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U. S. Nuclear Regulatory Commission
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Three Mile Island Nuclear Station Unit 1
Facility Operating License No. DPR-50
NRC Docket No.50-289

Subject: Response to NRC Request for Additional Information related to Three Mile Island Nuclear Station Unit 1 License Renewal Application (TAC No. MD7702)

Reference: Request for Additional Information regarding Severe Accident Mitigation Alternatives for Three Mile Island Nuclear Station, Unit 1, License Renewal (ML081330714)," dated 5/21/2008.

In the referenced letter, the NRC requested additional information related to Severe Accident Mitigation Alternatives analysis contained in the Three Mile Island Generating Station License Renewal Application (LRA). Enclosed are the responses to this request for additional information.

If you have any questions, please contact Fred Polaski, Manager License Renewal, at 610-765-5935.

I declare under penalty of perjury that the foregoing is true and correct.

Respectfully,

Executed on 07-17-2008

Michael P. Gallagher
Vice President, License Renewal
AmerGen Energy Company, LLC

Enclosure A: Response to Request for Additional Information

A131
LRR

cc: Regional Administrator, USNRC Region I, w/Enclosure
USNRC Project Manager, NRR - License Renewal, Environmental, w/Enclosure
USNRC Project Manager, NRR - License Renewal, Safety, w/o Enclosure
USNRC Project Manager, NRR - TMIGS, w/o Enclosure
USNRC Senior Resident Inspector, TMIGS, w/Enclosure
D. Allard, Director, Bureau of Radiation Protection - Pennsylvania Department of Environmental Protection, w/Enclosure
Chairman, Board of County Commissioners of Dauphin County, PA, w/o Enclosure
Chairman, Board of Supervisors of Londonderry Township, Dauphin County, PA, w/o Enclosure

File No. 08001

NRC Letter Dated: 7/17/2008

SAMA RAI 1. Provide the following information regarding the development of the TMI 1 probabilistic risk assessment (PRA) used for the severe accident mitigation alternative (SAMA) analysis:

RAI 1.a Discuss any peer reviews of the internal events model revisions subsequent to the August 2000 model, including the June 2007 model used for the SAMA analysis. Describe any significant review comments and their potential impact on the results of the SAMA analysis.

AmerGen Response:

Section E.2.4 of the SAMA submittal summarizes the results of the peer review that was performed in August of 2000 on the TMI "2000 Update" model. No other peer reviews have been performed since August of 2000; therefore, no additional peer review comments have been generated that could impact the SAMA analysis.

RAI 1.b. Discuss any peer reviews of the external events PRA, including the external flooding analysis used for the SAMA analysis. Describe any significant review comments and their potential impact on the results of the SAMA analysis.

AmerGen Response:

The IPEEE, which contains the external flooding analysis, included a peer review process, but the format is not comparable to the PWROG peer review process that is currently used for the industry's PWR internal events PRAs. In addition, the review was performed before the IPEEE was finalized so that the results of the review could be incorporated into the analysis, as appropriate. As a result, there are no peer review comments that could impact the results of the SAMA analysis.

RAI 1.c Section E.2.2.1 and Table E.2-1 of the Environmental Report (ER) provide a chronology of the development of the TMI-1 PRA. However, it is unclear what plant and PRA model changes were incorporated in each version of the PRA subsequent to the Individual Plant Examination (IPE). Clarify into which PRA model revision each of the 12 plant and procedure changes listed on pages E-4 and E-5 were originally incorporated.

AmerGen Response:

The 12 plant and procedure changes listed on pages E-4 and E-5 were observations and review comments that were developed prior to, and during development of the IPE model for TMI. These changes were actually incorporated into the final IPE model, which was dated 1992. Subsequent to the IPE, the TMI RISKMAN model dated 2000, which was developed by an outside contractor, mainly incorporated minor model revisions and plant modification updates. Per discussion with the TMI risk management engineer who was responsible for the PRA during the period from 1992 through 2000, any plant changes and modifications since the IPE were incorporated into the 2000 PRA model. The engineer also confirmed that there were no significant modifications made to the facility between 1992 and 2000 and therefore, major changes to the PRA resulting from plant changes were not required during that period. Even so, the PRA did undergo some structural changes in the mid to late 1990s. The PRA model structure was changed from a reliability block diagram basis to more of a traditional fault tree structure. Plant unavailability's and failure rates also underwent Bayesian updating by the contractor with input from the plant engineering staff.

The L2RV2 model of 2001 was strictly meant to provide a link from Level 1 core damage states to Level 2 release category endstates. Although the 2000 and 2001 PRA model core damage frequencies (CDFs) were accurate to two significant figures, the slight difference in CDF for the 2001 model was due to cutsets being subsumed as a result of this linking process.

The revisions and changes incorporated in the PRA model referred to as the "ABSA 2003" model was focused on addressing the Category A and B Findings and Observations generated from a peer review conducted in September 2000.

PRA model revisions that were incorporated following the development of the ABSA 2003 PRA model, which was quantified but never used as a basis for risk informed applications, are detailed in the following table with the corresponding model designator.

Model Name and Date	Comments
2004 Rev. 0 (Dec. 2004)	Model quantified but never officially used for plant PRA applications.
2004 Rev. 1 (Jun. 2005)	PRA model currently in use for plant PRA applications.
2004 Rev. 2 (Jun. 2007)	PRA model used for work involving the SAMA analysis.

RAI 1.d Identify the major PRA model changes incorporated in the August 2000 model.

AmerGen Response:

The PRA model structure was changed from a reliability block diagram basis to a traditional fault tree structure. Plant unavailability's and failure rates also underwent Bayesian updating by the contractor with input from the plant engineering staff.

RAI 1.e Identify any plant changes since the June 2007 model and provide a qualitative assessment of their potential impact on the PRA and the results of the SAMA analysis.

AmerGen Response:

No plant changes have been made since completion of the June 2007 model that would impact the PRA.

RAI 2. **Provide the following information relative to the Level 2 PRA analysis:**

RAI 2.a The ER mentions updated MAAP analyses in the context of re-evaluating success criteria for the 2003 PRA update (Section E.2.2.2), and enhancing the Oconee containment event tree (CET) model for TMI-specific analysis (Section E.2.2.3). However, it is not clear whether the MAAP source term calculations have been updated since the IPE. Describe the MAAP source term calculations used to support the SAMA analysis. Confirm whether these calculations were performed for the 9 major release categories or the complete set of 39 release categories.

AmerGen Response:

Section E.2.2.3.3 of the Environmental Report reported that although there were 39 containment event tree endstates, they were examined in order to determine how they could be consolidated for the assignment of source terms. Even though it would have been possible to develop source terms for every endstate in the CET, many of the results were similar in nature, such that maintaining unique source terms for every release category would not have provided any measurable benefit. As a result, endstates with similar traits were grouped together and a single source term then used to serve as a representative release category in order to streamline the Level 3 analysis. For TMI-1, nine major source term groups were identified that provided an adequate structure for segregating the source terms. To determine the source terms for each of the nine major release categories, new MAAP runs were performed specifically to support the SAMA analyses. Those specific MAAP cases were identified and their source term results provided in Tables E.2-17 and E.2-18.

RAI 2.b Provide additional discussion of how the source term frequencies for external floods in Table E.2-23 were derived. Describe how the release categories and release frequencies in Table E.2-23 relate to those shown in Figure E.2-3. Explain the relevance of the steam generator tube rupture (SGTR) frequency in Table E.2-23 to external flood events.

AmerGen Response:

In order to supplement the text from Section E.2.3.2 of the ER, examples of the calculations that were performed to populate Table E.2-23 of the ER are provided below.

For 305' to 310' floods, sequences B, D, E, and F, the entire sequence frequency is assigned to the RC-4 release category, which represents a small isolation failure. This release category assignment was made because all of these sequences include a failure to isolate the containment, by definition. The frequencies are taken from Section 5.2.6 of the IPEEE and include credit for implementation of the severe flooding guidelines (failure probability of 0.5). The IPEEE applies this credit to the total 305' to 310' flood frequency, so it may not be obvious that each sequence is credited with the use of the severe flood guidelines. For the purposes of the SAMA calculations, the credit is applied on a sequence basis in order to obtain the appropriate release category contributions. For example, the frequency for 305' to 310' Sequence B is calculated as follows:

305' to 310'Seq. B RC4 Freq. = $\Phi 2B * P_{failure,EFG}$

Where:

- 305' to 310'Seq. B RC4 Freq. = The contribution to RC 4 from 305' to 310' flood sequence B
- $\Phi 2B$ = 305' to 310' Flood Sequence B CDF from the IPEEE,
- $P_{failure,EFG}$ = Probability of failure of implementing the extreme flood guidelines (lineup of alt. primary and secondary side injection)

The frequency is, therefore:

305' to 310' Seq. B RC4 Freq. =1.33E-07 * 0.5 = 6.65E-08/yr

The same process is used for 305' to 310' flood sequences D, E, and F.

For 305' to 310' flood sequences A and C and for floods greater than 310', a simplified version of the internal events CET was developed to distribute events among the TMI release categories. This simplified CET, which is provided in Figure E.2-3 of the ER, uses the nodal values from the Level 2 model with the exception of the "containment isolated" node, which is defined to be "true" for these flooding sequences. Table E.2-22 of the ER provides additional information related to the interpretation of the nodes in the simplified CET. For a given sequence, the release category contributions are calculated by inputting the initial flood frequency from Table E.2-21 of the ER and passing it through the nodes of the CET.

For the flood sequences below 305' , information from the LOOP initiators and base case model was used to define how the flood sequence CDF should be distributed among the release categories.

Because of the low frequency of the floods below 305' and the fact that the distribution of the LOOP events for the 8 important release categories was similar to the base model distribution, a further simplification was made. Specifically, the fractions used to distribute the <305' flood frequency were based on the contributions of 8 important release categories to the overall CDF in the base model rather than retain a separate, additional set of fractions for the LOOP only quantification.

The only additional issue related to the calculation of the release category fractions was that the 5.3 percent of contributors that was not addressed by the 8 "important" release categories was conservatively binned into the "Large-Early" release category (RC-5). Once the release category fractions were obtained, they were each multiplied by the initial <305' flood frequency to obtain the corresponding release category frequencies.

Finally, to obtain the RC frequencies in Table E.2-23 of the ER, the frequencies of the individual release categories must be summed to obtain the "general" release category frequency.

The same process is used for each of the "general" release categories provided in Table E.2-23 of the ER. It should be noted that the process used to bin this sequence is overly complex for the contribution that it represents. If the entire <305' flood sequence was binned into the worst case release category (RC3), it would only increase the external flooding dose-risk by 1 percent.

Finally, the SGTR contribution in Table E.2-23 of the ER is the result of temperature/pressure induced tube rupture events. These contributors were identified through the process used to bin the <305' flood sequence. As documented in the response to RAI 2c, the contribution is actually only 1.68E-08 and represents a small portion of the sequence frequency.

RAI 2.c Table E.2-21 indicates a core damage frequency (CDF) of 2.5E-07 per year for external floods <305 feet. However, Table E.2-23 indicates a source term frequency for floods <305 feet of 4.01E-07 per year. Address this discrepancy.

AmerGen Response:

This is the result of a typographical error. The frequency for RC-1 in Table E.2-23 should have been 1.68E-08 instead of 1.68E-07. If the RC1 frequency is corrected in Table E.2-23 and the category frequencies for <305 feet are then summed, the correct total of 2.5E-07 would be the result.

RAI 3. **Provide the following information with regard to the treatment and inclusion of external events in the SAMA analysis:**

RAI 3.a In Section E.5.1.6.1, AmerGen provides the CDF for the five largest contributing fire scenarios, and identifies SAMAs that would help reduce the fire risk for each fire area. Identify other fire areas that were screened on low CDF and that have a fire CDF greater than 3.0E-7 per year (approximately equivalent to an averted cost risk of $50,000). Provide a discussion of each additional fire area, including identification and assessment of SAMAs to reduce the associated fire risk.

AmerGen Response:

The external events SAMA identification process is designed to use the IPEEE CDF quantification threshold of 1E-06/yr as a lower review limit for multiple reasons, including the following:

- Information for contributors below the 1.0E-06/yr threshold is often very limited because they are screened from quantification and the details related to the dominant risk factors are generally not fully investigated or documented.
- Any unique SAMA that may be identified based on a review of contributors below the threshold of 1.0E-06/yr would have an extremely limited chance of being cost beneficial and an even more limited chance of being an item that would be considered a priority to implement.

In summary, efforts to extend the external events review beyond what is directed in the NEI 05-01 guidance would not enhance the SAMA analysis in any meaningful way. Any unique SAMAs that could possibly be identified as cost beneficial would be designed to address poorly defined risks, their cost benefits would likely be based on even more generalized assumptions than for other external events SAMAs, and their benefits would be small, by definition.

If it is assumed that a fire CDF can be directly correlated to the minimum SAMA implementation cost, the only additional fire areas that would require evaluation are CB-FA-2f and the CC panel from CB-FA-4b. The "other" MCR panel group, which has a CDF of 3.17E-07, offers no new insights given that potential strategies to mitigate the initiators are subsumed by those already identified for the CC and CR panel fires. In addition, the consequences of fires in the "other" panels are limited to LOOP events, which are thoroughly addressed by other SAMAs.
The two additional fire areas identified above have been reviewed to determine if they could yield any potentially cost beneficial SAMAs.

Fire Area CB-FA-4b, panel CC: A fire in this panel impacts numerous balance of plant systems, reactor control systems, and RCS inventory systems. The IPEEE identifies the equipment that would be impacted by the fire and how it was modeled in the IPEEE.

The CDF from the CC fires is 8.4E-7, which would correspond to about $116,000 if this RAI's CDF correlation methodology is used ($3,271,711 * 8.4E-07 / 2.37E-5 = $115,959). No significant hardware changes could be performed for this cost range and

the implication is that the only potentially cost beneficial change would be a procedure change. Local operation of the ADVs is a potential action to recover remote control of the ADVs, but TMI already has a procedure for this that is not credited in the PRA. Operators already have guidance to start EFW pumps on auto start failure and to locally operate valves if the remote controls fail. It does not appear that the other equipment failures can be mitigated only by operator actions. Transient combustibles are controlled in other plant areas in which the combustible loading is an issue, but for the MCR, transient combustibles are not a significant contributor to fires. Development of administrative controls to limit materials in the MCR would not impact the CDF in a meaningful way. Therefore, no potentially cost beneficial changes are considered to be available to mitigate this fire scenario.

Fire Area CB-FA-2 (East Battery Room): A fire in this room has the potential to fail the "A" DC system through a battery fire. In a specific battery fire scenario, the control cable for emergency bus 1D could also be damaged given that the cable is routed over a portion of the battery.

The CDF from the CC fires is 7.35E-7, which would correspond to about $101,500 if this RAI's CDF correlation methodology is used ($3,271,711 * 7.35E-07 / 2.37E-5 = $101,464). As for CB-FA-4b, potentially cost beneficial SAMAs for this fire area would be limited to procedure changes. One recovery action that is cited in the IPEEE for addressing the battery fires is to disconnect the damaged battery from the rest of the DC train to isolate any potential short circuit that may exist in the battery room and restore power to the train using the chargers (a cross-tie to the other division is also possible if the chargers cannot supply all of the loads). It was determined that it is not possible to disconnect only the battery from the "A" DC train from the inverter room. The only action that could be taken from the inverter room to isolate battery "A" from the DC system would result in the de-energization of an entire bus, which was not analyzed in the IPEEE and does not appear to be an effective means of reducing plant risk. The battery disconnect switch is actually located in the battery room itself, which may be inaccessible due to the conditions created by the fire. TMI procedures already exist that direct operators to disconnect the "A" battery when short circuit conditions exist and operators would take this action in a fire scenario when conditions permit entry into the battery room. Consequently, no procedural changes related to isolation of the "A" battery have been identified that could further reduce the contribution from this fire area. A hardware modification to install an additional battery disconnect switch outside the battery room is a possible plant enhancement, but even the minimum expected cost of a hardware change of $100,000 would nearly match the cost-risk associated with this fire area. In addition, a battery disconnect switch would not address the fire damage to the 1D cables. Therefore, hardware changes would not be cost effective for Fire Area CB-FA-2.

RAI 3.b For each of the dominant fire areas, explain what measures have already been taken to reduce risk. Identify in the response: areas that are equipped with fire detection systems or enhanced fire suppression capabilities (e.g., CO_2), changes that have been made to improve cable separation, and administrative procedures/controls for monitoring and controlling the quantity of combustible materials in critical process areas.

AmerGen Response:

The following table summarizes the existing fire mitigation measures that are in place for the IPEEE's dominant fire areas.

Fire Area/ Scenario	Description	Existing Mitigation Measures **
CB-FA-2d	East Inverter Room	Ionization duct mounted and incipient detection systems. Additional transient combustible loads prohibited without administrative approval from Fire Protection.*
CB-FA-2e	West Inverter Room	Ionization duct mounted and incipient detection systems. Additional transient combustible loads prohibited without administrative approval from Fire Protection.*
CB-FA-3a	1D Switchgear Room	Ionization duct mounted and incipient detection systems. Additional transient combustible loads prohibited without administrative approval from Fire Protection.*
CB-FA-3b	1E Switchgear Room	Ionization duct mounted and incipient detection systems. Additional transient combustible loads prohibited without administrative approval from Fire Protection.*
CB-FA-4b	Control Room – Console CR	12 ionization detectors in panels and 8 ceiling mounted ionization detectors, manned 24 hours a day. Transient combustible controls are not required due to the margin in the fire loading for this room.

* Marked by signs posted in these areas reading "No additional transient combustibles permitted in this room/area without a continuous fire watch or specific fire protection approval per OP-TM-201-009-1001."

** No Changes to improve cable separation were identified for the fire areas listed in this table.

While automatic suppression systems are not in place in any of the areas identified above, they are not suggested for implementation due the consequential damage that could occur on actuation (for both spurious and actual demands). For water based systems, the water spray used to extinguish a fire would likely damage all of the equipment in the area (a significant concern for these rooms as they contain electrical equipment). Carbon dioxide and/or Halon systems would not damage the plant equipment, but they are undesirable for locations that are frequented by plant personnel, such as these Control Building areas, due to the potential for injury during actuation. In

addition, the cost of retrofitting a room to accommodate a CO_2 or Halon system is typically high.

RAI 3.c Section E.5.1.6.1 provides a list of PRA topics that are claimed to prevent the effective comparison of the CDF between the internal events PRA and the fire PRA. These topics appear to be derived from NEI 05-01, and are provided as general statements rather than specific arguments applicable to the TMI-1 fire PRA. Describe how each of these items specifically apply to the TMI-1 fire PRA.

AmerGen Response:

The following table provides a TMI-1 specific discussion of the IPEEE fire analysis conservatisms.

PRA Topic	TMI-1 Specific Comment
Initiating Events:	The TMI-1 IPEEE used the EPRI FIVE database to develop its initiating event frequencies; thus, the generic argument that fire frequency and severity estimates have been trending downward due to improved housekeeping, control of transient combustibles, and "other" improved fire protection measures is applicable to the plant specific analysis. However, the state of the art fire modeling techniques that are now being applied in the industry to develop fire initiators are dissimilar in nature to what was used in the IPEEE. As a result, the IPEEE initiating event frequencies do not lend themselves to direct comparisons with the latest initiating event frequencies.
System Response:	Automatic fire suppression systems are not credited in the TMI IPEEE fire analysis with the exception of the CO_2 suppression system in the relay room (CB-FA-3D). Instrument Air is failed for any fire in an area containing system piping. Main Feedwater failure is conservatively assumed in some cases, including for all turbine building fires.
Sequences:	The detailed fire area analysis allows for delineation of the more important characteristics of different fire scenarios; however, there is some grouping of ignition sources that may result in some increased conservatism.
Fire Modeling:	Fire damage and fire spread are conservatively characterized. Components impacted by a fire are generally assumed to transfer to the failure position even if the failure position is an "active" failure position (one that requires air or power). During the screening process, fires in a given area were assumed to destroy all equipment in the area, though in the detailed areas assessments this was not true. In those cases, however, bounding approaches regarding the immediate effects of a fire were made that would yield conservative results (e.g., any fire damages all components of a given type in a room independent of location, or a fire in any cubicle of a switchgear always results in loss of the entire switchgear).

PRA Topic	TMI-1 Specific Comment
HRA:	For TMI, no credit was explicitly taken for manual fire suppression or detection, though manual suppression is implicitly included in the use of severity factors. In addition, remote shutdown panel actions are sometimes conservatively not credited to recover equipment control failures caused by MCR fires.
Level of Detail:	While the IPEEE fire analysis used the IPE model to calculate conditional core damage frequencies, the fire impacts may be based on overly conservative assumptions related to complete room burn-up, as identified in the Fire Modeling category above.
Quality of Model:	The peer review process for fire PRAs is not as developed as internal events PRAs and the TMI IPEEE fire peer review was not in any way structured like the internal events review that are conducted today. For example, no industry standard, such as NEI 00-02, existed for the structured peer review of a fire PRA. As a result, a means to systematically address PRA practices, at the level that exists for internal events models, was not available at the time of the review.

RAI 3.d Flood gate installation failure is a significant contributor to external flooding CDF for floods between 305 and 310 feet. No SAMAs are proposed for reducing the failure frequency because of the long period of time that is available to properly install the gates. The IPEEE indicates that 15 hours are required to install the flood gates after a hydrograph warning is issued, yet the time available to respond to a fast developing flood such as a flood surge caused by a hurricane is less than 10 hours (which is the time interval for a fast developing flood to rise from 302 to 310 feet). Provide clarification regarding the time available for operator response to a fast developing flood and further justification for why potential SAMAs to reduce this response time were not evaluated (e.g., pre-staging of cranes and other equipment needed to install the flood gates).

AmerGen Response:

This question identifies two different times from the IPEEE related to external flood timing; however, it appears that those times have been misinterpreted.
The question states that the TMI IPEEE indicates that 15 hours are required to install the flood gates after a hydrograph warning is issued. The only text AmerGen has identified in the IPEEE that ties the time of 15 hours to words that could be interpreted as a flood panel installation time are in Figure 2 of Section 5.2. This figure is a hydrograph for the site and there is a demarcation at 45 hours that reads, "place watertight flood panels (hydrograph warning), 15 hours to place". The 15 hour interval referenced is actually the time available to install the flood panels from the time of the hydrograph warning to the time where the flood panels are required to protect against water incursion (305 foot level) given the onset of the probable maximum flood (PMF). This is evident on the hydrograph if one correlates the time of 60 hours (45 hours + 15 hours) to the river flow rate for the PMF. The flow rate at 60 hours is 1,250,000 cfs, which corresponds to a river level of 305 feet. A similar entry on the hydrograph for the "precipitation warning" confirms this interpretation. This entry, which is located at the 18 hour mark, reads, "place watertight flood panels (precipitation warning), 42 hours to place". Starting at the 18 hour point, 42 hours are available to install the flood panels before the 305 foot level is reached at 60 hours.

This question also indicates that the time available to install the flood gates in a hurricane scenario is a 10 hour interval based on a water level rise from 302 feet to 310 feet. As indicated in section 5.2.4 of the IPEEE, Emergency Closure (i.e., installation of the flood gates) is initiated with a 36 hour forecast of 940,000 cfs (now 900,000 cfs) and not when the water level reaches the 302 foot level, so the total time available for installation is significantly more than 10 hours. However, the installation is performed incrementally and there are many activities that are initiated at the 302 foot level, including the installation of the flood panels at the Intake Screen Pumphouse. There are six, three foot high flood panels that must be installed at this location before water level exceeds about 308 feet (bottom of the flood panel). Based on the extrapolated curve used to obtain the 10 hour interval between 302 feet and 310 feet, the time available to reach 308 feet would be about 7.5 hours (10 hours * 6 feet/ 8 feet = 7.5 hours). TMI-1 personnel estimate that 30 minutes may be required to install each flood panel. If the panel installation is performed in series (no parallel work), the installation time is only 3 hours, which leaves a margin of about 4.5 hours. This is not a time stressed action.

The specific issue of changing the flood panel design was reviewed for TMI with site personnel during a walkdown and it was eliminated from consideration based on the considerable time available for panel placement. In addition, no significant gains in installation reliability would be realized by changing the panel design, such as putting them on hinges; human reliability analysis (HRA) methodologies are not developed enough to distinguish between placing a flood panel in position by hand and swinging it into place like a door. The larger flood panels are more cumbersome, but their installation begins with the 36 hour forecast of 900,000 cfs and timing is not a concern for the installation of those panels.

RAI 3.e The maximum cost-risk for High Winds, Aircraft Impact, and Hazardous Chemicals is estimated in the ER to be $23,753, $12,073, and $4,908, respectively. These values were calculated by scaling the internal events maximum averted cost-risk (MACR) by the ratio of the relevant event CDF to the total external events CDF. However, the denominator in the ratio should be the total internal events CDF, not total external events CDF. Confirm that the revised cost-risk for High Winds, Aircraft Impact, and Hazardous Chemicals would therefore be approximately $107,000, $54,500, and $22,100, respectively. Discuss whether any additional SAMAs would be identified based on these increased cost-risk estimates. If so, provide a cost-benefit analysis for each.

AmerGen Response:

The process used to distribute the external events cost risk in the ER was designed to do so based on the relative risk of the external event contributors to one another. The only role the internal events model plays is to establish the overall cost-risk that is equated to external events risk. Using the external events CDFs in a ratio with the internal events CDF should be avoided in this calculation, not only for the reasons stated in Section E.5.1.6 of the ER, but because it would invalidate the initial assumption that the internal and external events risks are equal. For example, if the external events CDFs were each divided by the internal events CDF, multiplied by the total external events cost-risk, and then summed, the total would be greater than the external events cost-risk. The suggested change to the calculation would distort whatever initial assumption had been made about the relative risk of the internal and external events and bypass the method that was established to quantitatively address these minor contributors.

While it is true that the ER did not explicitly identify the reasons that the CDF values for High Winds, Aircraft Impact, and Hazardous Chemical Releases are not comparable to the internal events CDF, a discussion to address this topic was not considered to be required because:

- The more risk significant contributors, such as fire and seismic events, were used to define the process through which external events risk would be addressed and no compelling reasons were identified to treat the initiators identified in this question separately,
- The largest CDF for these initiators is about 30 times less than the fire CDF and contributors of this magnitude generally play an insignificant role in the external event SAMA identification process. Even though high level quantification methods were used to estimate the risk associated with High Winds, Chemical Releases, and Accidental Aircraft Impact, the relative risk shows that these events are minor issues for TMI compared with other contributors. In the unlikely event that explicit treatment of these initiators yielded SAMAs that would otherwise not have been identified, any potentially cost beneficial changes would be assigned a very low priority for implementation.
- The high level quantification methods used in the IPEEE to analyze the risk associated with each of these initiators do not provide any insights about specific areas of risk for the plant. In order to design an effective SAMA, some detailed information about specific accident scenarios is generally required.

Finally, even if the cost-risks for High Winds, Chemical Releases, and Accidental Aircraft Impact were calculated as suggested, the only types of changes that would potentially be cost effective are procedure based changes. As the risks for these initiators are defined in only the most general terms, it is not clear how any specific procedure changes could be suggested to effectively reduce the risk or how such a risk reduction could be quantified (apart from assuming the change would eliminate all risk, which is not credible).

In conclusion, even if the cost-risks for the High Winds, Chemical Releases, andAccidental Aircraft Impact initiators were calculated as suggested in this question, no additional SAMAs would be identified and the cost benefit calculations for the other SAMAs would not be impacted in a meaningful way.

RAI 3.f AmerGen doubled the estimated benefits for internal events to account for additional SAMA benefits in external events. However, the total CDF from external events, including seismic and fire (but excluding external flooding since external flood SAMAs are assessed separately), is a factor of 4.5 greater than the internal events CDF. This would suggest that a multiplier of 5.5 rather than 2 be used to account for external events. In Section E.4.6.3, AmerGen justified the use of a multiplier of 2 on the basis that the seismic CDF is conservative, and that the use of an over-inflated multiplier could skew the results of the analysis. AmerGen's approach effectively discounts the possibility that SAMAs for internal events could also provide benefits in seismic events. Based on the information presented, the NRC staff does not agree the seismic CDF can be entirely discounted in assessing SAMA benefits. Provide additional justification why the seismic risk contribution and CDF would realistically be much lower than implied by the seismic CDF in the IPEEE. Include an assessment of the plant-specific applicability of the conservatisms identified in Section E.5.1.6.2.1 and the impact of any plant improvements implemented since the IPEEE. Provide a revised multiplier based on the more realistic estimate of seismic CDF, if appropriate.

AmerGen Response:

The seismic CDF comparisons made in this question are based on the current internal events model and the IPEEE seismic CDF for a sensitivity case, which is not necessarily an appropriate comparison even if one discards the arguments related to the inequalities of internal and external event models (see further discussion below). Specifically, any comparison between the TMI seismic CDF and the internal events CDF should at least begin with contemporary models. Given that the TMI IPEEE seismic evaluation was based on the IPE model, the IPE internal events CDF of 4.19E-5/yr should be considered as the base internal events CDF. In this case, the model used to establish the base CDF is an important factor as the IPE CDF is nearly a factor of 2 greater than the 2004 Rev. 2 CDF that was used in the SAMA analysis (2.37E-5/yr). Another factor that impacts the comparison made in this question is the seismic CDF. The actual seismic CDF reported in the IPEEE is 3.21E-5/yr. When this CDF is compared to the IPE internal events CDF of 4.19E-5/yr, it is evident that seismic risk is less than internal events risk (given similar methodological bases), which is reasonable for a site located in a region of relative seismic stability. The seismic CDF of 8.43E-5/yr that is reported in the SAMA analysis is based on a sensitivity case provided in the IPEEE that was used in the SAMA calculations to increase the benefit of seismic-related SAMAs only. If the non-flooding external events CDF total is recalculated using the base case seismic CDF reported in the IPEEE, the total is about 5.5E-5, which is approximately equivalent to the IPE's internal events CDF of 4.19E-5. The similarity of these CDFs is considered to justify the use of the multiplier of 2 when the known conservatisms of the external events models are taken into account, especially for the seismic contributors. If these numbers are scaled to correspond to the current internal events analysis, the external events CDF (excluding external flooding) would be 3.1E-05/yr (2.37E-05 / 4.19E-05 * 5.5E-05 = 3.1E-05/yr).

The ability to scale the external events CDFs based on the change in the internal events risk is predicated on the assumption that the underlying PRA model has a significant impact on the external events CDFs and that the reduction in external events risk is proportional to internal events risk reduction. In this case, the non-flooding external

events CDF is driven by seismic and fire contributors. In general, it is recognized that the conditional core damage probabilities and accident sequences from the internal events PRA model are integral to the fire results and that changes to the internal events risk profile can have somewhat of a similar impact on fire risk. For seismic evaluations, seismically induced failures can dominate the results and the conditional core damage probabilities and risk profile from the internal events PRA can be only minor factors in the seismic CDF. For TMI, core damage sequences totaling only 70% of seismic CDF are available in the IPEEE. From these results, seismically induced failures are seen as much more important than random system failures. The highest Fussel-Vesely value for a random system failure top event is only 7.6E-3, which would imply that the risk profile of the internal events PRA has little direct impact on the seismic CDF and that the seismic CDF should not be scaled based only on changes to the internal events CDF. While this is true, the fire portion of the non-flooding external events CDF could be scaled to the current internal events model to yield a total of 4.56E-05/yr (3.21E-05 + (2.37E-05 / 4.19E-05 * 2.16E-05) + 1.33E-06 = 4.56E-05/yr). The value of 1.33E-06 is the sum of the high winds, accidental aircraft impact, and chemical release contributors, which were not scaled in this specific calculation. The CDF estimate of 4.56E-05/yr is nearly a factor of 2 greater than the current internal events estimate, but it does not account for the conservative modeling issues prevalent in the external events analyses. While the reliance on conservative modeling practices still present challenges in current external events PRA models, the general trend in PRA since the performance of the IPEEE has been to remove conservative modeling practices as better techniques for assessing risk are developed.

The ER listed generic areas in which the seismic PRA process is dependent on conservative modeling techniques to compensate for the lack of plant response knowledge (refer to Section E.5.1.6.2.1). The following table identifies how the generic issues identified in the ER correlate to the TMI-1 IPEEE seismic evaluation.

SPRA Topic	TMI-1 Specific Comment
Hazard Curves:	The information provided in Section E.5.1.6.2.1 of the ER about the development of hazard curves is applicable to any seismic evaluation that uses hazard curves. Both the EPRI NP-6395-Dhazard curves that were used in the base case and the NUREG-1488 curves that were considered in a sensitivity case are based on a limited set of data that has been extrapolated to create probability distributions for seismic events around the TMI site. While the NUREG-1488 hazard curves were modified since the TMI-IPEEE was performed to more closely resemble the curves published in EPRI NP-6395-D, they are still a source of uncertainty. The curves will likely be updated again in the future; however, it is clear that the seismic risk for a site in a seismically stable region should not drastically exceed the fire risk for a plant of TMI's vintage due solely to the seismic hazard curves that are chosen.

SPRA Topic	TMI-1 Specific Comment
Fragility Curves:	For TMI-1, the important fragilities appear to be plant specific, which reduces the likelihood that grossly inappropriate fragilities will be assigned to plant components based on equipment mismatches. This may result in a higher confidence in the consistency of treatment for important components, but an additional issue appears to be related to how fragility distributions are developed. In most cases, destructive testing data is not available for plant components and analytical assessments are used to calculate the component fragilities. Generally, PRA practice relies on the use of conservative methods to address issues which are not well known, such as component fragility.
Correlation of Seismic Failures:	Similar components that would be impacted in the same way by a seismic event are 100 percent correlated such that if one component is failed, then all are failed. Examples of systems in which this type of correlation plays a role include the Class 1E power system, vital instrument power, decay heat river water pumps, and reactor river water pumps.
Treatment of Offsite Power:	Consistent with standard practice, no recovery credit is assumed to be available for seismically induced failure of the offsite power system.
Treatment of BOP Equipment:	MFW, which is one of the more important BOP systems, is included in the model and supported by offsite power. No major conservatisms are identified related to the overall exclusion of BOP systems.
Modeling Simplifications:	The impact of some seismic failures is assumed to damage critical components 100 percent of the time. For example, for main control room ceiling failure, the failure of the ceiling is always assumed to damage train B of Class 1E AC power. Another example is that for seismically induced failure of the RCS, a Large LOCA of a size that exceeds the makeup capability of the ESF equipment is always assumed to occur. These failures lead directly to core damage and do not account for the realistic spectrum of leaks that could occur.

A similar breakdown of conservative fire modeling issues is provided in the response to RAI question 3c. By definition, elimination of conservative external events modeling techniques, like those identified here would reduce the seismic and fire CDFs. For example, the TMI-1 internal events analysis was reduced by a factor of about 2 from the time of the IPE to the development of the SAMA model.

Also, in response to the IPEEE, TMI implemented some plant enhancements that would reduce the seismic CDF. As documented in Section E.5.1.5 of the ER, these changes included:

- Installation of additional supports for the main control room ceiling to help prevent failure in seismic events,
- Modification of the anchorage for the EDG air receivers to improve their seismic ruggedness.

While it is desirable to use a multiplier that will not consistently underestimate a SAMA's

external events benefit, using a direct comparison of the current internal events CDF and external events CDFs from the IPEEE as the sole basis for a multiplier is not technically correct (for the reasons described above). When the conservative biases of the seismic analysis are considered in conjunction with the appropriate seismic and internal events CDFs, the ER's use of an external events multiplier of 2 (excluding external flooding) is considered to be justified and no changes to the multiplier are believed to be required.

RAI 3.g Provide an assessment of the impact on the initial and final screenings if the internal events risk reduction estimates are increased by a factor of 5.5, or the revised multiplier based on the more realistic estimate of seismic CDF. This assessment need only be performed for those SAMAs that would offer additional risk reduction in seismic events.

AmerGen Response:

The multiplier of 2 is justified in the response to RAI question 3.f and no additional calculations have been performed.

RAI 4. **Provide the following information concerning the MACCS2 analyses:**

RAI 4.a In Section E.7.3.2, population sensitivity case TMI30INC shows that increasing the (baseline) year 2034 population by 30 percent results in a 28 percent increase in population dose and offsite economic cost risk (OECR). In contrast, population sensitivity case TMISIT00 shows that use of year 2000 census data rather than year 2034 population results in a 29 percent decrease in population dose and OECR. However, the year 2034 population data reported in Tables E.3-1 and E.3-2 appears to represent only a 12 percent increase in population relative to year 2000 census data (USCB 2000). Explain the disproportionately larger sensitivity to population change in case TMISIT00. Provide the URL address for both the 1990 and 2000 census data used in AmerGen's analysis.

AmerGen Response:

The 1990 and 2000 census data were taken from SECPOP2000, as referenced in Section E.3.2. No URL address was utilized for population data. The reference to the use of a geographic information system was intended to describe the SECPOP methodology of allocating census data to a geographic grid.

The year 2034 50-mile projected population utilized in the base case analysis is 3,609,252 persons, as noted in Section E.3.2. The year 2000 population utilized in sensitivity case TMISIT00 is 2,557,573 persons (which was inadvertently not specified in Section E.7.3). This year 2000 population value is approximately 29.1% less than the year 2034 population value. The radial growth factors, identified in header row of Table E.3-2 with the footnote (1) for each ring, were used successively to achieve a year 2034 projection. The 29.1% population change correlates well with the 29 percent decrease in population dose and OECR and is in good analytical agreement with population sensitivity case TMI30INC where a 30 percent population increase resulted in a population dose and OECR increase of approximately 28 percent. T The following table includes the intermediate population projections for the total 50 mile region:

Year	50 Mile Population
1990	2,315,104 (SECPOP)
2000	2,557,573 (SECPOP)
2010	2,826,917 (Projection)
2020	3,126,339 (Projection)
2030	3,459,993 (Projection)
2034	3,609,252 (Projection)

RAI 4.b Section E.7.6.4 provides a breakdown of the population dose-risk and OECR results by release category for internal events, after the SECPOP2000 correction. Provide a corresponding breakdown (by release category) for the external flooding events.

AmerGen Response:

The table below provides the requested information for each of the nine general release categories. The results are presented at this level because the source terms were developed at the general release category level and because the external flooding binning generally did not distinguish between the sub-release categories (such as RC4-01, RC4-02, etc).

		Release Category									
	Flood Sequence	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	Total
Frequency	>310	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.92E-06	4.93E-06	4.44E-05	1.43E-06	4.05E-06	
	305' to 310' sequence A	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.82E-07	4.88E-07	4.39E-06	1.41E-07	4.01E-07	
	305' to 310' sequence B	0.00E+00	0.00E+00	0.00E+00	6.65E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	305' to 310' sequence C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.27E-07	7.00E-08	6.31E-07	2.03E-08	5.76E-08	
	305' to 310' sequence D	0.00E+00	0.00E+00	0.00E+00	6.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	305' to 310' sequence E	0.00E+00	0.00E+00	0.00E+00	3.66E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	305' to 310' sequence F	0.00E+00	0.00E+00	0.00E+00	8.65E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
	<305' (uses LOOP RC distribution)	1.68E-08	0.00E+00	0.00E+00	3.32E-09	2.11E-08	0.00E+00	1.09E-08	3.38E-08	1.64E-07	
	Total	**1.68E-08**	**0.00E+00**	**0.00E+00**	**9.91E-06**	**9.95E-06**	**5.49E-06**	**4.94E-05**	**1.62E-06**	**4.67E-06**	**8.11E-05**

		Release Category									
	Flood Sequence	**RC1**	**RC2**	**RC3**	**RC4**	**RC5**	**RC6**	**RC7**	**RC8**	**RC9**	**Total**
Dose-Risk (person-rem)	>310	0.00	0.00	0.00	0.00	54.85	13.76	59.05	3.11	1.05	
	305' to 310' sequence A	0.00	0.00	0.00	0.00	5.42	1.36	5.84	0.31	0.10	
	305' to 310' sequence B	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	
	305' to 310' sequence C	0.00	0.00	0.00	0.00	0.78	0.20	0.84	0.04	0.01	
	305' to 310' sequence D	0.00	0.00	0.00	17.81	0.00	0.00	0.00	0.00	0.00	
	305' to 310' sequence E	0.00	0.00	0.00	10.67	0.00	0.00	0.00	0.00	0.00	
	305' to 310' sequence F	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	
	<305' (uses LOOP RC distribution)	0.10	0.00	0.00	0.01	0.13	0.00	0.01	0.07	0.04	
	Total	**0.10**	**0.00**	**0.00**	**28.93**	**61.18**	**15.32**	**65.74**	**3.53**	**1.20**	**176.00**

		Release Category									
	Flood Sequence	RC1	RC2	RC3	RC4	RC5	RC6	RC7	RC8	RC9	Total
OECR ($/yr)	>310	$0	$0	$0	$0	$206,006	$54,234	$193,579	$10,245	$1,195	
	305' to 310' sequence A	$0	$0	$0	$0	$20,374	$5,364	$19,145	$1,013	$118	
	305' to 310' sequence B	$0	$0	$0	$678	$0	$0	$0	$0	$0	
	305' to 310' sequence C	$0	$0	$0	$0	$2,927	$771	$2,750	$146	$17	
	305' to 310' sequence D	$0	$0	$0	$62,220	$0	$0	$0	$0	$0	
	305' to 310' sequence E	$0	$0	$0	$37,281	$0	$0	$0	$0	$0	
	305' to 310' sequence F	$0	$0	$0	$882	$0	$0	$0	$0	$0	
	<305' (uses LOOP RC distribution)	$539	$0	$0	$34	$487	$0	$48	$243	$48	
	Total	**$539**	**$0**	**$0**	**$101,095**	**$229,794**	**$60,369**	**$215,522**	**$11,647**	**$1,378**	**$620,344**

RAI 5. **Provide the following with regard to the SAMA identification and screening process:**

RAI 5.a None of the 33 identified SAMAs were screened out in the Phase I evaluation. However, the identification of potential SAMAs in the Level 1 and 2 importance lists (Tables E.5-1 and E.5-2) indicate that at least two potential SAMAs were pre-screened: (1) independent DHR/injection system (i.e., events %SBL, NOEXSCRUBEFF, NONCGASHIGH), and (2) flooded rubble bed (i.e., event MELT). Identify all SAMAs that were pre-screened prior to the Phase I evaluation, and the bases for their dispositioning.

AmerGen Response:

The information included in Tables E.5-1 and E.5-2 related to the alternate potential SAMAs identified in this question was intended to provide some additional background for the types of contributors that were being reviewed. The inclusion of this information was optional and the text could have been written to discuss only the final SAMAs that were considered to address the risk corresponding to the events in question. There is no formal "pre-screening process" associated with the development of Table E.5-1 and E.5-2 that necessitates the consideration of any specific set of SAMAs.

The SAMA identification process is focused on the identification of plant enhancements to address plant specific risk. Accordingly, the TMI PRA is the primary source of information used to develop the SAMA list. Specifically, the importance list is analyzed item by item using cutset analysis to determine the main risk contributors for each basic event and methods to mitigate the main risk contributors for each basic event are devised. An industry SAMA list, such as the one provided in NEI 05-01, is typically consulted to aid in the development of SAMAs. In many cases, other plants have identified general types of plant enhancements that could be used to address the issues raised in the importance list review. These general enhancements are then tailored to address plant specific issues, as required, and included on the SAMA list. This practice reduces the effort required for SAMA development and helps to ensure potentially reasonable changes are not overlooked in the SAMA development process. In many cases, however, the industry SAMA list does not include a plant enhancement that is applicable to the risk contributor in question and an entirely new SAMA is developed. The result of the process is a list of SAMAs that can impact the important risk contributors for the plant.

In addition to the importance list review, which is performed for both the Level 1 and Level 2 contributors, previous plant specific risk analyses (including the IPE and IPEEE) are reviewed to determine if any previously identified plant improvements remain unimplemented. Any unimplemented plant enhancement is included on the SAMA list for evaluation.

Beyond the IPEEE plant enhancement review noted above, the results of the external events analyses were reviewed to determine if any other potentially cost effective plant enhancements may exist that were not identified during the IPEEE process. This review is generally difficult given that IPEEEs typically lack detailed quantitative information for many of the external events initiators, but the major risk contributors are examined to

identify the types of changes that could be used to mitigate risk. The plant enhancements developed as part of this review are included on the SAMA list for evaluation.

The potentially cost effective SAMAs from a set of selected submittals are also reviewed to identify potentially cost beneficial changes that may have been overlooked in the plant specific SAMA identification process. The majority of the sites chosen for this type review are usually of a similar design to the plant being analyzed as the SAMAs have a better chance of being relevant; however, at least one dissimilar plant is included to introduce an alternate set of potential changes. There is no formal review process used to evaluate the cost effective SAMAs from these plants; the analyst qualitatively assesses the SAMAs to identify changes that impact risk areas that were not the focus of the plant specific importance list review. The objective is to identify reasons why those types of changes are not relevant to the plant being analyzed. In addition, SAMAs that address common risk areas using different methods are also considered to determine if they could be used in place of an existing SAMA. The use of these industry SAMA analyses is similar to the use of the generic SAMA list, but it provides a means of maintaining a link to the latest industry thinking without forcing a formal analysis of an ever growing SAMA list.

In summary, the TMI SAMA identification process uses the PRA to focus resources on developing plant changes that would most effectively reduce plant risk. The process relies on previous industry analyses to ensure a complete set of SAMA designs are considered and to reduce the workload related to SAMA development. This is considered to be the most effective and prudent method of generating a plant's SAMA list.

RAI 5.b In Table E.5-2, it is indicated that event GADF-PALL6-CP2FS (common cause failure of the emergency diesel generator standby pump) is addressed by a similar event in the Level 1 importance list. However, no event by this name is in the Level 1 importance list. Clarify this discrepancy. Explain if this event is mitigated by existing Phase II SAMAs 2 and 11. If not, identify a SAMA to mitigate this event and provide an associated cost-benefit analysis.

AmerGen Response:

This is the "fail to start term" that compliments the "fail to run" term "GADF-PALL6-CP2FR", which is explicitly addressed in Table E.5-2. The entry for "GADF-PALL6-CP2FS" should also have identified that the event was almost exclusively a contributor to SBO and addressed by the events "RECOVERY-LOOP-03" and "RECOVERY-LOOP-04" from Table E.5-1. The SBO scenarios related to the events (and the equipment failure identified) are effectively addressed by SAMAs 2 and 11.

RAI 6. **Provide the following with regard to the Phase II cost-benefit evaluations:**

RAI 6.a Section E.6 provides various references regarding implementation costs, including cost estimates from other SAMA evaluations. However, for most SAMAs an explanation for the cost estimate is not provided, nor are sufficient details describing the modification. Provide additional details regarding the cost estimates and modification details for Phase II SAMAs 1, 2, 3, 5, 6, 10, 11, 14, 15, 20, 21, 26, 27, 28, 29, 31, 32, and 33.

AmerGen Response:

As described in Section E.6, the implementation costs used in the Phase II analysis include both TMI-1 specific estimates developed by plant personnel and estimates taken from other SAMA submittals for those SAMAs that were determined to be highly similar. Definitive scope and cost estimates were not prepared for the TMI-1 specific SAMAs due to the significant engineering resources required preparing such estimates. Rather, order of magnitude estimates were developed by senior engineering managers for each major SAMA cost component, for example, procedures and training, hardware, simulator modifications and modification design and installation. It should be noted that the estimated implementation costs do not include contingency costs for unforeseen difficulties nor do they account for any replacement power costs that may be incurred due to consequential shutdown time.
Available modification scope details for Phase II SAMAs are provided in Environmental Report Section E.6 and Table E.5-3 under the column heading "SAMA Description".

Order of magnitude cost estimates for SAMAs 1, 2, 3, 5, 6, 10, 11, 14, 15, 20, 21, 26, 27, 28, 29, 31, 32, and 33 are provided below, in dollars, broken down by major cost component:

SAMA 1

Procedures and training:	150,000
Hardware:	400,000
Simulator modifications:	75,000
Modification design and installation:	2,500,000
Total estimated cost:	3,125,000

SAMA 2

Procedures and training:	150,000
Hardware:	5,000,000
Simulator modifications:	150,000
Modification design and installation:	2,000,000
Total estimated cost:	7,300,000

SAMA 3

Procedures and training:	100,000
Hardware (4 non-safety related valves & piping):	300,000
Simulator modifications:	50,000
Modification design and installation:	2,000,000
Total estimated cost:	2,450,000

SAMA 5

Procedures and training:	100,000
Hardware (3 non-safety related actuators, cables, controls, breakers, contactors) :	1,000,000
Simulator modifications:	50,000
Modification design and installation:	2,000,000
Total estimated cost:	3,150,000

SAMA 6

Procedures and training:	100,000
Hardware (2 non-safety related actuators & cables):	600,000
Simulator modifications:	50,000
Modification design and installation:	2,000,000
Total estimated cost:	2,750,000

SAMA 10

Procedures and training:	50,000
Heated, insulated tank, installed	2,300,000
Piping, installed	1,200,000
Pump, installed	150,000
Simulator modifications:	100,000
Total estimated cost:	3,800,000

SAMA 11

Procedures and training:	150,000
Hardware:	1,000,000
Simulator modifications:	100,000
Modification design and installation:	3,000,000
Total estimated cost:	4,250,000

SAMA 14

Procedures and training:	100,000
Hardware (3 NSR actuators, cables, controls, breakers, contactors):	1,000,000
Simulator modifications:	50,000
Modification design and installation:	2,000,000
Total estimated cost:	3,150,000

SAMA 15

Total estimated cost: (Source: Turkey Point ER)	450,000

SAMA 20

Procedures and training:	25,000
Hardware:	500,000
Simulator modifications:	5,000
Modification design and installation:	2,500,000
Total estimated cost:	3,030,000

SAMA 21

Procedures and training:	0
Hardware:	200,000
Simulator modifications:	0
Modification design and installation:	1,000,000
Total estimated cost:	1,200,000

SAMA 26

Procedures and training:	0
Hardware:	200,000
Simulator modifications:	0
Modification design and installation (3 hour fire barriers required for 2 cable trays w/ complex intersections):	700,000
Total estimated cost:	900,000

SAMA 27

Procedures and training:	0
Hardware (custom brackets) :	75,000
Simulator modifications:	0
Modification design and installation:	500,000
Total estimated cost:	575,000

SAMA 28

Procedures and training:	0
Hardware (custom brackets):	75,000
Simulator modifications:	0
Modification design and installation:	500,000
Total estimated cost:	575,000

SAMA 29

Procedures and training:	0
Hardware (2 ground resistor banks):	600,000
Simulator modifications:	0
Modification design and installation:	200,000
Total estimated cost:	800,000

SAMA 31

Procedures and training:	50,000
Hardware (4 air operated valves)	1,600,000
Simulator modifications:	50,000
Modification design and installation:	2,400,000
Total estimated cost:	4,100,000

SAMA 32

Procedures and training:	250,000
Hardware:	700,000
Simulator modifications:	0
Modification design and installation:	750,000

Total estimated cost:	1,700,000

SAMA 33

Procedures and training:	50,000
Material:	400,000
3 Class 1 access points	1,500,000
Simulator modifications:	0
Modification design and installation:	750,000
Total estimated cost:	2,700,000

RAI 6.b The cost estimates for SAMA 13 ($950K), SAMA 16 ($1.1M), and SAMA 17 ($950K) seem high for what appear to be just logic changes. Provide additional justification for these cost estimates.

AmerGen Response:

As described in Section E.6, the implementation costs used in the Phase II analysis include both TMI-1 specific estimates developed by plant personnel and estimates taken from other SAMA submittals for those SAMAs that were determined to be highly similar. Definitive scope and cost estimates were not prepared for the TMI-1 specific SAMAs due to the significant engineering resources required preparing such estimates. Rather, order of magnitude estimates were developed by senior engineering managers for each major SAMA cost component, for example, procedures and training, hardware, simulator modifications and modification design and installation. It should be noted that the estimated implementation costs do not include contingency costs for unforeseen difficulties nor do they account for any replacement power costs that may be incurred due to consequential shutdown time

Order of magnitude cost estimates for SAMAs 13, 16 and 17 are as follows, broken down by major cost component:

SAMA 13

Procedures and training:	100,000
Hardware (3 non-safety related relays, 2 time delay relays, cables):	100,000
Simulator modifications:	50,000
Modification design and installation:	700,000
Total estimated cost:	950,000

SAMA 16

Procedures and training:	100,000
Hardware (3 bistables, 3 bypass switches, isolators & wiring from existing 3 pressurizer transmitters):	300,000
Simulator modifications:	100,000
Modification design and installation:	600,000
Total estimated cost:	1,100,000

SAMA 17

Procedures and training:	100,000
Hardware:	100,000
Simulator modifications:	50,000
Modification design and installation:	700,000
Total estimated cost:	950,000

RAI 6.c In assessing the benefits for seismic-related SAMAs (SAMAs 27, 28, 29, 30, and 31), AmerGen assumed that the maximum averted cost risk (MACR) for external events is equal to that for internal events, and applied a multiplier of 0.786 (the ratio of seismic CDF to total external event CDF, excluding external flooding) to estimate the maximum benefit associated with seismic events. However, the CDF for seismic events is 3.5 times the internal events CDF. Thus, the maximum benefit associated with seismic events would more appropriately be based on a multiplier of 3.5 rather than 0.786. Provide a revised cost-benefit evaluation for these SAMAs using a multiplier of 3.5 or the more realistic multiplier developed in response to RAI 3f.

AmerGen Response:

As described in the response to RAI question 3.f, the multiplier of 2.0 that was used in the ER to account for non-flooding external events contributions is considered to be justified; therefore, the re-performance of the cost benefit analysis for SAMAs 27, 28, 29, 30, and 31 is not required.

RAI 6.d A key assumption in the analysis of SAMAs 27 and 28 was that the improvements would result in failure probabilities similar to that assumed for the borated water storage tank (BWST), which has a HCLPF capacity of 0.3g. Provide additional justification for this assumption.

AmerGen Response:

The seismic calculations in SAMAs 27 and 28 were based on information available in the IPEEE, which included very limited component specific fragility information. In many cases, components were grouped and represented by the most limiting component so that fragilities of the components in such groups were masked. This contributed to the difficulty of identifying an adequate surrogate for the component modifications proposed in SAMAs 27 and 28. Another complicating factor is that the seismic response of equipment is so component specific that even fragilities of like components in the same plant may not be representative of the "improved" components that are the subject of SAMAs 27 and 28. As a result, obtaining best estimate fragility information for the 480V AC load centers (for SAMA 27) and the decay heat service coolers (for SAMA 28) would require a unique, component specific fragility analysis to evaluate the impacts of the proposed changes. This is beyond the scope of the SAMA analysis. The central point of this question is well taken, however, and it is recognized that dissimilar components may not share failure traits that may be important in seismic events. As a result, an effort was made to review the SAMA calculations to evaluate the impact of the fragility data on the analysis.

For SAMA 27, the first issue to note is that the SAMA's net value is $731,819, which is nearly 1.3 times the cost of implementation. This is an indication that this SAMA is cost beneficial by a wide margin and that only extreme fragility data changes could impact this result.

If one were to assume that the BWST fragility data (FRAG21) underestimated the failure probabilities for the load centers (implying that the BWST is actually more durable than the improved load centers), the actual averted cost-risk for SAMA 27 would be less than what was reported. The only goal of pursuing this path would be to classify the SAMA as "not cost beneficial", which is a less conservative result (in terms of SAMA) than what is presented in the ER. Further, the differences in the failure probabilities between the FRAG21 data and the "realistic" load center data would have to be very large to reclassify SAMA 27 as "not cost beneficial" and such differences are not likely for components with the same HCLPF value.

For SAMA 28, the TMI IPEEE does include fragility data for a component group that only includes heat exchangers (FRAG10). These components are functionally and physically similar to the decay heat service coolers that are examined in the SAMA (FRAG11 component group); however, the FRAG10 data was not used in the SAMA analysis to represent the results of improving the decay heat service coolers. The reason FRAG10 was not used was because the FRAG10 HCLPF value is only 0.25g, which is less than the value assumed to be achieved through implementation of the SAMA. Use of the FRAG10 data was considered to be non-conservative for the purposes of the SAMA calculation and the BWST data (FRAG21 component group) was chosen as a surrogate because it met the 0.3g criterion and yielded slightly larger averted cost-risks. While it is

true the FRAG21 and FRAG11 components are dissimilar physically, a comparison of the failure data demonstrates that they generally have similar failure probabilities for the initiating events evaluated in the IPEEE.

RAI 6.e Based on the Fussell-Vesely values reported in Section E.5.1.6.2.2, offsite power insulator failure contributes about 12 percent of the seismic CDF. SAMA 2, which would allow the plant to operate without AC power for extended periods of time, is proposed as a potentially cost-effective means of addressing this issue. However, the cost-benefit analysis for SAMA 2 does not account for additional benefits of this SAMA in seismic events. Provide a revised cost-benefit analysis for SAMA 2 that accounts for additional benefits in seismic events.

AmerGen Response:

The external event quantification process uses a general multiplier to account for these types of contributions and the seismic contribution is considered to be adequately addressed.

While the insulator failures may comprise 12% of the seismic CDF, which is only a part of the external events contribution, the implementation of this SAMA yielded a 53% reduction in the internal events CDF, which is translated to a comparable benefit for the non-flooding external events (the external flooding benefit is calculated separately and added to these contributions). The use of the external events multiplier appears to conservatively address any seismic benefit associated with SAMA 2. Finally, SAMA 2 is already identified as cost beneficial and further quantitative manipulations to increase the multiplier used to account for poorly defined external events contributions would not significantly increase the likelihood that the SAMA would be implemented by the plant.

RAI 6.f The baseline cost-benefit analysis and sensitivity analyses assume that manual refill of the BWST will prevent core damage in SGTR events, an assumption that AmerGen indicates has recently been called into question. The sensitivity analysis in Section E.7.2 shows that SAMA 10, automated BWST refill, is potentially cost-beneficial if it is assumed that manual BWST refill is not effective at preventing core damage. Identify any other SAMAs that may be cost-beneficial assuming manual BWST refill does not prevent core damage, for both the baseline and sensitivity analyses.

AmerGen Response:

In order to identify cases that could be impacted by removing credit for BWST refill in SGTR scenarios, the SAMA results were first reviewed to identify the plant enhancements that impacted the SGTR frequency (RC2-02, RC2-04) by more than a few percent. SAMAs that had a very small impact on the SGTR frequency would not be impacted by changes to the BWST capability and were excluded from consideration. It was determined that the cost benefit analysis for SAMAs 2, 11, 13, 16, 22, and 24 could be impacted by changes to BWST refill assumptions.

While BWST refill may be important to each of these plant enhancements, SAMAs 2, 11, 16, and 24 were already identified as cost beneficial in the baseline analysis. No further review of these SAMAs is required. It follows, therefore, that the only SAMAs that could be reclassified as cost beneficial are SAMAs 13 and 22.

In order to quantify the impact of eliminating BWST refill credit for these two SAMAs, their cutset files were modified to fail the refill process (for all cases) according to process outlined in Section E.7.2 of the ER and compared to a revised base case that also does not credit BWST refill. The results of this process and the corresponding cost benefit calculations are provided below for both SAMA 13 and SAMA 22 as a sensitivity.

SAMA 13 - Change IA System Logic to Automatically Start IA-P-1A/B After a Low Voltage Trip in Conjunction with an ESAS

The model changes identified above yielded a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk, as summarized below:

SAMA 13 - Internal Events Results (No BWST Refill)

	CDF (/yr)	Dose-Risk	OECR
No Refill Base Results	2.75E-05	54.04	$216,329
SAMA 13/No Refill Results	2.52E-05	43.80	$167,588
Percent Change	-8.4%	-18.9%	-22.5%

A further breakdown of this information is provided below according to release category. Note that the results for the following RCs are not provided given that the frequencies are always zero: RC2-01, RC2-03, RC3-05, RC3-06, RC4-05, RC4-06, RC4-07, RC4-08, RC6-01, RC6-02, AND RC6-06.

SAMA 13 Internal Events Results By Release Category (No BWST Refill)

Release Category	RC1-01	RC1-02	RC2-02	RC2-04	RC3-01	RC3-02	RC3-03	RC3-04	RC4-01	RC4-02	RC4-03	RC4-04	RC5-01	RC5-02	RC6-03
Freq.(/yr)$_{norefill}$	2.33E-06	3.46E-06	1.81E-07	1.27E-08	9.07E-11	9.07E-11	1.90E-10	2.88E-10	3.90E-08	1.46E-08	8.54E-09	3.16E-07	7.39E-07	1.66E-07	2.20E-08
Freq. (/yr)$_{SAMA}$	1.50E-06	2.58E-06	1.81E-07	1.27E-08	9.07E-11	9.07E-11	1.90E-10	2.88E-10	3.89E-08	1.46E-08	8.54E-09	3.16E-07	6.99E-07	1.64E-07	2.15E-08
Dose-Risk$_{norefill}$	13.33	19.79	0.91	0.06	0.00	0.00	0.00	0.00	0.11	0.04	0.03	0.93	4.54	1.02	0.06
Dose-Risk$_{SAMA}$	8.58	14.76	0.91	0.06	0.00	0.00	0.00	0.00	0.11	0.04	0.03	0.93	4.30	1.01	0.06
OECR$_{norefill}$	$64,774	$96,188	$3,367	$236	$3	$3	$7	$11	$351	$131	$77	$2,841	$14,928	$3,353	$208
OECR$_{SAMA}$	$41,700	$71,724	$3,367	$236	$3	$3	$7	$11	$350	$131	$77	$2,841	$14,120	$3,313	$203

Release Category	RC6-04	RC6-05	RC6-07	RC6-08	RC7-01	RC7-02	RC7-03	RC7-04	RC8-01	RC9-01	RC9-02	RC9-03	RC9-04	Sum of Annual Risk
Freq.(/yr)$_{norefill}$	2.36E-10	2.08E-11	8.00E-08	1.43E-08	2.25E-07	2.75E-09	7.45E-07	2.89E-07	3.19E-06	1.33E-05	1.69E-08	2.36E-06	1.91E-08	2.75E-05
Freq. (/yr)$_{SAMA}$	2.36E-10	2.08E-11	8.00E-08	1.43E-08	2.19E-07	2.75E-09	7.44E-07	2.89E-07	3.16E-06	1.28E-05	1.40E-08	2.34E-06	1.91E-08	2.52E-05
Dose-Risk$_{norefill}$	0.00	0.00	0.22	0.04	0.30	0.00	1.01	0.39	7.08	3.54	0.00	0.63	0.01	54.04
Dose-Risk$_{SAMA}$	0.00	0.00	0.22	0.04	0.30	0.00	1.00	0.39	7.02	3.41	0.00	0.62	0.01	43.80
OECR$_{norefill}$	$2	$0	$756	$135	$860	$11	$2,846	$1,104	$20,033	$3,476	$4	$618	$5	$216,329
OECR$_{SAMA}$	$2	$0	$756	$135	$837	$11	$2,842	$1,104	$19,845	$3,349	$4	$613	$5	$167,588

Based on these results, the averted cost-risk for all non-external flooding contributors can be calculated using the 2.0 multiplier on the internal events results:

SAMA 13 - Non-External Flooding Averted Cost-Risk (No BWST Refill)

No Refill Base Case Internal Events Cost-Risk	SAMA Case Internal Events Cost-Risk	Internal Events Averted Cost-Risk	Non-Flood External Events Multiplier	Total Non-Flood Averted Cost-Risk
$5,578,084	$4,478,557	$1,099,527	2.0	$2,199,054

As the changes related to BWST refill do not impact induced SGTR events (because core damage has already occurred), there are no changes to the external flooding contributions for this SAMA. In this case, external flooding does not contribute to the averted cost-risk and the value of $2,199,054 is the total averted cost risk. Using the $950,000 cost of implementation from the ER, the net value for this SAMA is $1,249,054 ($2,199,054 - $950,000 = $1,249,054) and represents a change in the SAMA's classification to "cost beneficial".

SAMA 22 - Install an Independent EFW System

The model changes identified above yielded a reduction in the CDF, Dose-risk, and Offsite Economic cost-risk, as summarized below:

SAMA 22 - Internal Events Results (No BWST Refill)

	CDF (/yr)	Dose-Risk	OECR
No Refill Base Results	2.75E-05	54.04	$216,329
SAMA 22/No Refill Results	2.61E-05	48.93	$191,640
Percent Change	-5.1%	-9.5%	-11.4%

A further breakdown of this information is provided below according to release category. Note that the results for the following RCs are not provided given that the frequencies are always zero: RC2-01, RC2-03, RC3-05, RC3-06, RC4-05, RC4-06, RC4-07, RC4-08, RC6-01, RC6-02, AND RC6-06.

SAMA 22 Internal Events Results By Release Category (No BWST Refill)

Release Category	RC1-01	RC1-02	RC2-02	RC2-04	RC3-01	RC3-02	RC3-03	RC3-04	RC4-01	RC4-02	RC4-03	RC4-04	RC5-01	RC5-02	RC6-03
Freq.(/yr)$_{norefill}$	2.33E-06	3.46E-06	1.81E-07	1.27E-08	9.07E-11	9.07E-11	1.90E-10	2.88E-10	3.90E-08	1.46E-08	8.54E-09	3.16E-07	7.39E-07	1.66E-07	2.20E-08
Freq. (/yr)$_{SAMA}$	2.33E-06	2.56E-06	1.80E-07	9.45E-09	9.07E-11	9.07E-11	1.90E-10	3.46E-10	3.81E-08	2.43E-08	8.54E-09	5.12E-07	6.88E-07	1.70E-07	2.14E-08
Dose-Risk$_{norefill}$	13.33	19.79	0.91	0.06	0.00	0.00	0.00	0.00	0.11	0.04	0.03	0.93	4.54	1.02	0.06
Dose-Risk$_{SAMA}$	13.33	14.64	0.91	0.05	0.00	0.00	0.00	0.00	0.11	0.07	0.03	1.50	4.23	1.05	0.06
OECR$_{norefill}$	$64,774	$96,188	$3,367	$236	$3	$3	$7	$11	$351	$131	$77	$2,841	$14,928	$3,353	$208
OECR$_{SAMA}$	$64,774	$71,168	$3,348	$176	$3	$3	$7	$13	$343	$218	$77	$4,603	$13,898	$3,434	$202

Release Category	RC6-04	RC6-05	RC6-07	RC6-08	RC7-01	RC7-02	RC7-03	RC7-04	RC8-01	RC9-01	RC9-02	RC9-03	RC9-04	Sum of Annual Risk
Freq.(/yr)$_{norefill}$	2.36E-10	2.08E-11	8.00E-08	1.43E-08	2.25E-07	2.75E-09	7.45E-07	2.89E-07	3.19E-06	1.33E-05	1.69E-08	2.36E-06	1.91E-08	2.75E-05
Freq. (/yr)$_{SAMA}$	2.72E-10	0.00E+00	8.02E-08	1.49E-08	2.18E-07	2.86E-09	7.47E-07	2.90E-07	3.14E-06	1.27E-05	2.70E-09	2.34E-06	3.08E-09	2.61E-05
Dose-Risk$_{norefill}$	0.00	0.00	0.22	0.04	0.30	0.00	1.01	0.39	7.08	3.54	0.00	0.63	0.01	54.04
Dose-Risk$_{SAMA}$	0.00	0.00	0.23	0.04	0.29	0.00	1.01	0.39	6.97	3.40	0.00	0.62	0.00	48.93
OECR$_{norefill}$	$2	$0	$756	$135	$860	$11	$2,846	$1,104	$20,033	$3,476	$4	$618	$5	$216,329
OECR$_{SAMA}$	$3	$0	$758	$141	$833	$11	$2,854	$1,108	$19,719	$3,332	$1	$613	$1	$191,640

Based on these results, the averted cost-risk for all non-external flooding contributors can be calculated using the 2.0 multiplier on the internal events results:

SAMA 22 - Non-External Flooding Averted Cost-Risk (No BWST Refill)

No Refill Base Case Internal Events Cost-Risk	SAMA Case Internal Events Cost-Risk	Internal Events Averted Cost-Risk	Non-Flood External Events Multiplier	Total Non-Flood Averted Cost-Risk
$5,578,084	$5,017,472	$560,612	2.0	$1,121,224

As the changes related to BWST refill do not impact induced SGTR events (because core damage has already occurred), there are no changes to the external flooding contributions for this SAMA. In this case, external flooding contributes only $35,816 to the averted cost-risk and the final averted cost-risk is the sum of this value and the internal events averted cost-risk. The total is $1,157,040 ($1,121,224 + $35,816 = $1,157,040). Using the $5,000,000 cost of implementation from the ER, the net value for this SAMA is -$3,842,960 ($1,157,040- $5,000,000 = -$3,842,960). Even when the 95th percentile PRA results are used, the averted cost-risk is only $3,181,860 and the net value remains highly negative at -$1,818,140.

RAI 6.g Provide additional detail on how SAMA 10 mitigates the fundamental issue that the BWST cannot be refilled at a rate that will completely make up the inventory lost through tube rupture (i.e., the SAMA may only delay, not prevent, core damage).

AmerGen Response:

As identified in Table E.5-3 of the ER, the SAMA 10 design includes the installation of a higher flow pump.

RAI 6.h Describe AmerGen's plans for resolution of the technical concern that manual refill of the BWST does not prevent core damage, and plans for further evaluation or implementation of SAMA 10.

AmerGen Response:

There is no Current Licensing Basis requirement for BWST refill to prevent core damage through long term primary side makeup and, therefore, no requirement for action. However, the existing refill process, which is proceduralized, takes advantage of existing plant equipment to help mitigate SGTR scenarios. An effort was made in the PRA model to reflect the BWST refill capability, but the logic used to do this was optimistic for scenarios in which cooldown and depressurization fails.

The SAMA process, in conjunction with other plant analyses, has identified the limited BWST refill capability as a potential area for improvement at TMI. This issue has been captured in the TMI-1 Corrective Action Program. While the SAMA analysis does not explicitly evaluate the cost benefit associated with only enhancing the existing manual makeup capability, the site is aware that this is a potential option and will consider it in conjunction with the automation of the BWST refill function.

RAI 6.i The estimated benefit of SAMA 10 only accounted for mitigating SGTR events. Provide an assessment of the potential additional benefit of mitigating interfacing system LOCA (ISLOCA) events in addition to SGTR events, and the impact on the net value of this SAMA.

AmerGen Response:

ISLOCA is a relatively small contributor to CDF, dose-risk, and Offsite Economic Cost-Risk (OECR) compared with SGTR and even if SAMA 10 is assumed to eliminate all ISLOCA risk, the impact is small. A revised averted cost-risk can be obtained for this scenario by modifying the baseline SAMA 10 results to also reduce the ISLOCA contributors to zero (RC2-02 and RC2-04). The following tables summarize the results of these changes:

Internal Events Results By Release Category (SAMA 10 Also Eliminates ISLOCA)

Release Category	RC1-01	RC1-02	RC2-02	RC2-04	RC3-01	RC3-02	RC3-03	RC3-04	RC4-01	RC4-02	RC4-03	RC4-04	RC5-01	RC5-02	RC6-03
Freq.(/yr)$_{BASE}$	4.57E-07	1.59E-06	1.81E-07	1.27E-08	9.07E-11	9.07E-11	1.90E-10	2.88E-10	3.90E-08	1.46E-08	8.54E-09	3.16E-07	7.39E-07	1.66E-07	2.20E-08
Freq. (/yr)$_{new10}$	5.86E-08	1.19E-06	0.0	0.0	9.07E-11	9.07E-11	1.90E-10	2.88E-10	3.90E-08	1.46E-08	8.54E-09	3.16E-07	7.39E-07	1.66E-07	2.20E-08
Dose-Risk$_{BASE}$	2.61	9.09	0.91	0.06	0.00	0.00	0.00	0.00	0.11	0.04	0.03	0.93	4.54	1.02	0.06
Dose-Risk$_{new10}$	0.34	6.81	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.04	0.03	0.93	4.54	1.02	0.06
OECR$_{BASE}$	$12,705	$44,202	$3,367	$236	$3	$3	$7	$11	$351	$131	$77	$2,841	$14,928	$3,353	$208
OECR$_{new10}$	$1,629	$33,082	$0	$0	$3	$3	$7	$11	$351	$131	$77	$2,841	$14,928	$3,353	$208

Release Category	RC6-04	RC6-05	RC6-07	RC6-08	RC7-01	RC7-02	RC7-03	RC7-04	RC8-01	RC9-01	RC9-02	RC9-03	RC9-04	Sum of Annual Risk
Freq.(/yr)$_{BASE}$	2.36E-10	2.08E-11	8.00E-08	1.43E-08	2.25E-07	2.75E-09	7.45E-07	2.89E-07	3.19E-06	1.32E-05	1.69E-08	2.36E-06	1.91E-08	2.37E-05
Freq. (/yr)$_{SAMA}$	2.36E-10	2.08E-11	8.00E-08	1.43E-08	2.25E-07	2.75E-09	7.45E-07	2.89E-07	3.19E-06	1.32E-05	1.69E-08	2.36E-06	1.91E-08	2.27E-05
Dose-Risk$_{BASE}$	0.00	0.00	0.22	0.04	0.30	0.00	1.01	0.39	7.08	3.53	0.00	0.63	0.01	32.61
Dose-Risk$_{SAMA}$	0.00	0.00	0.22	0.04	0.30	0.00	1.01	0.39	7.08	3.53	0.00	0.63	0.01	27.14
OECR$_{BASE}$	$2	$0	$756	$135	$860	$11	$2,846	$1,104	$20,033	$3,461	$4	$618	$5	$112,259
OECR$_{SAMA}$	$2	$0	$756	$135	$860	$11	$2,846	$1,104	$20,033	$3,461	$4	$618	$5	$86,510

In order to account for the reduction in the RC2 frequency, the CDF is reduced from 2.29E-05/yr to 2.27E-05/yr based on the assumption that all ISLOCA sequences go to a successful endstate (no core damage). These results (CDF = 2.27E-05, Dose-Risk = 27.14, OECR = $86,510) correspond to a configuration specific internal events cost-risk of $2,692,215. The non-external flooding averted cost risk is calculated in the same manner as it was in the ER:

Non-External Flooding Averted Cost-Risk (SAMA 10 Also Eliminates ISLOCA)

Base Case Internal Events Cost-Risk	Internal Events Cost-Risk for Modified SAMA 10	Internal Events Averted Cost-Risk for Modified SAMA 10	Non-Flood External Events Multiplier	Total Non-Flood Averted Cost-Risk for Modified SAMA 10
$3,271,711	$2,692,215	$579,496	2.0	$1,158,992

This represents an increase of $230,944 over the base case internal events averted cost-risk value of $928,048. Given that external flooding risk is not impacted by SAMA 10, this is the final result. The net value remains highly negative at -$2,641,008.

RAI 6.j SAMA 2 identifies the need for a portable 480V generator to support turbine-driven emergency feedwater operation during a station blackout (SBO) event based on the need for steam generator level instrumentation. Table A.4-3 of the B.5.b Phase 2 and 3 Mitigation Strategies identifies three potential steam generator level control options, including local steam generator level control. Discuss how the B.5.b enhancements relate to this SAMA, and impact the estimated cost and benefit for the SAMA.

AmerGen Response:

At the time the TMI-1 SAMA analysis was performed, the B.5.b changes were not finalized, the design details of the potential changes were not available to the license renewal staff, and any associated implementation costs would have been highly uncertain. For these reasons, it was not possible to integrate the security modifications into the SAMA analysis in a constructive way.

The TMI-1 cost estimate that was developed for SAMA 2 conservatively did not include the cost to install a 480V AC generator as it was considered to be a minor contributor compared with the other equipment required for the SAMA. As a result, replacing the 480V generator with a local SG level control scheme would have no impact on the SAMA's cost benefit analysis.

RAI 6.k Section E.4 provides the calculated results for each of the cost-risk elements used to develop the internal and external flooding events MACRs. Provide the revised results for each of these cost-risk elements that reflects the SECPOP2000 corrections.

AmerGen Response:

The following tables provide the elements of the MACR calculation accounting for the SECPOP2000 corrections, as requested:

Maximum Averted Internal Events Cost-Risk (Post-SECPOP2000 Corrections)

Off-site exposure cost-risk	=	$972,461
Off-site economic cost-risk	=	$1,939,164
On-site exposure cost-risk	=	$14,670
On-site cleanup cost-risk	=	$461,912
Replacement Power cost-risk	=	$125,917
Internal Events Maximum Averted Cost-Risk	=	$3,514,124

Maximum External Flooding Cost-Risk (Post-SECPOP2000 Corrections)

Off-site exposure cost-risk	=	$5,289,732
Off-site economic cost-risk	=	$9,321,762
On-site exposure cost-risk	=	$50,177
On-site cleanup cost-risk	=	$1,579,915
Replacement Power cost-risk	=	$430,685
External Flooding Maximum Averted Cost-Risk	=	$16,672,271

RAI 6.I The benefit analysis for SAMA 1 assumes that modifications to automate start of the SBO emergency diesel generator (EDG) only reduces the probability of failure to start the SBO EDG by a factor of 10 (from 2.66E-02 to 2.66E-03). The new probability of failure of 2.66E-03 seems high for a function that is automated (e.g., SAMAs 10 and 13 assume a reduction in human error probability of greater than a factor of 100 for automating BWST refill and reloading instrument air compressors). Provide justification for the use of the factor of 10 reduction. In addition, provide an assessment of the impact on results if the human error probability were reduced by a factor of 100.

AmerGen Response:

As with most SAMA evaluations, once the targeted contributors are reduced by a factor of 10, further reductions have a limited impact on the results. In this case, the actual Human Error Probability (HEP) is not the dominant issue and even if GSHEO1A----HDGOA is set to zero, the CDF only changes from 1.880E-05 to 1.879E-05, which is a negligible change. The results are similar for the level 2 cutsets. Most of the benefit for this SAMA comes from recovering the sequences that were previously sent to core damage based on the inability to provide power for RCP seal cooling within the required 13 minute timeframe.

In addition, while the independent failure probability of an automated signal may be lower than the value used in the SAMA 1 analysis, use of the independent failure probability may be overly optimistic in that it does not account for dependencies (power, shared logic, etc.) that may exist.

RAI 7. **AmerGen's cost-benefit analysis showed that eight of the SAMA candidates (SAMAs 8, 11, 12, 16, 19, 27, 32, and 33) were potentially cost-beneficial in the baseline analysis and that an additional seven SAMAs (SAMAs 2, 7, 15, 21, 23, 24, and 26) were potentially cost-beneficial based on the results of the sensitivity analysis. AmerGen stated that all 15 of these potentially cost-beneficial SAMAs will be considered for implementation through the established TMI-1 work management processes. In view of the significant number of potentially cost-beneficial SAMAs, it is likely that several of these SAMAs address the same risk contributors. As such, implementation of an optimal subset of these SAMAs could achieve a large portion of the total risk reduction at a fraction of the cost, and render the remaining SAMAs no longer cost-beneficial. (An assessment of this type was described in Section E.7.5 but was limited to consideration of only one SAMA.) In this regard: identify those SAMAs that AmerGen considers highest priority for implementation, provide a revised cost-benefit analysis assuming these high priority SAMAs are implemented, and identify those SAMAs that would no longer be cost-beneficial given implementation of the high-priority SAMAs. Also, provide any specific plans/commitments regarding implementation of the high priority SAMAs.**

AmerGen Response:

The SAMA with the highest potential for implementation at TMI is considered to be SAMA 32 given its large risk reduction and the relatively low cost of implementation. The site is currently investigating the practicality of the implementation process and will make a determination on whether or not to proceed based on the results of the investigation.

Other SAMAs have the potential to further reduce risk, but as with SAMA 32, none are aging related and would only be pursued on a voluntary basis.

While initial inspection of the TMI SAMA list appears to indicate that there are many options to effectively reduce the site's risk, further analysis would reveal that several of the SAMAs address the same contributors. As a result, implementation of a specific subset of the SAMAs would achieve a large majority of the potential risk reduction and the remaining, redundant SAMAs would no longer be cost beneficial. It is possible to perform extensive PRA model quantifications to define a "minimal set" of SAMAs for implementation and to explicitly demonstrate that the remaining SAMAs are not cost effective; however, this is a resource intensive effort. In response to this question, a qualitative assessment was performed to achieve this goal.

Based on a review of the averted cost-risk values of the remaining cost effective SAMAs after implementation of SAMA 32 (from Section E.7.5.2 of the ER), SAMA 2 was identified as the most effective and comprehensive means of reducing plant risk. SAMA 24 is highly similar to SAMA 2, but the additional risk reduction gained by addressing Turbine Driven (TD) EFW failures relative to the increase in implementation cost makes it less desirable than SAMA 2. As a result, the two primary "minimal SAMAs" were considered to be SAMAs 2 and 32. From this point, the remaining SAMAs were examined in more detail to identify the SAMAs that would address unique areas of plant

risk. The SAMAs addressing the areas of risk that would not be addressed by other SAMAs were included in the "minimal SAMA" set, as summarized in the following table:

TMI-1 Minimal SAMAs

Minimal SAMA Group	Subsumed SAMAs	Comment
2 - Install Damage Resistant, High Temperature RCP Seals with a Portable 480V Generator for Extended EFW Operation	7 - Use Fire Service Water as an Alternate Cooling Source for the ICCW Heat Exchangers	SAMA 7 is focused on providing an alternate means of cooling the NSCCW system to support RCP thermal barrier cooling. Installation of the enhanced seals would eliminate the need for this SAMA.
	8 - Automate Reactor Coolant Pump Trip	The RCP seal failure phenomena associated with loss of RCP motor bearing cooling is not well defined and may not be a significant issue for the plant even with the current seals. Installation of the enhanced seals may eliminate concerns related to vibration induced RCP seal LOCAs.
	19 - Install Battery Backed Hydrogen Igniters or a Passive Hydrogen Ignition System	The benefits of the battery backed hydrogen igniters are linked to the CDF for both flooding and internal events. Given the large reduction in both of these CDFs resulting from implementation of SAMAs 2, 32 and the others, SAMA 19 may no longer be cost beneficial.
	23 - Develop Alarm Response Procedures to Direct Operation of RR-V-5 on Low RBEC Flow	The benefit of the procedure to bypass the failed RBEC cooling valve is linked to the late loss of DHR cases (RCs 6 and 7). SAMA 2 greatly reduces these contributors and SAMA 23 would not be cost effective after implementation of SAMA 2.
	24 - Install Damage Resistant, High Temperature RCP Seals with a Diesel Engine as an Alternate Drive for an EFW Pump and a Portable Generator for Level Control Instrumentation	SAMA 24 is an enhanced, more expensive version of SAMA 2 designed to address TD EFW failures. The additional cost associated with installing the diesel drive for one of the motor driven EFW pumps would not be offset by the risk reduction associated with mitigating the TD EFW failures. This is evident in the results presented in Section E.7.5.2 of the ER, which shows that after implementation of SAMA 32, the averted cost-risk for SAMA 24 is only $327,800 greater than SAMA 2 while the implementation cost is $1,100,000 greater (95th percentile results). SAMA 24 would not be cost effective after implementation of SAMA 2.
12 - Use the DHR System as an Alternate Suction Source for HPI		SAMA 12 is useful for standard LOCA initiators as well as RCP seal LOCAs. While SAMA 2 would eliminate the seal LOCA contributions, the benefit provided for the non-seal LOCA contributors (over 50%) would still be enough to make this SAMA cost beneficial.

TMI-1 Minimal SAMAs

Minimal SAMA Group	Subsumed SAMAs	Comment
15 - Automate Swap to Recirculation Mode		SAMA 15 is useful for standard LOCA initiators as well as RCP seal LOCAs. While SAMA 2 would eliminate the seal LOCA contributions, most of the benefit for this SAMA would not be related to shorter term LOCAs and it would still be cost beneficial after implementation of the other SAMAs.
16 - Automate HPI Injection on Low Pressurizer Level		Quantitatively, automation of HPI mostly impacts loss of secondary side heat removal cases (CCF of EFW) and implementation of the other "minimal SAMAs" would not significantly impact the averted cost risk for this SAMA.
26 - Reroute Cables so that They Do Not Pass Over Ignition Sources in Fire Area CB-FA-2e (West Inverter Room) or Wrap them in Fire Proof Material		The true benefit of re-routing the cables in fire zone CB-FA-2b may be impacted in some way by the other "minimal SAMAs", but SAMA 26 would still likely be marginally cost beneficial.
27 - Improve the 480V AC load center welds		The true benefit of enhancing the 480V AC load center's welds may be impacted in some way by other SAMAs that impact internal events risk, but SAMA 27 would still be cost beneficial.
32 - Pre-stage Severe Flooding Equipment	11 - Enhance Extreme External Flooding Mitigation Equipment to Address SBO and Loss of Seal Cooling Scenarios	SAMA 11 is an enhanced, more expensive version of SAMA 32. If the decision were made to implement SAMA 32 over SAMA 11, it would be illogical to then implement SAMA 11 after SAMA 32 even though SAMA 11 would still potentially offer some additional flooding benefit. The benefit related to RCP seal cooling would be superseded by the enhanced RCP seals from SAMA 2 and SAMA 11 would not provide a significant, additional internal events benefit.
	21 - Install Concrete Shields to Block Direct Pathways from the RPV to the Containment Wall and/or Direct Containment Flooding Early in External Flooding Scenarios	The benefits of the concrete shields are linked to the CDF for both flooding and internal events. Given the large reduction in both of these CDFs resulting from implementation of SAMAs 2 , 32 and the others, SAMA 21 would no longer be cost beneficial. This is demonstrated in Section E.7.5.2 of the ER, which shows that SAMA 21 is not cost beneficial after implementation of SAMA 32.

TMI-1 Minimal SAMAs

Minimal SAMA Group	Subsumed SAMAs	Comment
	33 - Increase the Flood Protection Height	A large portion of the external flooding risk would be addressed by SAMA 32. While Section E.7.5.2 of the ER shows that SAMA 33 was still cost beneficial after implementation of SAMA 32, that result is highly dependent on the methods used to model its impact on risk. In addition, there is a risk associated with the implementation of SAMA 33 that an unidentified flood pathway could exist and that the other measures taken to exclude floodwaters from critical equipment would be bypassed. As a result, this SAMA may not be cost beneficial and it is not considered to be the most practical to implement.