterford 3 Response

As explained in the response to 1.e, the CDF value differs from that given for the 2015 (R5) PSA model used for the SAMA analysis because it is from a prior interim model revision which did not include the revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. The prior interim LERF model had a slightly lower value due to the update in the SGTR sequences which are binned as LERF which saw an increase due to the change in values of thermal-induced SGTR and pressure-induced SGTR failure probabilities.

As noted in Section D.1.3.2 of the ER, a fire CDF of 1.80E-05/rx-yr was used in calculating the SAMA internal/external events multiplier discussed in Section 4.15.1.4.4. This is the fire CDF reported in the revised Attachment W to the WF3 NFPA 805 LAR mentioned in the question and was the most recent value at the time the SAMA analysis was performed. As noted in the response to question 1.e, the CDF for the 2015 (R5) PSA model used for the SAMA analysis is larger because that model includes the revision of the battery depletion modeling to includet procedural direction to strip batteries to allow for extended battery life. This change and the induced SGTR change for LERF in the internal events model would not have such a significant impact on the Fire PRA model results since those model results are driven by fire-specific factors. Also, with the conservatisms included in both the fire PRA and the SAMA analysis, it is judged that the multiplier provided in ER Section 4.15.1.4.4 is appropriate for the SAMA analysis.

3.c. ER Section D.1.3.4 indicates that internal flooding is not included in the 2015 internal events PSA used for the SAMA analysis. It is also stated that changes were made to internal flooding analysis that allowed the internal flooding analysis to satisfy the requirements in the ASME Standard and RG 1.200. Provide further information on this analysis including consistency with the system modeling in the 2015 (R5) PSA, the impact of any differences on the internal flood CDF and the SAMA analysis and the process used to insure the technical adequacy of the internal flooding analysis.

Waterford 3 Response

The internal flooding analysis has not been updated since the peer review. The internal flooding analysis is documented in report PRA-W3-01-002, “W3 Internal Flooding Analysis.” The last major revision of this report, Revision 2, was completed in April 2008. In April 2009, editorial Revision 3 was completed to update the Appendix B walkdown notes. Revision 3 of PRA-W3-01-002 was included in the 2009 peer review of the WF3 internal events model and calculates a total CDF contribution of 2.48E-06/rx-yr from internal floods. This value was used, along with external events CDF values, to calculate the internal/external events multiplier for the SAMA analysis. The multiplier was utilized because the current internal flooding model hasn’t been integrated with the current internal events model or the Level 2 and 3 models.

The contribution the flood scenarios make to the core damage frequency was calculated by manipulating event trees and data prepared in quantifying other accident scenarios in the 2003 (R3) PSA model. The sequence probabilities were then combined with initiating event (flooding) frequencies to determine the contribution of internal flooding to the core damage frequency. The differences between the R3 PSA model and the R5 PSA model are described in Sections D.1.4.3 and D.1.4.4 of the Environmental Report. The R3 CDF of 6.75E-06/rx-yr was increased to 1.05E-05/rx-yr in R5. This increase was predominantly due to a revision of the battery depletion modeling to include procedural direction to strip batteries to allow for extended battery life. This modeling increased the CDF from sequences initiated by a loss of offsite power. Since the internal flooding CDF comes from sequences initiated by internal floods, it would not be significantly impacted by this model change. Thus, there is no expected impact on the SAMA analysis.

The PSA analyst performing the internal flooding analysis was an experienced, trained professional and the analysis was reviewed by a second, experienced, trained PSA analyst. The internal flooding analysis was performed in accordance with guidance documents existing at the time (ASME PRA standard ASME RA-Sb-2005, NRC Regulatory Guide 1.200 for Trial Use, April 2004, Draft Regulatory Guide DG-1161, September 2006, and draft EPRI guidance document, “Guidelines for Performance of Internal Flooding Probabilistic Risk Assessment (IFPRA)”, September 2006.) However, the internal flooding model hasn’t been updated since the peer review and hasn’t been integrated with the current internal events model or the Level 2 and 3 models. Therefore, the WF3 internal flooding model was not deemed to be technically adequate for analyzing individual SAMA candidates. Thus, the internal flooding CDF was included with the external event CDF values to calculate the internal/external events multiplier for the SAMA analysis.

3.d. As discussed in the NRC staffs "Interim Staff Response to Reevaluated Flood Hazards" at WF3 dated April 12, 2016, there are a number of reevaluated flood hazards that exceed the current design-basis. Provide a discussion of the current status of the WF3 Mitigation Strategy Assessment (MSA) and integrated assessment or focused evaluation, and a discussion of the impact of flood hazards on the WF3 risk. Provide support for the ER's conclusion that flood hazards are negligible and need not be included in the external events multiplier.

Waterford 3 Response

The WF3 Mitigation Strategy Assessment has been completed and concluded that the WF3 FLEX design basis flood is not affected by the results of the Mitigating Strategy Flood Hazard Information (MSFHI). Specifically, the following flood mechanisms, which bound the reevaluated flood hazards that exceed the current design basis, do not impact the site FLEX strategies.

- local intense precipitation event
- probable maximum flood on the Mississippi River
- probable maximum flood combined with an hypothetical dam break within the Mississippi River and levee failure at WF3
- combined event H.3 (alternative 3): 25-year flood in the Mississippi River, probable maximum surge including antecedent water level, levee failure, and coincident wind-generated waves

Therefore, the current FLEX strategies can be fully deployed with no additional operator actions. The letter documenting these results was sent to the NRC on 11/14/2016 (ML16319A089).

The focused evaluation has not yet commenced at WF3. No appreciable impact on risk is expected due to interim actions taken as part of the Flood Hazard Re-evaluation to begin sump pump actuation promptly and utilize weather warning time triggers.

RAI SAMA 4

4. Please provide the following information regarding the Level 3 PRA used in the SAMA analysis. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs, if not previously considered, in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF3 SAMA analyses, NRC staff evaluates the applicant's analysis of accident consequences in the Level 3 PRA. The requested information is needed in order for the NRC staff to reach a conclusion on the sufficiency of the applicant's Level 3 PRA model for supporting the SAMA evaluations.

4.a. ER Table D.1-10 includes a time to declaration of general emergency (GE) and a warning time that is said to include a 15 minute GE declaration. The GE declaration time is 15 minutes for all release categories while the warning time ranges from 15 minutes to 9 hours. Discuss the use of these times in the consequence analysis and how they were determined. The GE declaration time would be expected to be sequence specific and based on site procedures.

Waterford 3 Response

RDOALARM is utilized in the WinMACCS code to represent the initiation of the movement of the cohorts. Within the WinMACCS code, the value of RDOALARM provides the required context with both the timing of the accident scenarios and the progression of emergency response measure.

WF3 procedures facilitate the determination of general emergency (GE) conditions. Using the WF3 procedures, a determination of the timing for GE conditions is evaluated based on degraded fission product barriers. To establish GE conditions, an assessment of conditions that lead to the loss of two barriers with a potential loss of the third barrier is required for declaration of a WF3 General Emergency.

MAAP results were used to establish the timing of the loss or potential loss of the fission product barriers (GE condition) during accident progression. Timings were established from MAAP results for the loss or potential loss of each barrier. The maximum time to achieve a plant GE condition was used to represent the scenario-specific GE condition for each release scenario.

WF3 recognizes a 15-minute “assessment” period following the indication of plant conditions to a General Emergency and in advance of notification to offsite responders or populations. The start of this assessment period is coincident with the timing of the WF3 plant GE conditions. The emergency director is expected to make the emergency declaration promptly without waiting for the 15-minute period to elapse once the emergency action level is recognized as being exceeded. However, since the declaration of a GE could take up to 15 minutes beyond the time that the necessary plant conditions are reached, the sum of the time to achieve plant GE conditions and the 15-minute assessment period is conservatively defined as the earliest time that offsite response

actions associated with sheltering or evacuation may occur. This is the timing value of the WinMACCS parameter RDOALARM.

Updates to the plume characteristics and accident progress timing have been made to include this 15-minute "assessment" period in context with the onset of plant General Emergency conditions with the WinMACCS parameter RDOALARM. The revised Table D.1-10 provides updates to the WinMACCS parameter RDOALARM.

4.b. The NRC staff notes in ER Table D.1-12 that while the population dose for the Low-Intermediate (L-I) RC is greater than that for the High-Early (H-E) RC, the cesium and Iodine release fractions given in Table D.1-10 are about 4 percent of those for the H-E RC. Similarly, while the population dose for the Moderate-Intermediate RC is higher than that for the H-E RC, the cesium and iodine release fractions are about 33 percent and 12 percent of those for the H-E RC, respectively. Explain the reason for this unexpected result and the impact on the SAMA cost-benefit analysis. As part of this explanation and to the extent applicable, summarize the treatment of relevant release characteristics (e.g., energy of release, source term, etc.) used to define each RC.

Waterford 3 Response

A screening and review of the accident scenarios associated with each RC was performed for the purpose of selecting both a conservative and representative sequence to best represent each RC. Two Level 3 RC scenarios, M-I and L-I, represent a conservative accident scenario based on energy of release and source terms derived from the MAAP analyses. However, these scenarios generate population doses that are greater than scenarios with higher or earlier release scenarios (H-E).

The scenarios selected for the RC M-I and L-I represent early phase in-vessel core melt conditions under high RCS pressure (> 200 psi) and partially recovered/maintained reactor pressure vessel (RPV) water levels. Under these conditions, increased production of steam and hydrogen enhances fission product releases from the fuel rods and other core materials. These in-vessel conditions facilitate the release of the alkaline and rare earth (non-volatile) isotopes from fuel fracturing or powdering. A review of the FP fractions for both the M-I and L-I accident sequences show these sequences to be outliers with regard to the ratio of barium to iodide in comparison to the other accident scenarios. In the case of the L-I scenario, barium exceeded iodide at a ratio of 6.61:1.

Alternate accident sequences were selected to represent the M-I and L-I RC and were used in the Level 3 model. Results obtained from the Level 3 model using scenarios with representative ratios of alkaline and rare earth isotopes are shown in the revised Table D.1-12 in the response to RAI SAMA 2.f. By replacing the outlier accident sequences, the M-I and L-I RC have PDR less than earlier RC such as H-E.

Since the outlier sequences are not being used in the revised SAMA cost-benefit analysis, a discussion of their impact on the SAMA cost-benefit analysis is not provided.

4.c. ER Table D.1-11 provides the estimated core inventory input to the Level 3 analysis; however, there is no description regarding how this input was developed. Clarify that the core inventory estimates applied in support of the Level 3 analysis are specific to WF3. Additionally, clarify whether additional adjustments of the core inventory values are necessary to account for differences between fuel cycles expected during the period of extended operation and the fuel cycle upon which the Level 3 analysis is based (e.g., to account for any changes in future fuel management practices or fuel design).

Waterford 3 Response

The reactor core inventory used in the Level 3 analysis is based on long-term operation at a core thermal power level of 3,735 MWt (100.5% of the extended full power uprate of 3,716 MWt). This core inventory is the LOCA Alternative Source Term in the WF3 FSAR [FSAR, Table 12.2-12] and is specific to WF3.

The core inventory represents a bounding core design based on five power uprate fuel management cycles. The bounding core inventory was determined using ORIGEN2 and based on a cycle length, rated thermal power, assembly loading, average core enrichment and feed batch size. Based on sensitivity analyses, contributors to the highest core activities included low enrichment, longest cycle length and highest quantity of once burned fuel. Entergy believes that the core inventory values account for expected fuel management practices and fuel design during the period of extended operation.

4.d. Regarding ER Section D.1.5.3, the NRC staff notes that the consequence analysis assumed site-specific meteorological data from year 2010, given that it generated the highest population dose and offsite economic cost. However, Section D.1.5.2.6 indicates that certain meteorological data, including that for year 2010, was not available and was addressed, at least in part, by using “data from approved data substitution methods as needed.” Quantify the amount of missing meteorological data, which were estimated using data substitution, and clarify the methods used.

Waterford 3 Response

Data substitution methods were used to augment missing meteorological data for 2010. Missing data for 2010 include the following:

- 153 hours of wind speed, wind direction and temperature difference data (1.7% of annual data); and
- 18 hours of precipitation data (0.2% of annual data)

Data substitution methods were used to augment missing meteorological data for 2011. Missing data for 2011 include the following:

- 64 hours of wind speed, wind direction and temperature difference data (<0.1% of annual data); and

- 6 hours of precipitation data (<0.1% of annual data)

Precipitation data was missing for a few scattered hours (<0.1% of annual data) in 2005, 2008, and 2009. The data for 2013 was missing all the hourly precipitation data (100% of annual data). The missing precipitation data was zero-filled as discussed below.

Missing data was completed using approved substitution methods (Atkinson and Lee 1992). Data substitution methods used to complete the missing wind speed, wind direction and temperature difference data included:

- Replacement of primary tower data with secondary tower data (method utilized for 6% of data replacement); and
- Substitution with data from previous year that is representative (method utilized for 94% of data replacement)

Data substitution methods used to complete the missing precipitation data included:

- Zero filling precipitation data. Zero filling the precipitation data results in a conservative result from the WinMACCS model (method utilized for 100% of data replacement)

4.e. ER Section D.1.5.2.1 discusses population data. Explain why the population distribution used in the analysis is appropriate, and justify the method used for population extrapolation. In doing so, describe how those parishes with declining population projections were addressed (if applicable). Additionally, clarify whether transient and special facility populations were included, and if not, justify their exclusion.

Waterford 3 Response

The US Census 2010 data was used as the basis for the population projections. Parish level population projection estimates were obtained from Woods & Poole Economics, Inc. This data provided population projection estimates for every year from 2011 through 2040. A cohort component method with an employment driven migration model was used by Woods & Poole Economics, Inc. for Louisiana to establish population projections by parish. Excel was used to establish the growth trends in known parish population projections. Linear and 2nd order polynomial regression equations were used, as appropriate, to extend the trend past the given projection dates to create projected population data to the half decade year (2045) following the end of the WF3 period of extended operation (2044). This method is appropriate, and conservative, since population projections beyond the period of extended operation were used for the SAMA analysis, while NEI-05-01A recommends projecting the population to a time within the second half of the period of extended operation.

For parishes with a projected negative population growth, the highest estimated population value was held constant for the remaining portion of the projection period.

- One Louisiana parish, Orleans Parish, was shown to have a declining population trend. To produce conservative population estimates for this parish throughout the projection period, the population value for 2011 was held constant.
- The graphs for Iberville, Plaquemines, St. Helena, St. James, and St. Mary parishes illustrated a growth tendency in the beginning of the projection, then a decline in growth rate and, in some cases, a decline in population. Linear regression did not fit the data for these three parishes and the R squared values were low. Second order polynomial regression equations fit the data better and had better R squared values. However, when projected to the end of the time period, the population tended to decline. For these five parishes, a composite line was used. This line used the second order polynomial regression and, following the highest year of projected population, that year's data was held constant. Because the composite curve was not allowed to decline below the highest projected population data point, the results are conservative.

Transient populations were included. Transient population data for Louisiana was obtained from official state sources (The University of New Orleans, Hospitality Research Center), 2014. "Louisiana Tourism Forecast 2014 – 2017", prepared for Louisiana Department of Culture, Recreation and Tourism. Retrieved from <http://www.crt.state.la.us/tourism/louisiana-research/latestresearch/index>, (May 14, 2014). Using corresponding years, a ratio of the transient population value and the parish permanent population value was produced for each parish. A transient ratio was calculated for 2013, 2014, 2105, 2016, and 2017, but the 2013 ratio was used as it was the largest. This ratio was assumed to be constant, and was used to project the transient population to 2045 values, because it is an economic value which is proportional to population changes.

Special facility populations were included as part of the permanent population counted in the US Census 2010 data.

4.f. ER Section D.1.5.2 describes the assumptions used for many of the parameters applied in support of the Level 3 analysis, but significant gaps exist in the information provided. Specifically, the guidance in Section 3.4.2 of NEI 05-01, "SAMA Analysis Guidance Document," identifies several economic parameters utilized in the WinMACCS model that are not discussed (e.g., cost of evacuation, cost of temporary relocation, cost of land decontamination, etc.). Describe how each of these cost parameters were developed, and provide the values and technical basis for any inflation/escalation factors utilized.

Waterford 3 Response

The current parameter values in the following table for CHEVACST, CHRELCST, CHCDFRM, CHCDNFRM, CHDLBCST, and CHPOPCST, are based on recommended cost values in 1987 dollars and are adjusted to represent the increase in values to present pricing values. These adjustments were calculated using average U.S. consumer prices indices. A proportional factor of 2.08 was developed using the annual average for 1987 CPI (113.6) and the annual average for 2014 CPI (236.736). This CPI factor was applied to the 1987 values of the following parameters to represent current values as shown below.

The 1987 values are based on the parameters described in NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" and NUREG/CR-3673, "Economic Risks of Nuclear Power Reactor Accidents" and are consistent with the inputs used in MACCS2 Sample Problem A. These values have been subject to extensive peer review since the late 1980s and continue to be used in licensee PRA and SAMA analyses and state-of-the-art severe accident analyses. In these analyses, the values are commonly escalated to account for inflation. The base values are considered applicable to the region around WF3 because five nuclear power plants were analyzed in NUREG-1150, some of which have comparable or larger population densities than the region around WF3. For example, the Zion plant was part of NUREG-1150, is just north of Chicago, and has a large population density. Since economic parameters tend to increase with population density, and the base values take into account sites with larger population density, the values are considered applicable to the region around WF3.

MACCS Parameter	Description	1987 Parameter Value	Current Parameter Value (Updated to 12/2014)
CHEVACST001	Cost of evacuation	27	56.27
CHRELCST001	Cost for temporary relocation	27	56.27
CHCDFRM0001	Farmland decontamination cost (dose reduction factor of 3)	562.5	1,172
	Farmland decontamination cost (dose reduction factor of 15)	1,250	2,605
CHCDNFRM001	Non-farmland decontamination cost (dose reduction factor of 3)	3,000	6,252
	Non-farmland decontamination cost (dose reduction factor of 15)	8,000	16,672
CHDLBCST001	Labor cost of a decontamination worker	35,000	72,938
CHPOPCST001	Per capita removal cost for temporary or permanent relocation of population and businesses in a region rendered uninhabitable during the long-term phase time period.	5,000	10,420

4.g. NUREG-1530, Revision 1, Reassessment of NRC's Dollar per Person-Rem Conversion Factor Policy (DRAFT) is publicly available in ADAMs at ML15049A114. Since Commission approval of the NUREG is expected by the middle of 2017, this would be new and significant information that would need to be evaluated before the WF3 license renewal is issued. WF3 used the old value of $2000 per person-rem in the current SAMA analysis. In anticipation of this change, please provide a sensitivity analysis using the anticipated new value of $5,200 per person-rem.

Waterford 3 Response

A sensitivity analysis was performed that utilizes the value of $5,200 per person-rem rather than a value of $2000 per person-rem. This resulted in one additional potentially cost beneficial SAMA (SAMA 9 to add a new backup source of diesel cooling). The results of this sensitivity can be seen in Table D.2-4.

4.h. On May 4, 2016, the Commission issued a decision (CLI 16-07) in the Indian Point license renewal proceeding, in which it directed the Staff to supplement the Indian Point SAMA analysis with sensitivity analyses. Specifically, the Commission held that documentation was lacking for two inputs (TIMDEC and CDNFRM) used in the MACCS computer analyses, and that uncertainties in those input values could potentially affect the SAMA analysis cost-benefit conclusions. The Commission therefore directed the Staff to perform additional sensitivity analyses.

The two inputs (TIMDEC and CDNFRM) are commonly used in the SAMA analyses performed for LRAs. These two input values were generally based on the values provided in NUREG 1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" and NUREG/CR 3673, "Economic Risks of Nuclear Power Reactor Accidents." The TIMDEC input value defines the time required for completing decontamination to a specified degree. The CDNFRM input parameter defines the cost (on a per person basis) of decontaminating non-farmland by a specified decontamination factor. The CDNFRM values used in NUREG 1150 ($3,000/person for decontamination factor of 3 and $8,000/person for decontamination factor of 15) stem from decontamination cost estimates provided in NUREG/CR 3673, the same 1984 economic risk study referenced in support of the decontamination time inputs. These decontamination cost inputs are commonly escalated to account for inflation.

The NRC Staff believes the Commission's decision in CLI 16-07 may be applicable to the SAMA analysis performed for WF3, inasmuch as that analysis may have also relied upon the NUREG 1150 values for TIMDEC and CDNFRM. We therefore request that Entergy either justify why CLI 16-07 does not apply to the SAMA analysis performed for WF3 or supplement the SAMA analysis with sensitivity analyses for the CDNFRM and TIMDEC values. Entergy is requested to review the input values specified in CLI 16-07 for the

Indian Point LRA, and (1) to apply the maximum values specified by the Commission (one year (365 days) for TIMDEC and $100,000 for the CDNFRM values for the decontamination factor of 15) or, in the alternative, (2) to explain, with sufficient justification, its rationale for choosing any other value(s) for its sensitivity analyses. In any event, Entergy should execute sensitivity analyses for the release categories modeled that exceed 10^{15} Becquerels of Cs 137 released. Entergy is requested to evaluate how these sensitivity analyses may affect its identification of potentially cost-beneficial SAMAs. Finally, upon completing its sensitivity analysis, Entergy is requested to submit the spreadsheet (or equivalent table if another method is used) that conveys the population dose and off-site economic cost for each release category and integrates the results into a Population Dose Risk and an Offsite Economic Cost Risk for WF3.

Waterford 3 Response

To address this, Entergy has chosen to use Option 1, and a new WinMACCS TIMDEC and CDNFRM sensitivity case was developed with the following changes (as compared to the WF3 WinMACCS base case documented in the Environmental Report (ML16088A335)):

- TIMDEC was escalated to one year (365 days) for decontamination factor (DF) =15
- CDNFRM was escalated to $100,000/person for DF=15
- These changes were applied to all release categories (even those with total releases of Cs-137 below 1015 Becquerels).

Both the conditional and frequency weighted WinMACCS results of this sensitivity case for offsite dose and economic cost are presented in the table below for each release category, as the audit question requests. The frequencies used to weight the results are those from the Environmental Report (ER) Table D.1-12. For the specified TIMDEC and CDNFRM input changes, the WinMACCS Offsite Economic Cost Risk (OECR) increased approximately 98% and the Population Dose Risk (PDR) increased approximately 31% as compared to the WinMACCS base case results of $1.63E+5/yr and 17.1 person-rem/yr (presented in updated Table D.1-12 in the response to RAI SAMA 2.f). The increases seen in the OECR and PDR for this TIMDEC and CDNFRM sensitivity case are bounded by the 95th percentile uncertainty factor of 2.06, which was included as part of the SAMA candidate cost-benefit evaluation. Therefore, no new SAMA candidates are identified as potentially cost-beneficial based on this new TIMDEC and CDNFRM sensitivity case. There are no changes to the conclusions of the SAMA analysis based on the TIMDEC and CDNFRM sensitivity case.

Characteristics of Release Mode		Population Dose (person-sv)[1]		Offsite Economic Cost ($)	
ID	Frequency (per year)	Baseline (person-sv)	ECON (person-sv)	Baseline ($)	ECON ($)
Intact	3.68E-06	1.28E+03	1.28E+03	1.25E+08	6.29E+08
H-E	1.88E-06	3.20E+04	4.08E+04	2.88E+10	5.10E+10
H-I	4.75E-06	2.20E+04	2.96E+04	2.25E+10	4.61E+10
M-E	2.74E-08	1.75E+04	2.30E+04	1.56E+10	4.01E+10
M-I	1.34E-07	8.94E+03	9.85E+03	4.57E+09	1.82E+10
M-L	1.84E-08	1.12E+04	1.31E+04	8.54E+09	3.06E+10
L-I	2.42E-09	5.70E+03	5.96E+03	1.75E+09	7.33E+09
L-L	5.56E-10	4.15E+03	4.38E+03	7.86E+08	3.35E+09
LL-L	3.85E-10	6.47E+03	6.91E+03	2.74E+09	1.09E+10
	Totals	1.71E+01	2.24E+01	1.63E+05	3.21E+05
	% Change	NA	30.92%	NA	97.50%
	Units	person-rem/yr	person-rem/yr	$/yr	$/yr

1 Conversion Factor: 1 sv = 100 rem

RAI SAMA 5

5. Provide the following information with regard to the selection and screening of Phase I SAMA candidates. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF3 SAMA analysis, NRC staff evaluates the applicant's basis for the selection and screening Phase I SAMA candidates. The requested information is needed in order for the NRC staff to reach a conclusion on the adequacy of the applicant's Phase I SAMA selection and screening process for the SAMA evaluation.

5.a. Based on the review of importance analysis in ER Tables D.1-2:

5.a.i. The risk reduction worth (RRW) for event %TAC3, "Loss of 4.16Kv Bus 3A3-S" (1.0914), is considerably less than that for %TAC4, "Loss of 4.16Kv Bus 3B3-S" (1.318). Explain the reasons for this difference and consider a potential SAMA that addresses the cause of this difference.

Waterford 3 Response

This difference is attributed to an asymmetry related to component cooling water (CCW). If a safety injection actuation signal (SIAS) occurs, the CCW system automatically splits into two independent trains by closing the CCW pump suction and discharge cross-connect valves and the train B supply and return valves to the AB header. Flow to the AB header (i.e., reactor coolant pumps (RCPs)) continues to be supplied from train A. Thus, following an SIAS, CCW train B does not provide flow to the RCPs. Thus, when initiator %TAC4 (Loss of 4.16kV Bus 3B3-S) occurs and the operators fail to align CCW train AB and fail to trip the RCPs, it leads to a failure of the RCP seals. Phase II SAMA 5 was evaluated to address this asymmetry. Phase II SAMA 77 which was proposed, evaluated, and found potentially cost-beneficial as presented in RAI SAMA 7.b (to provide diverse backup auto-start signals for the standby CCW trains on loss of the running train) also mitigates this failure.

5.a.ii. Event ZDHFBAT_LSP, "Failure to shed loads on the A or B battery," is failure of a human action and is addressed by several hardware related SAMAs. Discuss the potential for SAMAs relating to improvements in procedures and training to reduce the impact of this human error and other human error events (e.g. Events ZHF-C2-011).

Waterford 3 Response

The RRW tables (ER Tables D.1-2, D.1-4, and D.1-5) are intended to show the Phase II SAMAs which were evaluated in the cost-benefit analyses, which would mitigate each of the important events. Many enhancements to procedures and additional training to reduce the impact of human errors were also considered for

human actions in the RRW tables, but were screened out during Phase I and are, therefore, not listed in the RRW tables.

ZDHFBAT_LSP, Failure to shed loads on the A or B battery, is a good example.

NEI-05-01A recommends a SAMA candidate to “Improve DC bus load shedding.” During the Phase I screening analysis, procedure OP-902-005, “Station Blackout Recovery Procedure,” was reviewed to determine if improvements could be made. Since no improvements were identified, this candidate SAMA was screened as “already installed.”

ZHF-C2-011, is a combination of two human actions, failure to align CCW train AB to replace lost train A or B and failure to trip RCPs after loss of seal cooling, and is another good example.

For the first human action, failure to align CCW, NEI-05-01A recommends a SAMA candidate to “Enhance procedural guidance for use of cross- tied component cooling or service water pumps.” During the Phase I screening analysis, procedure OP-901-510, “Component Cooling Water System Malfunction,” was reviewed to determine if improvements could be made. No improvements were identified, so the CCW portion of the candidate SAMA was considered “already installed.” (Since this SAMA candidate addresses two systems, it was retained to evaluate adding the ability to cross-tie the ACCW pumps and was found to not be cost-beneficial (Phase II SAMA 21).

For the second human action, failure to trip RCPs after loss of seal cooling, NEI-05-01A recommends a SAMA candidate, “On loss of essential raw cooling water, proceduralize shedding component cooling water loads to extend the component cooling water heat-up time.” During the Phase I screening analysis, procedure OP-901-510, “Component Cooling Water System Malfunction,” was reviewed to determine if improvements could be made. No improvements were identified, so the CCW portion of the candidate SAMA was considered “already installed.”

In addition, for the second human action, failure to trip RCPs after loss of seal cooling, another SAMA candidate, “Human actions to automatically trip the RCP on loss of CCW” was found in the Sequoyah SAMA analysis. During the Phase I screening analysis, procedure OP-901-510, “Component Cooling Water System Malfunction,” was reviewed to determine if improvements could be made. No improvements were identified, so the candidate SAMA was considered “already installed.”

Phase I SAMA candidates related to training were also investigated to determine if additional training would mitigate high RRW events. Examples include the following.

- Increase training on response to loss of two 120V AC buses which causes inadvertent actuation signals.
- In training, emphasize steps in recovery of offsite power after an SBO.
- Emphasize timely recirculation alignment in operator training.
- Additional training on loss of component cooling water.
- Improve operator training on ISLOCA coping.
- Increase training and operating experience feedback to improve operator response.
- Institute simulator training for severe accident scenarios.

During the Phase I screening analysis, procedure EN-TQ-114, “Licensed Operator Requalification Training Program Description,” was reviewed to determine if significant improvements could be made. The operators are repeatedly trained on risk-significant actions. Classroom exercises and simulator training are provided on these actions as well as on implementation of the severe accident guidelines. Severe accident scenarios are also developed for emergency planning exercises. The need for improvements in this area was not identified.

5.b. ER Section D.1.3.4 indicates that, while the internal flooding analysis is not integrated with the internal events analysis, changes were made to the internal flooding analysis that allowed the internal flooding analysis to satisfy the requirements in the ASME Standard and RG 1.200. Two SAMAs, SAMA 67, “Improve internal flooding response procedures and training to improve the response to internal flooding events,” and SAMA 68, "Install flood doors to prevent water propagation in the electric board room,” were included in the in the Phase II evaluation. Provide a discussion of the identification of additional candidate SAMAs for mitigating internal flooding risk based on review of important contributors to the internal flooding CDF.

<u>Waterford 3 Response</u>

In addition to phase II SAMAs 67 and 68, a number of phase I candidate SAMAs related to internal flooding, from NEI-05-01A, were considered and found to be non-applicable or already installed. Phase I SAMA candidates from other plants, listed below, were also considered. These SAMA candidates, and the two that were retained for evaluation, were compared with the internal flooding scenarios to determine if the candidates would significantly mitigate the internal flooding CDF. The SAMA candidates were considered globally, rather than specifically. Phase II SAMAs 67 and 68 were found to be potentially significant and were retained for evaluation, but the others were not.

- Install spray protection on motor-driven AFW pumps and space coolers.
- Install a globe valve or flow limiting orifice upstream in the fire protection system.
- Protect important equipment in the turbine building from internal flooding.
- Install spray protection on component cooling pumps and space coolers.
- Modifications to lessen impact of internal flooding path through Control Building dumbwaiter.
- Replace mercury switches in fire protection system to decrease probability of spurious fire suppression system actuation.

In addition to considering these phase I SAMAs, the internal flooding analysis was reviewed to identify significant unique vulnerabilities that WF3 has to internal flooding. A flood in the Reactor Auxiliary Building which propagates between Electrical Switchgear rooms A, B, and AB has the largest scenario contribution to the WF3 internal flooding and was identified as a vulnerability. SAMA 68 to "Install flood doors to prevent water propagation in the electric board room" was evaluated to address this vulnerability and was not found to be cost-beneficial.

5.c. The ER indicates that the WF3 fire PRA was utilized to identify potential SAMAs. Three fire related SAMAs (74, 75 and 76) are included in the SAMA analysis based on their being commitments in the WF3 NFPA 805 LAR. The WF3 fire PRA model gives a CDF for internal fires that is 1.7 times higher than the internal events CDF after crediting these commitments. Provide a discussion of the identification of other candidate SAMAs for mitigating internal fire risk based on review of important contributors to the internal fire CDF.

Waterford 3 Response

The three fire-related SAMAs included in the SAMA analysis because they were commitments in the WF3 NFPA-805 LAR have been changed to the following based on the NFPA 805 LAR supplement letter dated January 18, 2016. These SAMAs have already been implemented.

- Update six fire area heat detectors that have incorrect trip set points.
- Remove personnel offices and other combustible materials in Fire Area RAB 27 (RAB+7).
- In Fire Area RAB 6 install a 1-hour fire resistance rating ERFBS fire wrap barrier from fire damage.

Similar to the review for internal flooding, described in the previous response, a number of phase I candidate SAMAs related to internal fires, from NEI-05-01A and from other plants, were considered and found to be non-applicable or already installed. Some examples are listed below. These SAMA candidates were considered globally, rather than specifically.

- Upgrade fire compartment barriers.
- Install additional transfer and isolation switches.
- Enhance control of combustibles and ignition sources.
- Install lower amperage fuses for various 14 American wire gauge (AWG) control circuits in the main control room (MCR).
- Modify quick response sprinkler heads in cable chases A–11, C–30, and C–31
- Install redundant fuses and isolation switches for MCR evacuation procedure
- Add fire wrap to the B Chilled Water cables in the vicinity of the A Chiller.

In addition to considering these phase I SAMAs, the significant fire scenarios were reviewed for significant unique vulnerabilities, but no additional SAMAs were identified to mitigate the fire risk at WF3. No fire-related SAMAs were retained for cost-benefit evaluation.

5.d. The disposition of Individual Plant Examination (IPE) and Individual Plant Examination of External Events (IPEEE) insights is given in Table D.2-1.

5.d.i. Phase I SAMA 184, “Install a portable generator to charge the AB battery,” is screened out as "already installed". The stated disposition indicates that the intent of this SAMA is met by the ability to manually control the turbine-driven emergency feedwater pump after loss of direct current (DC). Provide the importance of this human action and the potential for a SAMA involving the use of a portable generator.

<u>Waterford 3 Response</u>

The operator action to manually control the turbine-driven EFW pump is not credited in the version of the PRA model utilized for the SAMA analysis. The intent of this SAMA is to use a portable generator that can continue to supply DC power to the EFW turbine driven pump controls (and necessary monitoring instrumentation) to decrease the likelihood of core melt before AC power is restored. The intent of the SAMA is already installed by implementation of the FLEX strategy to manually control the turbine-driven emergency feedwater pump. Phase II SAMA 7 evaluated a similar modification to install a gas turbine generator which was retained as cost beneficial.

5.d.ii. Phase I SAMA 185, “Add guidance for aligning the low pressure safety injection (LPSI) pump for containment spray,” is screened out because it is "already installed." The procedure implemented is stated to address use of LPSI pumps for containment spray only for Large LOCAs. Discuss the benefit of this SAMA for other LOCAs or transients.

Waterford 3 Response

The procedural guidance to align the LPSI pump for containment spray is a standard appendix to the emergency operating procedures (EOPs). Standard appendices are used for evolutions that are called-out by several different EOPs when conditions warrant. Thus, this guidance can be utilized if both containment spray pumps are not available and high containment pressure exists, not only during large LOCAs. The disposition for phase I SAMA 185 has been updated to avoid confusion to state, “Using LPSI to replace containment spray is proceduralized in OP-902-009, Attachment 28.”

5.e. Identify the number of Phase I SAMA candidates identified from the various sources (i.e. NEI 05-01 Generic List, other industry documents of PWR SAMAs, the WF3 IPE and IPEEE, plant specific internal events importance analysis and other sources). If the total number of Phase 1 SAMA candidates is different than the 201 identified in Section D.2.1 of the ER, then provide an explanation for this difference.

Waterford 3 Response

The total number of Phase I SAMA candidates identified from various sources (i.e. NEI-05-01A Generic List, other industry documents of PWR SAMAs, the WF3 IPE and IPEEE, plant specific internal events importance analysis and other sources) is 202. The breakdown by source is as follows.

- NEI-05-01A Generic List 153

(Some of the NEI-05-01A SAMA candidates were also potentially cost-beneficial in other PWR SAMAs, but are not counted in the next bullet.)

- Other PWR SAMAs 32
- Plant-Specific Fire Risk Analysis 3
- Plant-Specific IPE 8
- Plant-Specific IPEEE 5
- NRC RAI SAMA 7.b 1

5.f. Section D.1.2.1 states that Table D.1-5 provides the correlation between all level 2 release states RRW risk significant events down to 1.005 identified from the WF3 PRA Level 2 model and the SAMAs evaluated in Section D.2. Clarify specifically which release categories are included in the importance analysis: all release categories, all except the intact RC, or all except intact and high-early release categories?

Waterford 3 Response

Table D.1-5 includes all release categories except the intact release category. Basic events that are correlated in Tables D.1-2 (based on CDF) and D.1-4 (based on LERF) are not listed again in Table D.1-5.

5.g. It is noted that the Phase II candidate SAMAs did not include adding an emergency diesel generator (EDG). Discuss why the cost-benefit of adding an EDG was not performed or provide such an evaluation.

Waterford 3 Response

A phase I SAMA candidate to add an emergency diesel generator was evaluated and determined to be already installed. WF3 has two emergency diesel generators (EDGs) with each Diesel oil feed tank containing a minimum of 339 gallons of fuel, a separate diesel generator fuel oil storage tank, and a separate fuel transfer pump.

WF3 also has “temporary” diesel generators (TEDs) that are staged on-site prior to removing a permanent plant Emergency Diesel Generator (EDG) from service for extended preplanned maintenance work or prior to exceeding the 72-hour AOT for extended unplanned corrective maintenance work. When the TEDs are installed in place of an out of service EDG, the TEDs are aligned in the event of a loss of offsite power and failure of the operable EDG and can be started and ready to load within 25 minutes.

In addition, WF3 has two FLEX diesel generators capable of supplying 400kW. One is pre-staged in an enclosure situated on the reactor auxiliary building (RAB) +41’ el. roof and placed into service within 12 hours of the onset of a beyond design basis external event, which is 30 minutes before the batteries deplete with the extended load shed strategy. The other, N+1 FLEX diesel generator, is stored in the “N+1” storage building (south of the nuclear plant island structure) and can be swapped out with the FLEX diesel generator should the FLEX diesel generator become unavailable. The N+1 generator may be pre-staged within the RAB due to hurricane or flood warning.

Therefore, WF3 has many sources of power already installed and the cost-benefit of adding another EDG was not evaluated.

RAI SAMA 6

6. Provide the following information with regard to the Phase II cost-benefit evaluations. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF3 SAMA analysis, NRC staff evaluates the applicant's cost-benefit analysis of Phase II SAMAs. The requested information is needed in order for the NRC staff to reach a conclusion on the acceptability of the applicant's cost estimations for individual SAMAs and cost-benefit evaluation.

6.a. The benefit of SAMA 31, "Install a digital feedwater upgrade," is addressed by Case 2, "Improve Feedwater Reliability." Case 2 was evaluated by eliminating the loss of feedwater initiating event. Discuss the added benefit that might occur if the upgrade would increase the availability of feedwater subsequent to other initiating events.

Waterford 3 Response

The added benefit that might occur if the upgrade would increase the availability of feedwater subsequent to other initiating events may be seen by looking at analysis Case 17, Main Feedwater System Reliability. Case 17 analyzed the benefit of increasing the availability of the feedwater system for phase II SAMA 33. The following discussion is provided for Case 17.

> *"This analysis case was used to evaluate the change in plant risk from installing a motor-driven feedwater pump. A bounding analysis was performed by setting loss of main feedwater to zero in the PSA model. Initiator %T4 was set to zero and gate BT02 was deleted, which resulted in an internal and external benefit (with uncertainty) of approximately $3,572,561. This analysis case was used to model the benefit of phase II SAMA 33."*

By removing gate BT02, analysis Case 17 included the benefit of increasing the availability of feedwater subsequent to other initiating events. Analysis Case 17 resulted in an internal and external benefit (with uncertainty) of $3,572,561. SAMA 31, with a cost of $6,100,000, remains not cost-beneficial when compared with the Analysis Case 17 benefit.

6.b. The assumption for Case 7, "Reduced Frequency of Loss of Auxiliary Component Cooling Water (ACCW)," given in ER Table D.2-2 is the elimination of failure of ACCW. Section D.2.3 indicates that the model was changed by adding the ability to cross-tie the ACCW. Provide further information on the modeling to clarify this apparent difference.

Waterford 3 Response

Case 7 was performed to evaluate the risk reduction from adding the ability to cross-tie the ACCW trains. Instead of modeling the cross-tie of the ACCW trains, a bounding case was modeled by eliminating the ACCW system failure, which will provide a conservative benefit

compared to adding the cross-tie capability. This was done by removing the gates listed in the Case 7 description in Section D.2.3 of the ER.

6.c. SAMA 19, “Add redundant DC control power for SW pumps,” is evaluated in Case 12, “Increase Availability of ACCW,” by eliminating the DC control power gates to the ACCW pumps. While this SAMA is from the generic PWR list in NEI 05-01 and does not necessarily represent an important failure mode at WF3, discuss the benefit associated with eliminating DC control power failures for the component cooling water (CCW) pumps, in addition to the ACCW pumps.

Waterford 3 Response

A sensitivity was performed for Case 12 in which the DC control power to the CCW pumps was removed via gates D100A (under gate SB4R3), D200A (under gate SA4R3), and D300AW (under gates SAB9R3 and SAB9R3W) in addition to the DC power gates that were removed previously in the Case 12 analysis. This resulted in a relatively small increase in the total benefit. With this change incorporated, the benefit (internal and external events with uncertainty) is $38,944. Adding redundant DC control power to more pumps would also increase the implementation cost. However, with the existing cost estimate of $100,000, the conclusion that the SAMA is not cost-beneficial is unchanged.

6.d. Provide more details on the WF3 specific cost estimate for SAMA 35, “Provide a redundant train or means of ventilation.” It is not clear if the scope of the cost estimate is consistent with the assumed elimination of failure of emergency diesel generator (EDG) room 3A cooling for Case 23, “Increased availability of [Heating, ventilation and air conditioning] HVAC used to assess the benefit of SAMA 35.”

Waterford 3 Response

The cost estimate is consistent with providing a redundant train of EDG room ventilation for EDG 3A. The cost estimate assumes that the train would include instruments, an exhaust fan, and exhaust damper controls. A redundant power source is not needed because the EDG ventilation system is designed to maintain room temperature whenever the EDGs are in operation. Therefore, the existing EDG ventilation system is powered by the EDG, through safety-related bus and MCC, and the cost estimate assumes the new train would also be powered by the EDG.

Since a new train of ventilation for a battery room or the main control room would need a redundant source of power, the implementation cost for such a modification would be larger for those rooms.

6.e. Clarify that the scope of SAMA 36, Implement procedures for temporary HVAC, is applicable to rooms other than EDG room 3A. Analysis of this SAMA only assumed elimination of failure of EDG room 3A cooling (Case 23). Based on the benefit results for Case 23, it appears likely that the implementation of temporary HVAC for the other rooms listed in SAMA 36 may also be potentially cost-beneficial.

Waterford 3 Response

The scope of SAMA 36 is to implement procedures for temporary HVAC for the MCR, EDG rooms, and battery rooms. Analysis Case 23 included three cases, each eliminating one system, MCR HVAC, EDG Room 3A cooling, or EDG Room 3B cooling. The case with EDG Room 3A cooling removed provided the greatest benefit; therefore, it was used to represent the bounding benefit for Case 23. Since SAMA 36 was determined to be potentially cost-beneficial, it is potentially cost-beneficial to implement procedures for temporary HVAC for the battery, EDG, and main control rooms.

6.f. Case 24, "Debris Coolability and Core Concrete Interaction," was evaluated by eliminating failure of debris coolability and core concrete interaction to determine the benefit associated with the relatively low cost SAMAs; 38, 47, 72 and 73. These low cost SAMAs provide water to the cavity or otherwise improve core coolability or reduce core concrete interaction. Case 28, "Increase Cooling and Containment of Molten Core Debris," was evaluated by eliminating containment core melt propagation and was used to determine the benefit associated with relatively high cost SAMAs 44, 45, and 46. The benefit associated with Case 28 is approximately $6,900,000 compared to that for Case 24 of $61, 000. It appears that the SAMAs evaluated by Case 24 would achieve much of the benefit associated with Case 28. Discuss the reasons for this significant difference and the potential for SAMAs 38, 47, 72 and 73, or some combination of them, to be cost-beneficial.

Waterford 3 Response

Phase II SAMAs 44, 45, and 46 were conservatively evaluated using Case 28. Case 28 removed failure to maintain the cavity at lower pressure via the containment cooling fans, which removes all possibility of basemat failure. Case 28 is a very conservative SAMA case which did not need to be further refined due to the high cost of phase II SAMAs 44, 45, and 46.

Phase II SAMAs 38, 47, 72 and 73 were evaluated using Case 24, which is less conservative than Case 28, but still bounds the achievable benefit of the SAMAs. Case 24 removed failure to cool debris and core-concrete interaction, but did not remove failure to maintain the cavity at lower pressure. This modeling bounds the achievable benefit from the SAMAs which would introduce water to the cavity or otherwise cool the external lower vessel head.

6.g. Case 43, “Gagging Device to Close a Stuck Open Safety Valve,” is evaluated by eliminating failure events for stuck open relief valves and was used to estimate the benefit of SAMA 71, “Manufacture a Gagging Device for a Steam Generator Safety Valve and develop a procedure or work order for closing a stuck-open valve.”

6.g.i. Provide a more detailed description of the failure events listed and their relevance to limiting release following a steam generator tube rupture (SGTR) event.

Waterford 3 Response

The description for Case 43 lists 13 basic events that were set to zero: PRYMS106BT, PRYMS112BT, PRYMS108BT, PRYMS113BT, PRYMS110BT, PRYMS114BT, PRYMS106AT, PRYMS112AT, PRYMS108AT, PRYMS113AT, PRYMS110AT, PRYMS114AT, and OHFMSSGAGR. Basic event OHFMSSGAGR represents the failure to gag a leaking main steam safety valve following a SGTR. The other 12 basic events represent Steam Generator safety valves failing to close (e.g., PRYMS106BT is safety valve MS106B fails to close). Gagging or closing the safety valves will limit the loss of inventory from the steam generator. SAMA 71 has been changed to conservatively use the same benefit as SAMA 61 and is now retained as potentially cost-beneficial.

6.g.ii. The benefit of SAMA 61, “Direct steam generator flooding after a SGTR,” prior to core damage as assessed in Case 33, “Reduce Consequences of Steam Generator Tube Ruptures,” is approximately $100,000 whereas the benefit of SAMA 71 is only $76. Both of these SAMAs are intended to reduce the releases resulting from a SGTR. The very large difference between assessed benefit is not expected. Explain the reasons for this difference or revise the assessments as appropriate.

Waterford 3 Response

SAMA 71 has been changed to use the same benefit as SAMA 61 and is now retained as potentially cost-beneficial.

6.h. Case 41, “Improve Internal Flooding Response Procedures and Training,” and Case 42, “Water Tight Doors for the Largest Contributor to Internal Flooding,” were evaluated by assuming that the reduction in risk was proportional to the reduction in internal flooding CDF. SAMAs evaluated by these cases were SAMA 67, “Improve internal flooding response procedures and training to improve the response to internal flooding events,” and SAMA 68, “Install flood doors to prevent water propagation in the electric board room.” An examination of the reductions in risk given in ER Table D.2-2 for other cases indicates that this assumption may be non-conservative depending on the failures

resulting from the specific flooding events mitigated. Describe the system failures involved in the internal flood events mitigated by these SAMAs and select evaluation cases that would be more representative for these specific internal flooding SAMAs.

Waterford 3 Response

It is acknowledged that the assumption that the reduction in risk is proportional to the reduction in internal flooding CDF could be non-conservative. However, even if one were to multiply the benefit produced by Cases 41 and 42 by three, SAMAs 67 and 68 would remain not cost beneficial. Multiplying the benefit by three is considered conservative as the largest contributor causes loss of power and the PDR or OECR reduction would not be three times greater than the CDF reduction. In addition, removing all of the internal flooding contribution for the identified scenarios in each analysis case is conservative.

6.i. The cost for SAMA 68, “Install flood doors to prevent water propagation in the electric board room,” is given as $4,695,000 and stated to be from the Sequoyah cost estimate. The Sequoyah LRA ER indicates that this is the cost for both Sequoyah units. Further, the cost of such a modification would appear to be strongly dependent on a specific plant layout. Provide a cost that is valid for the WF3 plant configuration. Also discuss if something less than a full flood door, such as a flood barrier, might achieve the same risk reduction benefit.

Waterford 3 Response

A plant specific WF3 cost estimate was developed to modify doors D16 and D9 to be flood doors to prevent water propagation to the other electric board rooms. The WF3 plant specific cost estimate is $1,268,119, which is substantially lower than the Sequoyah cost estimate of $4,695,000. A flood barrier is not expected to achieve the same risk benefit as a flood door. SAMA 68 remains not cost beneficial.

6.j. The cost for SAMA 8, “Use fire water system as a backup source for diesel cooling,” is given as $2,000,000 and stated to be from the Seabrook cost estimate. Implementation of a similar SAMA for the Grand Gulf plant (SAMA 9) was estimated to cost $1,344,000. This is very near the assessed benefit at WF3 of $1,338,000. Provide a WF3-specific justification for the cost estimate for SAMA 8.

Waterford 3 Response

The implementation cost estimate for the Grand Gulf plant was a conceptual estimate performed using 2012 dollars. A recent PWR implementation estimate was considered more applicable than the Grand Gulf estimate. Escalating the Grand Gulf 2012 estimate to current dollars using a ratio of the consumer price indices would increase the estimate to just over $1.4 million. SAMA 8 is now retained as potentially cost-beneficial.

6.k. In the evaluation of the benefit of SAMA 61, “Direct steam generator flooding after a SGTR,” prior to core damage in Case 33, ER Table D.2-2 states that the SGTR CDF contribution was assigned from the H-E RC to the L-I RC. However, the NRC staff notes that the population dose for the L-I RC is greater than that for the H-E RC. Justify the approach used to evaluate the benefit of SAMA 61 in Case 33.

Waterford 3 Response

Based on the updated Level 3 results and approach presented in RAI SAMA 4.b the population dose results for the L-I RC are no longer greater than that for the H-E RC. The updated benefit for SAMA 61 in Case 33 is $557,676 and this SAMA is now retained as potentially cost beneficial.

<u>RAI SAMA 7</u>

7. For certain SAMAs considered in the WF3 ER, there may be lower cost or more effective alternatives that could achieve much of the risk reduction. In this regard, provide an evaluation of the following SAMA. The basis for this request is as follows: Applicants for license renewal are required by 10 CFR 51.53(c)(3)(ii)(L) to consider SAMAs if not previously considered in an environmental impact assessment, related supplement, or environmental assessment for the plant. As part of its review of the WF3 SAMA analysis, NRC staff considers additional SAMAs that may be more effective or have lower implementation costs than the other SAMAs evaluated by the applicant. The requested information is needed in order for the NRC staff to reach a conclusion on the adequacy of the applicant's determination of cost-beneficial SAMAs.

7.a. SAMA 27, "Install an additional component cooling water pump," is evaluated as a means to increase cooling water availability. Consider a potentially lower cost modification of replacing one of the pumps with a diverse design that would lower the common cause pump failure.

<u>Waterford 3 Response</u>

The common cause failure of the CCW pumps to fail to run (SCCMDPNRUN) is 8.51E-07/yr and 9.03E-11/yr for fail to start (SCCMDPSTRT) in the PRA model utilized for the SAMA. A sensitivity was performed in which basic events SCCMDPNRUN and SCCMDPSTRT were set to zero. This resulted in a benefit (internal and external events with uncertainty) of $7,257. Replacing a CCW pump would cost significantly more than this amount; therefore, this lower cost modification would not be cost-beneficial.

During evaluation of this response, an error was found in the calculation of the CCW type codes which affects the CCW independent and Common Cause Failure (CCF) basic event probabilities. A Model Change Request and condition report have been initiated to fix the issue during the next model update. To evaluate the impact of the error, a sensitivity was performed on the current WF3 internal events model in which the CCW type codes were corrected and which resulted in an insignificant (less than 1%) change in the model results. Thus, the impact to the WF3 SAMA analysis is negligible.

7.b. Also, regarding SAMA 27, Table D.1-2 indicates a portion of this benefit is due to eliminating the operator failure to align CCW train AB to replace lost Train A or B. Provide an assessment of a potentially lower cost SAMA candidate to provide diverse backup auto-start signals for the standby CCW trains on loss of the running train.

<u>Waterford 3 Response</u>:

Installation of diverse backup auto-start signals would improve the reliability of the CCW system and lower the importance of the operator action to align the standby CCW train. A bounding analysis was performed in which the operator action SHFABCCWRP (Failure to

align CCW train AB to replace lost train A or B) was set to zero, and this led to a benefit of $4,524,670. The plant-specific estimated cost for this modification is $1,091,240, so this SAMA is retained as potentially cost-beneficial.

Table D.1-10

WF3 Release Category Source Terms

Release Category	Release Frequency (per year)	Level 2 MAAP Run ID	RDOALARM - Time to declare GE, sec		Release Time - Time from scram (sec)	Elasped Time - GE to Release (sec) / (hr)	RDPDELAY - Start of Plume release - from scram time (sec)	MAAP Timing Release Ends (sec)	RDPLUDUR - Duration of Release (sec)	RDPLHITE - Height of plume release - centerline of Escape Hatch (26.5 ft)	PLHEAT - Energy of Release EREL(6), W
			Time (sec)	Basis							
		TPQU_BI			0	0					
INTACT	**3.68E-06**	*Plume #1*	5429.33	Loss of Fuel Clad (FCB3) [2]	172800	0	5429	43200	37771	65.38	1.28E+03
		Plume #2			48.00		43200	129600	86400	65.38	2.07E+03
		TQX_H			49984.47	< 0					
H-E	**1.88E-06**	*Plume #1*	55827.95	Loss of Fuel Clad (FCB3)	222784.47	0	58	49984	49926	8.08	0.00E+00
		Plume #2			61.88		49984	129600	79616	8.08	3.52E+06
		SBO			80629.98	68892.98					
H-I	**4.75E-06**	*Plume #1*	11737.00	Loss of Fuel Clad (FCB3)	253429.98	19	11737	80630	68893	8.08	0.00E+00
		Plume #2			70.40		80630	129600	48970	8.08	9.10E+05
H-L	NA[1]	NA			---		---	---	---	---	---
		SX_B			39185.41	19673.41					
M-E	**2.74E-08**	*Plume #1*	19512.00	Potential Loss of Containment Pressure (CNB2) [3]	211985.405	5.5	39185	43200	4015	8.08	0.00E+00
		Plume #2			58.88		43200	129600	86400	8.08	6.46E+04
		TB_B			53997.67	48852.11					
M-I	**1.34E-07**	*Plume #1*	5145.56	Loss of Fuel Clad (FCB3)	226797.67	13.6	5146	53998	48852	8.08	0.00E+00
		Plume #2			63.00		53998	129600	75602	8.08	3.98E+04
		TB_F			72552	69353.03					
M-L	**1.84E-08**	*Plume #1*	3198.58	Potential Loss of Fuel Clad (FCB3) [4]	245351.613	24	3199	72552	69353	8.08	0.00E+00
		Plume #2			68.15		72552	129600	57048	8.08	5.52E+06
L-E	NA[1]	NA			---		---	---	---	---	---
		TKC_B			73785.99	43337.63					
L-I	**2.42E-09**	*Plume #1*	30448.37	Loss of Fuel Clad (FCB3)	246585.991	12	30448	73786	43338	8.08	0.00E+00
		Plume #2			68.50		73786	129600	55814	8.08	2.87E+04
		TQX_B			112915	87573.07					
L-L	**5.56E-10**	*Plume #1*	25341.71	Loss of Fuel Clad (FCB3)	285714.786	24.33	25342	112915	86400	8.08	0.00E+00
		Plume #2			79.37	72	112915	129600	16685	8.08	7.79E+04
LL-E	NA[1]	NA			---		---	---	---	---	---
LL-I	NA[1]	NA			---		---	---	---	---	---
		AX_D			123785	117007.42					
LL-L	**3.85E-10**	*Plume #1*	6777.97	Loss of Fuel Clad (FCB3)	296585.385	33	37385	123785	86400	8.08	0.00E+00
		Plume #2			82.38		123785	129600	5815	8.08	2.40E+06

NOTES:

1. These Release Categories were included as part of the Level 2 PRA Model, but were not present in the Level 2 cutset results. As a result, release scenarios were not developed as part of the Level 3 analysis.
2. Basis for OALARM is Loss of Fuel Clad Barrier FCB3 [EP-001-001, Rev. 030] as defined by core exit thermocouple reading >= 1200 deg F. This is conservatively defined by MAAP Event code 690.
3. Basis for OALARM is Potential Loss of Containment Barrier CNB2 [EP-001-001, Rev. 030] as defined by containment pressure >= 17.7 psia. This is defined by MAAP parameter PRB(4) as found in MAAP data file ".d85".
4. Basis for OALARM is Potential Loss of Fuel Clad Barrier FCB3 [EP-001-001, Rev. 030] as defined by core exit thermocouple reading >= 700 deg F. This is defined by MAAP parameter TCRHOT as found in MAAP data file ".d85".

Table D.1-10 (cont'd)

Release Category	Release Frequency (per year)	Level 2 MAAP Run ID	**RDRELFRC001** - Release Fractions								
			Noble Gases	I	Cs	Te	Sr	Ru	La	Ce	Ba
INTACT	**3.68E-06**	**TPQU_BI**									
		Plume #1	2.79E-03	5.31E-05	1.33E-04	9.36E-05	1.97E-07	8.72E-07	3.07E-09	7.17E-08	3.86E-07
		Plume #2	1.36E-02	3.24E-04	1.92E-04	1.18E-04	2.15E-07	9.28E-07	3.30E-09	7.80E-08	4.81E-07
H-E	**1.88E-06**	**TQX_H**									
		Plume #1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.9998	0.3476	0.2127	0.2402	9.90E-04	1.36E-02	4.43E-05	1.02E-04	6.49E-03
H-I	**4.75E-06**	**SBO**									
		Plume #1	0.00E+00	0.00E+00	0.0000	0.0000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.9986	0.3152	1.57E-01	1.77E-01	1.80E-03	9.04E-04	2.99E-05	1.11E-03	1.03E-03
H-L	NA[1]	NA	---	---	---	---	---	---	---	---	---
M-E	**2.74E-08**	**SX_B**									
		Plume #1	0.0000	1.82E-07	1.40E-07	2.92E-08	1.13E-10	2.10E-09	3.03E-12	1.73E-12	3.50E-09
		Plume #2	0.6661	0.0934	7.17E-02	1.58E-01	3.33E-04	3.59E-03	1.72E-05	4.19E-05	2.14E-03
M-I	**1.34E-07**	**TB_B**									
		Plume #1	0.0000	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.5552	6.27E-02	9.97E-03	4.84E-03	1.75E-08	3.86E-07	1.03E-09	2.14E-09	5.66E-06
M-L	**1.84E-08**	**TB_F**									
		Plume #1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.9996	7.87E-02	2.10E-02	1.16E-02	2.84E-08	5.76E-07	1.87E-09	4.88E-09	5.62E-06
L-E	NA[1]	NA	---	---	---	---	---	---	---	---	---
L-I	**2.42E-09**	**TKC_B**									
		Plume #1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.5039	6.59E-03	4.20E-03	5.44E-03	1.67E-05	1.59E-05	3.98E-07	1.55E-06	3.39E-05
L-L	**5.56E-10**	**TQX_B**									
		Plume #1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.5108	1.07E-02	1.57E-03	3.58E-02	4.54E-07	8.65E-06	2.42E-08	1.61E-07	4.69E-06
LL-E	NA[1]	NA	---	---	---	---	---	---	---	---	---
LL-I	NA[1]	NA	---	---	---	---	---	---	---	---	---
LL-L	**3.85E-10**	**AX_D**									
		Plume #1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Plume #2	0.6151	5.80E-04	6.22E-03	3.39E-03	2.22E-06	5.66E-06	6.34E-08	1.71E-07	1.11E-05

NOTES: 1 These Release Categories were included as part of the Level 2 PRA Model, but were not present in the Level 2 cutset results. As a result, release scenarios were not developed as part of the Level 3 analysis.

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
1. Case SBO Reduction	Eliminated SBO contribution.	**34.4%**	**44.0%**	**46.8%**	**$3,791,951**	**$7,811,419**		
1. Provide additional DC battery capacity.	WF3 plant specific cost						$3,172,695	Retain
2. Replace lead-acid batteries with fuel cells.	WF3 plant specific cost						$6,185,319	Retain
7. Install a gas turbine generator.	Davis-Besse cost estimate						$2,000,000	Retain
2. Case Improve Feedwater Reliability	Eliminated failure of feedwater.	**0.9%**	**0.2%**	**0.2%**	**$21,596**	**$44,488**		
31. Install a digital feed water upgrade.	SeaBrook Cost estimate						$6,100,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
3. Case Add DC System Cross-ties	Changed gates to require multiple DC bus failures.	**20.8%**	**31.1%**	**29.5%**	**$2,430,355**	**$5,006,532**		
3. Provide DC bus cross-ties.	WF3 plant specific cost						$1,449,686	Retain
4. Case Increase Availability of On-Site AC Power	Changed gates to require multiple AC bus failures.	**22.2%**	**32.1%**	**30.5%**	**$2,515,301**	**$5,181,520**		
5. Improve 4.16-kV bus cross-tie ability.	WF3 plant specific cost						$1,554,988	Retain
Case 5. Reduce Loss of Off-Site Power	Reduce the frequency of the LOOP initiator by removing severe weather contribution affecting OSP lines.	**11.3%**	**11.8%**	**12.4%**	**$1,022,379**	**$2,106,100**		
10. Bury off-site power lines.	SeaBrook Cost estimate						$3,000,000	Not cost effective
6. Install an additional, buried off-site power source.	SeaBrook Cost estimate						$3,000,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
Case 6. Provide Backup EDG Cooling	Eliminated failure of CCW cooling to the EDGs.	**4.4%**	**10.0%**	**10.8%**	**$847,186**	**$1,745,203**		
8. Use fire water system as a backup source for diesel cooling.	Grand Gulf Cost estimate						$1,400,000	Retain
9. Add a new backup source of diesel cooling.	SeaBrook Cost estimate						$2,000,000	Not cost effective
Case 7. Reduced Frequency of Loss of Auxiliary Component Cooling Water[3]	Eliminated failure of ACCW.	**6.4%**	**0.9%**	**0.4%**	**$92,762**	**$191,089**		
21. Enhance procedural guidance for use of cross-tied component cooling or service water pumps.	WF3 is adding the ability to cross-tie ACCW and not procedure change. WF3 plant specific cost.						$6,528,828	Not cost effective
22. Add a service water pump.	Sequoyah cost estimate						$1,043,000	Not cost effective
Case 8. Increased availability of feedwater	Eliminated DWST failure to supply the CSP.	**1.2%**	**0.3%**	**0.2%**	**$27,688**	**$57,038**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
32. Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.	WF3 plant specific cost						$885,760	Not cost effective
Case 9. High Pressure Injection System	Eliminated failure of HPSI.	**8.4%**	**3.1%**	**2.5%**	**$267,690**	**$551,441**		
17. Replace two of the four electric safety injection pumps with diesel-powered pumps.	Callaway cost estimate						$1,500,000	Not cost effective
13. Install an independent active or passive high pressure injection system.	Callaway cost estimate						$1,500,000	Not cost effective
Case 10. Extend Reactor Water Storage Pool Capacity	Reduced failure from operator actions and tank rupture.	**1.8%**	**0.2%**	**0.1%**	**$22,100**	**$45,527**		
16. Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.	SeaBrook Cost estimate						$3,000,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
29. RWST fill from firewater during containment injection—Modify 6 inch RWST flush flange to have a 2½-inch female fire hose adapter with isolation valve.	WF3 plant specific cost						$747,640	Not cost effective
30. High-volume makeup to the refueling water storage tank.	Sequoyah cost estimate						$565,000	Not cost effective
49. Install automatic containment spray pump header throttle valves.	ANO-2 cost estimate						$2,500,000	Not cost effective
Case 11. Eliminate ECCS Dependency on Component Cooling Water System	Eliminated failure of ECCS motor cooling.	**0.7%**	**2.9%**	**3.2%**	**$246,497**	**$507,785**		
20. Replace ECCS pump motors with air-cooled motors.	SeaBrook Cost estimate						$6,000,000	Not cost effective
Case 12. Increase Availability of ACCW	Eliminated the DC control power gates to the ACCW pumps.	**0.2%**	**0.1%**	**0.1%**	**$12,454**	**$25,655**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
19. Add redundant DC control power for SW pumps.	Callaway cost estimate						$100,000	Not cost effective
Case 13. Low Pressure Safety Injection System	Eliminated failure of the Low Pressure Safety Injection system.	**0.0%**	**0.0%**	**0.0%**	**$8**	**$16**		
14. Add a diverse low pressure injection system.	Callaway cost estimate						$1,000,000	Not cost effective
15. Provide capability for alternate injection via diesel-driven fire pump.	Davis-Besse cost estimate						$6,500,000	Not cost effective
Case 14. Increase Component Cooling Water Availability	Eliminated failure of CCW pump failures and CCFs.	**13.5%**	**28.5%**	**27.5%**	**$2,210,419**	**$4,553,464**		
27. Install an additional component cooling water pump.	SeaBrook Cost estimate						$6,000,000	Not cost effective
Case 15. Decreased Charging Pump Failure	Eliminated the normal charging pump power gates.	**0.4%**	**0.8%**	**0.7%**	**$59,385**	**$122,332**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
12. Install modification to power the normal charging pump from an existing spare breaker from the alternate emergency power system.	Callaway cost estimate						$350,000	Not cost effective
Case 16. Reactor Coolant Pump Seals	Eliminated RCP Seal LOCA.	**16.0%**	**31.9%**	**30.7%**	**$2,475,719**	**$5,099,981**		
24. Install an independent reactor coolant pump seal injection system, with dedicated diesel.	Sequoyah Cost estimate						$8,233,000	Not cost effective
25. Install an independent reactor coolant pump seal injection system, without dedicated diesel.	Sequoyah Cost estimate						$8,233,000	Not cost effective
26. Install improved reactor coolant pump seals.	SeaBrook Cost estimate						$2,000,000	Retain
Case 17. Main Feedwater System Reliability	Set loss of main feedwater to zero.	**33.3%**	**19.4%**	**19.2%**	**$1,734,253**	**$3,572,561**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
33. Add a motor-driven feedwater pump.	Sequoyah cost estimate						$10,000,000	Not cost effective
Case 18. EDG Fuel Oil	Set the failure of fuel oil pumps to zero.	**17.1%**	**21.1%**	**22.3%**	**$1,815,628**	**$3,740,194**		
11. Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.	WF3 plant specific cost						$26,300,000	Not cost effective
Case 20. Create a reactor coolant depressurization system	Eliminated small LOCA events.	**14.5%**	**2.1%**	**0.9%**	**$203,552**	**$419,318**		
18. Create a reactor coolant depressurization system.	SeaBrook cost estimate						$1,000,000	Not cost effective
Case 21. Steam Generator Inventory	Reduced the frequency of turbine-driven AFW pump failure during SBO.	**67.3%**	**63.2%**	**65.8%**	**$5,511,067**	**$11,352,798**		
34. Use fire water system as a backup for steam generator inventory.	Cost from Indian point (IP2)						$3,073,130	Retain

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
Case 22. Instrument Air Reliability	Eliminated the loss of Instrument Air.	**0.1%**	**0.0%**	**0.0%**	**$2,783**	**$5,734**		
37. Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.	Callaway cost estimate						$500,000	Not cost effective
Case 23. Increased Availability of HVAC	Eliminated failure of EDG room 3A cooling.	**9.4%**	**12.0%**	**12.7%**	**$1,030,922**	**$2,123,699**		
35. Provide a redundant train or means of ventilation.	WF3 plant specific cost						$3,574,481	Not cost effective
36. Implement procedures for temporary HVAC.	Callaway cost estimate						$100,000	Retain
Case 24. Debris coolability and core concrete interaction	Eliminated failure of debris coolability and core concrete interaction.	**0.0%**	**0.5%**	**0.6%**	**$42,490**	**$87,530**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
38. Create a reactor cavity flooding system.	Cost from Indian Point (IP2)						$1,741,724	Not cost effective
47. Provide a reactor vessel exterior cooling system.	Cost from ANO-2						$2,500,000	Not cost effective
72. Provide water from the fire protection system to the containment sump.	WF3 plant specific cost						$715,918	Not cost effective
73. Enhance communication between sump and cavity.	WF3 plant specific cost						$702,551	Not cost effective
Case 25. Decay Heat Removal Capability	Eliminated late containment failure due to over-pressurization.	**0.0%**	**20.3%**	**22.7%**	**$1,690,200**	**$3,481,812**		
41. Install an unfiltered, hardened containment vent.	WF3 plant specific cost						$15,083,162	Not cost effective
42. Install a filtered containment vent to remove decay heat Option 1: Gravel Bed Filter	SeaBrook cost estimate						$20,000,000	Not cost effective

Table D.2-2 Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation								
Analysis Case (bold) SAMA Number and Title[2,4]	**Assumptions**	**CDF Reduction (%)**	**PDR Reduction (%)**	**OECR Reduction (%)**	**Internal and External Benefit ($)**	**Internal and External Benefit with Uncert ($)**	**WF3 Cost Estimate ($)**	**Conclusion**
Option 2: Multiple Venturi Scrubber								
Case 26. Improve Containment Spray Capability	Reduced failure of containment spray.	**5.8%**	**44.6%**	**52.3%**	**$3,908,776**	**$8,052,078**		
39. Install a passive containment spray system.	SeaBrook cost estimate						$10,000,000	Not cost effective
50. Install a redundant containment spray system.	SeaBrook cost estimate						$10,000,000	Not cost effective
40. Use the fire water system as a backup source for the containment spray system.	WF3 plant specific cost						$2,455,808	Retain
Case 27. Reduce Hydrogen Ignition	Eliminated hydrogen detonation.	**0.0%**	**0.1%**	**0.0%**	**$3,434**	**$7,075**		
43. Provide post-accident containment inerting capability.	Callaway cost estimate						$100,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
51. Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.	Callaway cost estimate						$100,000	Not cost effective
52. Install a passive hydrogen control system.	SeaBrook cost estimate						$100,000	Not cost effective
Case 30. Reduce Probability of Containment Failure	Eliminated containment failure.	**0.0%**	**85.8%**	**93.0%**	**$6,947,477**	**$14,311,803**		
48. Construct a building to be connected to primary/secondary containment and maintained at a vacuum.	SeaBrook cost estimate						$56,700,000	Not cost effective
Case 31. Containment Isolation	Eliminated containment isolation failure.	**0.0%**	**0.1%**	**0.1%**	**$9,153**	**$18,855**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
55. Add redundant and diverse limit switches to each containment isolation valve.	Sequoyah cost estimate						$692,000	Not cost effective
Case 32. Reduce Frequency of Steam Generator Tube Ruptures	Eliminated steam generator tube ruptures.	**1.0%**	**5.7%**	**5.5%**	**$430,225**	**$886,263**		
56. Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.	Callaway cost estimate						$3,000,000	Not cost effective
57. Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.	Callaway cost estimate						$10,000,000	Not cost effective
58. Install a redundant spray system to depressurize the primary system during a steam generator tube rupture	Callaway cost estimate						$10,000,000	Not cost effective
59. Route the discharge from the main steam safety valves through a structure where a water spray would condense	Callaway cost estimate						$10,000,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
the steam and remove most of the fission products.								
60. Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources	Callaway cost estimate						$10,000,000	Not cost effective
Case 33. Reduce Consequences of Steam Generator Tube Ruptures[5]	Reassigned the SGTR CDF contribution from H-E release category to release category L-I.	**0.0%**	**3.3%**	**3.6%**	**$270,716**	**$557,676**		
61. Direct steam generator flooding after a steam generator tube rupture, prior to core damage.	Generic cost estimate for procedural change with engineering and testing/training required.						$200,000	Retain
71. Manufacture a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve.	Cost from Indian Point (IP2)						$453,745	Retain

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
Case 34. Reduce ATWS Frequency	Eliminated ATWS contribution.	**1.4%**	**0.2%**	**0.1%**	**$21,060**	**$43,383**		
63. Add an independent boron injection system.	SeaBrook cost estimate						$500,000	Not cost effective
64. Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.	SeaBrook cost estimate						$500,000	Not cost effective
65. Install motor generator set trip breakers in control room.	Sequoyah cost estimate						$100,000	Not cost effective
66. Provide capability to remove power from the bus powering the control rods.	Sequoyah cost estimate						$100,000	Not cost effective
Case 37. Reduce Probability of a Large LOCA	Eliminated the initiators for a Large LOCA and a medium LOCA.	**0.4%**	**0.2%**	**0.2%**	**$17,568**	**$36,190**		
69. Install digital large break LOCA protection system.	SeaBrook cost estimate						$500,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
Case 38. Prevent Secondary Side Depressurization	Eliminated the initiator for a steam line break outside containment and for inadvertent closure of MSIVs.	**0.3%**	**0.1%**	**0.0%**	**$6,385**	**$13,153**		
70. Install secondary side guard pipes up to the main steam isolation valves.	SeaBrook cost estimate						$500,000	Not cost effective
Case 39. Eliminate Thermally Induced Tube Ruptures Following Core Damage	Eliminated thermal induced steam generator tube rupture.	**0.0%**	**0.2%**	**0.2%**	**$18,357**	**$37,816**		
54. Modify procedures such that the water loop seals in the reactor cooling system (RCS) cold legs are not cleared following core damage.	South Texas cost estimate						$100,000	Not cost effective
Case 40. Replace CARMVAAA201-B with a fail closed AOV	Eliminated motive power dependency from MOV CARMVAAA201-B.	**0.0%**	**0.0%**	**0.0%**	**$0**	**$0**		
62. Hardware change to eliminate MOV CS-V-17 AC power dependency.	SeaBrook cost estimate						$300,000	Not cost effective

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
Case 41. Improve Internal Flooding Response Procedures and Training[1]	Eliminated the contribution to internal flooding CDF from floods in the Turbine Generator Building +15 elevation and Reactor Auxiliary Building +46 elevation.	**N/A**	**N/A**	**N/A**	**$15,744**	**$32,433**		
67. Improve internal flooding response procedures and training to improve the response to internal flooding events.	Sequoyah cost estimate						$400,000	Not cost effective
Case 42. Water tight doors for the largest contributor to internal flooding[1]	Eliminated the contribution to internal flooding CDF from floods in flood zone RAB21-212/225B.	**N/A**	**N/A**	**N/A**	**$161,278**	**$332,233**		
68. Install flood doors to prevent water propagation in the electric board room.	WF3 plant specific cost						$1,268,119	Not cost effective
Case 44. CCW Backup Auto-Start Signal	Operator action SHFABCCWRP (Failure to align CCW train AB to replace lost train A or B) was set to zero.	**13.5%**	**28.3%**	**27.4%**	**$2,196,442**	**$4,524,670**		

Table D.2-2
Summary of Phase II SAMA Candidates Considered in Cost-Benefit Evaluation

Analysis Case (bold) SAMA Number and Title[2,4]	Assumptions	CDF Reduction (%)	PDR Reduction (%)	OECR Reduction (%)	Internal and External Benefit ($)	Internal and External Benefit with Uncert ($)	WF3 Cost Estimate ($)	Conclusion
77. Provide a diverse backup auto-start signal for the standby CCW trains on loss of the running train.	WF3 plant specific cost						$1,091,240	Retain

(1) These analysis cases only impact internal flooding and have been evaluated as described in Section D.2.3.

(2) The WF3 NFPA 805 SAMAs (Phase II SAMAs 74, 75, and 76) have been updated based on the latest NFPA 805 RAIs. Based on the latest NFPA 805 RAIs all of the modifications that impact the fire PRA have been installed.

(3) Phase II SAMA 23 (analysis case 7) to proceduralize shedding component cooling water loads to extend the component cooling water heat-up time upon loss of essential raw cooling water has been changed from retain to N/A. This has been changed due to the fact that if an SIAS is not generated before RCP seal failure, CCW can operate with only the dry cooling towers (without ACCW), so shedding CCW loads on loss of raw cooling water (ACCW) is not necessary. In those limiting cases when an SIAS is generated, the CCW trains automatically split and the non-safety CCW header is isolated. Since the SIAS automatically sheds non-essential CCW loads, a procedure is not necessary.

(4) Phase II SAMAs 44, 45, 46, and 53 (analysis cases 28 and 29) have been changed from retain to N/A as these SAMAs are for a new plant and it's not practical to back fit these modifications into a plant which is already built, and operating. The cost of implementation of these SAMAs would likely exceed the maximum benefit.

(5) Based on RAI response 6.g.ii Phase II SAMA 71 was moved to utilize the benefit of analysis case 33 rather than analysis case 43.

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	Baseline Internal and External Benefit with Uncert. ($)	Sensitivity with $5,200 per person-rem ($)	WF3 Cost Estimate ($)
Case 1. SBO Reduction	**$7,811,419**	**$9,738,737**	
1. Provide additional DC battery capacity.			$3,172,695
2. Replace lead-acid batteries with fuel cells.			$6,185,319
7. Install a gas turbine generator.			$2,000,000
Case 2. Improve Feedwater Reliability	**$44,488**	**$54,796**	
31. Install a digital feed water upgrade.			$6,100,000
Case 3. Add DC System Cross-ties	**$5,006,532**	**$6,364,746**	
3. Provide DC bus cross-ties.			$1,449,686
Case 4. Increase Availability of On-Site AC Power	**$5,181,520**	**$6,584,284**	
5. Improve 4.16-kV bus cross-tie ability.			$1,554,988
Case 5. Reduce Loss of Off-Site Power	**$2,106,100**	**$2,624,225**	
10. Bury off-site power lines.			$3,000,000
6. Install an additional, buried off-site power source.			$3,000,000
Case 6. Provide Backup EDG Cooling	**$1,745,203**	**$2,183,146**	
8. Use fire water system as a backup source for diesel cooling.			$1,400,000
9. Add a new backup source of diesel cooling.			$2,000,000
Case 7. Reduced Frequency of Loss of Auxiliary Component Cooling Water	**$191,089**	**$232,915**	
21. Enhance procedural guidance for use of cross- tied component cooling or service water pumps.			$6,528,828
22. Add a service water pump.			$1,043,000
Case 8. Increased availability of feedwater	**$57,038**	**$70,176**	
32. Create ability for emergency connection of existing or new water sources to feedwater and condensate systems.			$885,760
Case 9. High Pressure Injection System	**$551,441**	**$688,983**	
17. Replace two of the four electric safety injection pumps with diesel-powered pumps.			$1,500,000
13. Install an independent active or passive high pressure injection system.			$1,500,000
Case 10. Extend Reactor Water Storage Pool Capacity	**$45,527**	**$54,845**	

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
16. Throttle low pressure injection pumps earlier in medium or large-break LOCAs to maintain reactor water storage tank inventory.			$3,000,000
29. RWST fill from firewater during containment injection—Modify 6 inch RWST flush flange to have a 2½-inch female fire hose adapter with isolation valve.			$747,640
30. High-volume makeup to the refueling water storage tank.			$565,000
49. Install automatic containment spray pump header throttle valves.			$2,500,000
Case 11. Eliminate ECCS Dependency on Component Cooling Water System	**$507,785**	**$634,268**	
20. Replace ECCS pump motors with air-cooled motors.			$6,000,000
Case 12. Increase Availability of ACCW	**$25,655**	**$31,867**	
19. Add redundant DC control power for SW pumps.			$100,000
Case 13. Low Pressure Safety Injection System	**$16**	**$22**	
14. Add a diverse low pressure injection system.			$1,000,000
15. Provide capability for alternate injection via diesel-driven fire pump.			$6,500,000

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
Case 14. Increase Component Cooling Water Availability	**$4,553,464**	**$5,795,367**	
27. Install an additional component cooling water pump.			$6,000,000
Case 15. Decreased Charging Pump Failure	**$122,332**	**$156,136**	
12. Install modification to power the normal charging pump from an existing spare breaker from the alternate emergency power system.			$350,000
Case 16. Reactor Coolant Pump Seals	**$5,099,981**	**$6,492,656**	
24. Install an independent reactor coolant pump seal injection system, with dedicated diesel.			$8,233,000
25. Install an independent reactor coolant pump seal injection system, without dedicated diesel.			$8,233,000
26. Install improved reactor coolant pump seals.			$2,000,000
Case 17. Main Feedwater System Reliability	**$3,572,561**	**$4,429,752**	
33. Add a motor-driven feedwater pump.			$10,000,000
Case 18. EDG Fuel Oil	**$3,740,194**	**$4,663,364**	

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
11. Install a large volume EDG fuel oil tank at an elevation greater than the EDG fuel oil day tanks.			$26,300,000
Case 20. Create a reactor coolant depressurization system	**$419,318**	**$516,277**	
18. Create a reactor coolant depressurization system.			$1,000,000
Case 21. Steam Generator Inventory	**$11,352,798**	**$14,129,897**	
34. Use fire water system as a backup for steam generator inventory.			$3,073,130
Case 22. Instrument Air Reliability	**$5,734**	**$7,043**	
37. Replace service and instrument air compressors with more reliable compressors which have self-contained air cooling by shaft driven fans.			$500,000
Case 23. Increased Availability of HVAC	**$2,123,699**	**$2,649,042**	
35. Provide a redundant train or means of ventilation.			$3,574,481
36. Implement procedures for temporary HVAC.			$100,000
Case 24. Debris coolability and core concrete interaction	**$87,530**	**$109,415**	

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
38. Create a reactor cavity flooding system.			$1,741,724
47. Provide a reactor vessel exterior cooling system.			$2,500,000
72. Provide water from the fire protection system to the containment sump.			$715,918
73. Enhance communication between sump and cavity.			$702,551
Case 25. Decay Heat Removal Capability	**$3,481,812**	**$4,364,663**	
41. Install an unfiltered, hardened containment vent.			$15,083,162
42. Install a filtered containment vent to remove decay heat Option 1: Gravel Bed Filter Option 2: Multiple Venturi Scrubber			$20,000,000
Case 26. Improve Containment Spray Capability	**$8,052,078**	**$9,991,505**	
39. Install a passive containment spray system.			$10,000,000
50. Install a redundant containment spray system.			$10,000,000
40. Use the fire water system as a backup source for the containment spray system.			$2,455,808

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
Case 27. Reduce Hydrogen Ignition	**$7,075**	**$9,957**	
43. Provide post-accident containment inerting capability.			$100,000
51. Install an independent power supply to the hydrogen control system using either new batteries, a non-safety grade portable generator, existing station batteries, or existing AC/DC independent power supplies, such as the security system diesel.			$100,000
52. Install a passive hydrogen control system.			$100,000
Case 30. Reduce Probability of Containment Failure	**$14,311,803**	**$18,038,745**	
48. Construct a building to be connected to primary/secondary containment and maintained at a vacuum.			$56,700,000
Case 31. Containment Isolation	**$18,855**	**$24,180**	
55. Add redundant and diverse limit switches to each containment isolation valve.			$692,000
Case 32. Reduce Frequency of Steam Generator Tube Ruptures	**$886,263**	**$1,134,575**	
56. Institute a maintenance practice to perform a 100% inspection of steam generator tubes during each refueling outage.			$3,000,000
57. Increase the pressure capacity of the secondary side so that a steam generator tube rupture would not cause the relief valves to lift.			$10,000,000

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	Baseline Internal and External Benefit with Uncert. ($)	Sensitivity with $5,200 per person-rem ($)	WF3 Cost Estimate ($)
58. Install a redundant spray system to depressurize the primary system during a steam generator tube rupture			$10,000,000
59. Route the discharge from the main steam safety valves through a structure where a water spray would condense the steam and remove most of the fission products.			$10,000,000
60. Install a highly reliable (closed loop) steam generator shell-side heat removal system that relies on natural circulation and stored water sources			$10,000,000
Case 33. Reduce Consequences of Steam Generator Tube Ruptures	**$557,676**	**$702,769**	
61. Direct steam generator flooding after a steam generator tube rupture, prior to core damage.			$200,000
71. Manufacture a gagging device for a steam generator safety valve and developing a procedure or work order for closing a stuck-open valve.			$453,745
Case 34. Reduce ATWS Frequency	**$43,383**	**$53,201**	
63. Add an independent boron injection system.			$500,000
64. Add a system of relief valves to prevent equipment damage from pressure spikes during an ATWS.			$500,000
65. Install motor generator set trip breakers in control room.			$100,000
66. Provide capability to remove power from the bus powering the control rods.			$100,000

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
Case 37. Reduce Probability of a LOCA	**$36,190**	**$45,009**	
69. Install digital large break LOCA protection system.			$500,000
Case 38. Prevent Secondary Side Depressurization	**$13,153**	**$16,070**	
70. Install secondary side guard pipes up to the main steam isolation valves.			$500,000
Case 39. Eliminate Thermally Induced Tube Ruptures Following Core Damage	**$37,816**	**$48,495**	
54. Modify procedures such that the water loop seals in the reactor cooling system (RCS) cold legs are not cleared following core damage.			$100,000
Case 40. Replace CARMVAAA201-B with a fail closed AOV	**$0**	**$0**	
62. Hardware change to eliminate MOV CS-V-17 AC power dependency.			$300,000
Case 41. Improve Internal Flooding Response Procedures and Training[1]	**N/A**	**N/A**	
67. Improve internal flooding response procedures and training to improve the response to internal flooding events.			$400,000
Case 42. Water tight doors for the largest contributor to internal flooding[1]	**N/A**	**N/A**	
68. Install flood doors to prevent water propagation in the electric board room.			$1,268,119

Table D.2-4 Sensitivity Analysis Results			
Analysis Case (bold) SAMA Number and Title	**Baseline Internal and External Benefit with Uncert. ($)**	**Sensitivity with $5,200 per person-rem ($)**	**WF3 Cost Estimate ($)**
Case 44. CCW Backup Auto-Start Signal	**$4,524,670**	**$5,759,244**	
77. Provide a diverse backup auto-start signal for the standby CCW trains on loss of the running train.			$1,091,240

(1) These analysis cases only impact internal flooding and have been evaluated as described in Section D.2.3.