11 UNCERTAINTY AND SENSITIVITY ANALYSIS

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11 UNCERTAINTY AND SENSITIVITY ANALYSIS

11.1 INTRODUCTION

Various sensitivity analyses were conducted on the ESBWR Level 1 and Level 2 PRA at power, fire, flood, high wind and shutdown models. An uncertainty analysis was performed on the Level 1 baseline internal events PRA. The intent of these analyses was to evaluate the impacts to CDF, LRF and the PRA model and to provide risk insights.

Sensitivities and uncertainties included in Section 11 were identified from the following sources:

- Previously conducted in NEDO-33201 Section 11, Rev.1,
- Through the NRC Request for Additional Information (RAIs) process
- Support for key assumptions
- Identified by system/PRA engineer

Appendix 11A documents MAAP thermal-hydraulic sensitivities that were performed to address current issues and develop further knowledge related to the function and operation of the ESBWR passive systems.

Appendix 11B documents the top 100 cutsets for a variety of sensitivity studies.

11.2 METHODOLOGY

The methodology for conducting the sensitivity and uncertainty analysis was conducted in three phases, (1) selection/identification, (2) implementation/analyses and (3) results/benchmarking. The first step was to evaluate the importance of the sensitivity itself. In some cases, sensitivities were identified, but upon further evaluation were discarded due inherent model conservatisms or were delayed pending more detailed engineering.

Once the sensitivity had been identified, the models and supporting files were generated to facilitate the analysis. In general, the base PRA models were used to conduct the sensitivities with some changes. The base PRA models used for the sensitivity analysis reflect the NEDO-33201, Rev. 2 of the PRA model with some exceptions as noted in the individual sensitivities. Manipulation of existing data, revised engineering calculations or re-quantification of the model was used to obtain the results reflecting the specific sensitivity.

Finally, the results obtained from the sensitivities were benchmarked against the appropriate model results in order to gain insight. These units of measure for benchmarking the sensitivities included:

- CDF, LRF and importance measures from Level 1 and Level 2 PRA models,
- NRC Risk goals as discussed in NEDO-33201, Rev 2 Section 17.2, and
- “Significant” definitions as discussed in Section 18.2.

Based on this benchmark, risk important insights or findings were obtained and are summarized in Section 11.6.

11.3 SENSITIVITY ANAYLSES

Sensitivities were performed on the Level 1 and Level 2 PRA at power, fire, flood and shutdown models. The sensitivities included in Section 11.3 include the following:

- Level 1 Sensitivities
- Level 2 Sensitivities
- Focused Level 1 Sensitivities
- Focused Level 2 Sensitivities
- Shutdown Sensitivities
- Transportation and Nearby Facilities Sensitivity
- Fire Sensitivities

11.3.1 LEVEL 1 Sensitivities

A series of sensitivities were conducted on the Level 1 PRA model. The focus of these sensitivities was to develop a better understanding and to provide insights as it relates to core damage frequency (CDF) generated through model analysis. Based on uncertainties associated with design data, component selection, configuration and success criteria, the insights developed from the sensitivities have the potential to guide ongoing design and operational activities in the consideration of overall risk impact.

The following sections provide a more detailed discussion of the sensitivities conducted on the Level 1 PRA model. Sensitivities were grouped according to scope and methodology. The Level 1 sensitivities conducted included:

- Human Reliability
- Common Cause Failure
- Squib Valve Reliability
- Test and Maintenance Unavailability
- Standby Liquid Control System Success Criteria
- Component Type Code Data
- SRV Common Cause Factors
- SPC & LPCI Success Criteria
- Turbine Bypass Valve Success Criteria
- LOCA Frequency
- LOCA – IC Frequency
- CRD Injection post Containment Failure
- Accumulators

- Vacuum Breakers
- System Importance
- Demand for Passive Systems

The current Level 1 PRA model generated a CDF of 1.22E-08 at a truncation of 1E-15 with a total of 173,251 cutsets. A detailed discussion of the model development and quantification process along with a detailed results analysis can be found in Section 7, Rev. 2. As part of the sensitivity process, the level 1 PRA model will provide the benchmark against which the sensitivity results will be compared. A summary of the data generated from the level 1 PRA model is provided in Table 11.3-1 and includes distribution of initiating events, accident classes and drywell water level classes, as well as top accident sequences.

11.3.1.1 Human Reliability

A human reliability sensitivity was performed to better understand the impact of operator interactions to the model and to gain insight into the importance of these actions on CDF and the Level 1 PRA model. As part of the evaluation of human reliability, sensitivities were conducted on pre-initiator and post-initiator operator actions under conditions in which all the human error basic events result in either success or failure.

For the purpose of this human reliability sensitivity, no model or database changes were required. To simulate the success or failure of these human error basic events, additional flag files were generated and used during model quantification to provide the required manipulation of the operator actions. Flag files were generated for pre-initiator and post-initiator actions. In addition, a flag files were generated that set both pre-initiator and post-initiator operator actions to TRUE and FALSE (one flag for each setting).

The human reliability sensitivity model was run using the base PRA model at a truncation of 1E-15/yr with the additional flag files and noted changes. Results showed a significant impact to CDF over the base PRA model of over one order of magnitude and are shown in Table 11.3-2. At a truncation of 1E-15, the PRA model is impacted by a change of two orders of magnitude in CDF over the base model.

From the TRUE flag files, risk achievement worth (RAW) values can be calculated. The FALSE flag file results were used to simulate the success of all human error basic events within the system and to calculate the Fussell-Vesely (F-V) values. Using these RAW and F-V values, an indication of the risk significance of the human reliability sensitivities was determined based on criteria from Section 11.2. Table 11.3-3 contains the RAW and F-V results generated as part of the human reliability sensitivity. These results indicate that the pre-initiators have a more significant impact on the RAW value primarily due to the large number of potential latent failure and higher reliability for each of these operator actions. Similarly, the pre-initiator, post-initiator and ALL_T (all operator actions set to TRUE) sensitivities were found to be risk significant based in F-V values exceeding a value of 0.01. The distribution of latent failures (pre-initiators) and failure to respond (post-initiator) contribute about evenly, with a FV value of 0.42 for pre-initiators and 0.57 for post-initiators.

A more detailed summary of the human reliability results is shown in Table 11.3-3. Along with the noted changes (CDF, RAW and F-V), other significant changes occurred in the sensitivity results including changes to the distribution of initiator CDF, distribution of accident classes and distribution of drywell water level classes. In addition, the top accident sequences from the human reliability sensitivity showed some variation when compared to the top sequences in the base model.

Changes in the human error events, particularly pre-initiators, have the potential to impact the overall Level 1 PRA model CDF. This case shows that the base model is somewhat sensitive to changes in human error events. However, the model results are still well below the NRC stated goals for CDF even with all human error events set to TRUE.

11.3.1.2 Common Cause Failure

Common cause component failures (CCF) are predominant in the top cutsets for the Level 1 base PRA model. To better understand the impact of these common cause failures, a model sensitivity was performed to evaluate the impact to CDF and the base model if no common cause failures are considered. To simulate the elimination of the common cause failures, a flag file was generated that sets all common cause failure events to FALSE (.F.).

For the purpose of the common cause failure sensitivity, no model or database changes were required. The CCF sensitivity model was run using the base model at a truncation of 1E-15 with the additional CCF flag file. Results showed a three order of magnitude decrease in CDF and are shown in Table 11.3-4.

A more detailed summary of the common cause failure results is shown in Table 11.3-5. In addition to the significant changes in CDF as a result of changes in the system common cause failures, other significant changes occurred in the CDF results obtained from the individual systems including initiator CDF, distribution of accident classes and distribution of drywell water level classes. The top accident sequences from the common cause failure sensitivity showed no commonality to the top sequences represent by the base model. The common cause failure sensitivity results were dominated by sequences involving vessel rupture in combination with a single GDCS line check valve failure to open for injection (RVR014). This sequence accounts for about 78.5% of the CDF at a truncation of 1E-15. In contrast, this sequence does not appear in the base model results.

Changes in the common cause factors have the potential to impact the overall CDF and the Level 1 PRA model. It is important to note that while the elimination of a number of these common cause factors may lower the CDF, it is unlikely that these types of changes would be reflected in the Level 1 PRA model.

11.3.1.3 Squib Valves Reliability

In the current model, squib valve failure rates are based on generic data. For this reason, a series of sensitivities on the reliability of the squib valves in the Level 1 and Level 2 PRA models were performed to better understand the importance of this component and to provide insight into the CDF and LRF contribution of these valves. Squib valve sensitivities performed included the following:

- Increase of all squib valve failure rates by a factor of 10 (Level 1 and 2),
- Increase of all squib valve failure rates by a factor of 5 (Level 1),

- Increase of the failure rates of the squib valves functioning as part of the ADS system by a factor of 10 (Level 1),
- Increase of the failure rates of the squib valves functioning as part of the SLCS system by a factor of 10 (Level 1),
- Increase of the failure rates of the squib valves functioning as part of the GDCS injection system by a factor of 10 (Level 1), and
- Increase of the failure rates of the squib valves functioning as part of the GDCS equalization system by a factor of 10 (Level 1).

For the purpose of the squib valve reliability sensitivity, no fault tree or flag file changes were required. The appropriate single and common cause failure basic events contained in the database files were identified and modified to reflect the increased value.

The squib valve sensitivity models were run using the base PRA model at a truncation of 1E-15 with the noted changes to SQV failure rates. Results generated show some small impacts to CDF over the base PRA model and are provided in Table 11.3-6. According to the function-based study of the squib valves, the valves functioning as part of the ADS and GDCS injection systems showed the highest change in CDF over the Level 1 PRA model with an increase of less than an order of magnitude in CDF. A more detailed summary of the squib valve results obtained from the sensitivity is shown in Table 11.3-7. In addition to the significant changes in overall CDF due to the SQV reliability, the distribution of initiators, distribution of accident classes and distribution of drywell water level classes shifted as well. The top accident sequences from the squib valve sensitivities also showed differences from the top sequences in the Level 1 base PRA model.

Several of the passive safety features of the ESBWR utilize squib valves. As such, the PRA model is somewhat sensitive to changes in the failure data associated with the valves (especially ADS and GDCS function). Though sensitive to varying squib valve data, the results of this case show that even with higher failure rates, CDF values are still well below the NRC stated goals.

11.3.1.4 Test and Maintenance Unavailability

Current model values used for system/train unavailability due to test and maintenance (T&M) are generic and not representative of plant-specific operations. Model sensitivities were performed to evaluate the impact of these activities on the CDF and the Level 1 PRA model. As part of the evaluation of T&M unavailability, sensitivities were conducted to simulate the failure of all T&M activities and also to both increase and decrease the frequency of these activities by a factor of 10.

For the T&M sensitivity, a test and maintenance flag file was used to set the basic events identified by the string “-TM-“ to FALSE (.F.). For the other sensitivities, the database file was modified to either increase or decrease the T&M basic events by a factor of 10.

The T&M sensitivities were run using the base model at a truncation of 1E-15 with the additional flag file and noted database changes when applicable. Results for the sensitivity with a 10x increase in T&M activities showed a small increase in the CDF over the base Level 1 PRA model. Both the sensitivities decreasing the T&M frequency activities, one by a factor of 10 and the other to 0, showed negligible impact to CDF. The CDF results for the T&M sensitivity are shown in Table 11.3-8.

A more detailed summary of the T&M unavailability results obtained from the sensitivity analysis is shown in Table 11.3-9. In addition to the significant changes to CDF as a result of the increased frequency of T&M activities, other significant changes occurred in the evaluating the CDF results obtained from the individual systems including initiator CDF, distribution of accident classes and distribution of drywell water level classes. In addition, the top accident sequences from the T&M unavailability x10 sensitivity showed differences in the top sequences represented by the Level 1 base PRA model. Additional sequences, SL-S017, T-IORV027, T-IORV013, and TGEN-069, not found in the top twenty sequences of the Level 1 PRA model or the other T&M sensitivities were present in the 10xT&M case.

The Level 1 PRA model showed a small impact from the factor of 10 increase in T&M unavailability. A more detailed effort to accurately model T&M will be completed once procedures are developed for specific system operation and maintenance for the ESBWR. Currently, conservative estimates for T&M produce results that are several orders of magnitude below the stated NRC goals for CDF.

11.3.1.5 Standby Liquid Control Sensitivity

The current success criteria for the standby liquid control (SLC) system requires two trains functioning to maintain a plant shutdown without core damage. A sensitivity on the PRA model was conducted to evaluate the impact to the base Level 1 PRA model from changing the success criteria requirements to a single train of SLC.

The base fault tree model was modified to require the operation of just one SLC train. No other model or file changes were required for the SLC sensitivity. The SLC sensitivity was run using the base model at a truncation of 1E-15 with the noted changes to the fault tree. Results for the SLC sensitivity showed only a small decrease in the CDF when only one train of SLC is required. Results of the CDF for the SLC sensitivity are provided in Table 11.3-4.

Additional details of the SLC sensitivity are provided in Table 11.3-10. In addition to the decrease in the overall CDF as a result of requiring only one train the second SLC train, the initiator distribution, distribution of accident classes and distribution of drywell water level classes shifted as well. The top accident sequences from the SLC sensitivity showed differences in the top sequences represent by the Level 1 base PRA model. Most notable is the distribution CDF change of one of the top sequences, AT-T-GEN023, which was reduced from about 11% to less than 1%. This reduction is due to the elimination of the single failure of either SLC train.

Changes in the SLC success criteria have the potential to impact the overall CDF and the Level 1 PRA model. This SLC insight should be considered in future modifications and changes to the SLCS success criteria.

11.3.1.6 Component Type Code Data

In certain cases, component type code data used in the Level 1 PRA model was estimated based on available knowledge and source information. Model sensitivities were conducted to evaluate the potential impacts to CDF for changes to these estimated component type codes. Six component type codes were identified for this sensitivity and included:

- MTS CO Manual Transfer Switch Spuriously Opens
- NMO CC Nitrogen Motor Operated Valve Fails to Open
- NMO OC Nitrogen Motor Operated Valve Transfers Closed
- NMO OO Nitrogen Motor Operated Valve Fails to Close
- NPO CC - Pneumatic Operated Valve Fails to Open
- NPO OC Pneumatic Operated Valve Transfers Closed

These type codes were increased by a factor of 10 over the original values in the base model. Common cause basic events were increased by a factor of 10 as well.

In order to perform the type code sensitivity, the database file was modified with the increases. No change to the model or other changes to the database were required

Each of the type code data sensitivity model was run using the base model and modified database file at a truncation of 1E-14. The results showed little to no impact to the CDF and are shown in Table 11.3-11.

Should component type code change in the future, the component type code data insight should be considered.

11.3.1.7 SRV Common Cause Group

Common cause component failures are predominant in the top cutsets for the Level 1 base PRA model. These failures were evaluated for all components in Section 11.3.1.2. However, a sensitivity was performed to evaluate the impact of these common cause failures on CDF as they apply to the safety relief valve (SRVs) function specifically. Under the current PRA model, the function of the safety relief values is divided into two separate functions, namely (1) automatic depressurization, and (2) safety relief only. The common cause factors for SRVs sensitivity was performed under the premise that all 18 SRVs would all be covered under a single common cause category for fail to open in safety relief mode.

The base Level 1 PRA model was changed to capture all the values under the same common cause category; common cause failure data was revised to reflect the common grouping of the two functions of the SRVs.

The common cause factors SRVs sensitivity model was run using the base model at a truncation of 1E-15 with the noted modifications to the fault tree and database file. Truncation results for the common cause factors SRVs sensitivity showed no change in the CDF with the application of a single common cause category for the SRVs. The CDF results are provided in Table 11.3-4.

Additional details of the common cause factors SRVs sensitivity are provided in Table 11.3-10. The only changes from the SRV common cause sensitivity showed a slight change to the distribution of accident classes and distribution of drywell water level classes. This change would have little impact to the overall CDF and the Level 1 PRA model.

11.3.1.8 SPC & LPCI Success Criteria

Current success criteria for the suppression pool cooling (SPC) and low pressure injection system (LPCI) requires a single train for either function. A model sensitivity was conducted to evaluate the impact to the base Level 1 PRA model with the change in success criteria requiring both trains to function for SPC or LPCI.

The base fault tree model was modified to require both SPC and LPCI trains to function for SPC or LPCI. No other model or file changes were required for the SPC/LPCI sensitivity.

The SPC/LPCI sensitivity was run using the modified model files at a truncation of 1E-15. Truncation results for the SPC/LPCI sensitivity showed a small increase in the CDF over the Level 1 PRA model with the requirement of both trains operating. Results of the CDF for the SPC/LPCI sensitivity with truncation level are provided in Table 11.3-4.

Additional details of the SPC/LPCI sensitivity are provided in Table 11.3-10. Compared to the base model, the results showed a slight change to the distribution of accident classes and distribution of drywell water level classes. Needing two trains instead on one does not impact the results as significantly due to the system reliance on operators. This case reinforces the fact that operator errors, not equipment failures dominate the results for SPC/LPCI.

11.3.1.9 Turbine Bypass Valves Success Criteria

Current success criteria for the turbine bypass valves requires 4 of 12 valves to function for successful PCCS operation. A model sensitivity was conducted to evaluate the impact to the base Level 1 PRA model CDF supporting a change in success criteria requiring 6 of 12 turbine bypass valves.

The base fault tree model was modified to require the 6 of 12 turbine bypass valves. No other model or file changes were required for the turbine bypass sensitivity.

The turbine bypass sensitivity was run using the base model at a truncation of 1E-15 with the noted changes to the fault tree. Truncation results for the turbine bypass sensitivity showed negligible change in the CDF with the requirement of 6 of 12 turbine bypass valves. Results of the CDF for the turbine bypass sensitivity with truncation level are provided in Table 11.3-4.

Additional details of the turbine bypass sensitivity are provided in Table 11.3-10. Compared to the base model, the results showed a slight change to the distribution of accident classes and distribution of drywell water level classes.

Changes to the turbine bypass success criteria would have minimal impact to the overall CDF and the Level 1 PRA model.

11.3.1.10 LOCA Frequency

The loss of coolant accident (LOCA) frequencies in the current model were developed based on assumptions related to the number and location of lines. From these assumptions, LOCA initiator frequencies were generated and used in the base Level 1 and Level 2 PRA model. A LOCA frequency sensitivity was performed to increase the LOCA initiator values by a factor of 2 and evaluate the uncertainty associated with theses changes to the model.

The base fault tree model and database file were modified increasing the frequency of all the LOCA initiators by a factor of 2. In the process of making the LOCA initiator frequency increases, an error was found in the base model that overestimated the frequency for the initiator %BOC-IC. To properly evaluate CDF impacts associated with the LOCA frequencies, this error was corrected and a modified LOCA base model was generated for purpose of comparison.

The LOCA frequency sensitivity was run using the modified base model at a truncation of 1E-15 with the noted changes in initiator frequencies. Results for the LOCA frequency sensitivity showed only a small increase in the CDF compared to the modified LOCA base model. Results of the CDF for the LOCA frequency sensitivity are provided in Table 11.3-4.

Additional details of the LOCA frequency sensitivity are provided in Table 11.3-12. Changes on the order of a factor of 2 were shown in the initiator distribution for both the break outside of containment (BOC) and LOCA classes. Other changes included differences in the distribution of accident classes and drywell water level classes. Top sequences for the LOCA frequency sensitivity showed increases in the contribution from LOCA sequences. Medium LOCA sequences not found in the modified base LOCA model top sequences were present in the LOCA frequency sensitivity top sequences.

The most significant insight is the increase in “high” drywell water level core damage sequence from 5% of CDF in the base model to almost 9% in the LOCA sensitivity. These sequences are not mitigated in the Level 2 analysis, and contribute directly to LRF via ex-vessel explosion (EVE).

Uncertainties associated with the design of process piping have the potential to impact to the overall CDF and LRF. As piping details are finalized, LOCA frequencies should be review to ensure they adequate reflect the design.

11.3.1.11 LOCA –Inside Containment Structure (ICS) Frequency

In conjunction with the uncertainties associated with the number and placement of process piping, additional uncertainty can be associated with the proportioning of process piping either inside or outside of the containment structure. The current model assumes that 10% of the ICS piping is associated with break outside of containment (BOC) LOCAs. To better understand the impact of this assumption on the Level 1 PRA model, a LOCA-ICS frequency sensitivity was performed to increase the percentage of lines located outside of containment from 10% to 50%.

The base fault tree model and database file were modified increasing the frequency of the BOC LOCA initiators to reflect the higher percentage of lines outside of containment.. In the process of making the increase in the LOCA initiator frequency, an error was found in the base model that overestimated the frequency for the initiator %BOC-IC. To properly evaluate CDF impacts associated with the LOCA frequencies, this error was corrected and a modified LOCA base model was generated for purpose of comparison.

The LOCA-ICS sensitivity was run using the modified base model at a truncation of 1E-15 with the noted change to the %BOC-IC frequency. Results for the LOCA-ICS sensitivity showed no change in the CDF with the increased initiator frequency. Results of the CDF for the LOCA-ICS sensitivity with truncation level are provided in Table 11.3-4.

Additional details of the LOCA-ICS frequency sensitivity are provided in Table 11.3-12. No changes were shown in the initiator distribution for either the break outside of containment (BOC) and LOCA classes. No other differences in the distribution of initiators, accident classes, drywell water level classes or top sequences were shown.

While the model showed negligible sensitivity to the LOCA-ICS uncertainties, the LOCA-ICS frequencies should be reviewed as more detailed design and engineering data emerge to ensure they adequate reflect the design.

11.3.1.12 CRD Injection

The current model assumes that injection using the control rod drive (CRD) pumps is successful regardless of containment integrity. To better understand the impact of this assumption, a sensitivity was conducted to consider the failure of CRD injection post containment failure and to evaluate the impact to the base Level 1 PRA model.

In order to perform the CRD injection sensitivity, a flag file was generated to fail CRD in the sequences where containment failure also occurs. No model or database file changes were required.

The CRD injection sensitivity was run using the base model at a truncation of 1E-15 with the additional flag file. Results for the CRD injection sensitivity showed no change in the CDF; results for the CRD injection sensitivity with truncation level are provided in Table 11.3-4.

Additional details of the CRD injection sensitivity are provided in Table 11.3-10. These results showed minimal changes to the distribution of initiators, accident classes, distribution of drywell water level classes or sequence contribution. Changes to the CRD injection have negligible impact to the overall CDF and the Level 1 PRA model.

11.3.1.13 Accumulator

The current Level 1 PRA model credits accumulators to support the long term operation of pneumatically operated components. To better understand the impact of these accumulators on CDF and the PRA model, a sensitivity was conducted to fail the accumulators, leaving only the pneumatic supply system itself for operation.

In the accumulator sensitivity, a flag file was used to set the basic events for the accumulator tanks to TRUE (T). No other model or file changes were required for the accumulator sensitivity.

The accumulator sensitivity was run using the base model at a truncation of 1E-13 with addition of the accumulator flag file. Results for the accumulator sensitivity showed a significant change to CDF with an increase of more than two orders of magnitude over the base model. Results of the CDF for the accumulator sensitivity are provided in Table 11.3-4.

Results generated from the accumulator sensitivity show dominant sequences involve the loss of decay heat removal at high pressure where the isolation condensers are initially available. These dominant sequences include T-GEN004, T-SW002 and T-FDW003 which contribute about 58%, 38% and 4%, respectively to the overall CDF of the accumulator sensitivity. Additional details of the accumulator sensitivity are provided in Table 11.3-13.

The accumulator sensitivity shows that accumulator support for pneumatically operated components contributes significantly to the Level 1 PRA model. Based on the insights from the accumulator sensitivity, future consideration should be given to providing alarm/indication for accumulator pressure and operator response to low pressure.

11.3.1.14 Vacuum Breakers

The current ESBWR design utilizes prototype primary vacuum breakers and generic back-up valves to prevent leakage. In response to RAI 19.2-7 S01, a sensitivity was performed to better understand the impact of potential uncertainty in the vacuum breaker reliability. This study was also evaluated for the Level 2 PRA model and is discussed in Section 11.3.2.4.

In the vacuum breaker sensitivity, the failure rates of the vacuum breakers were increased by a factor of 10 in the database file to account for uncertainty in general reliability and anticipated number of cycles. No other model or file changes were required for the vacuum breaker sensitivity.

The vacuum breaker sensitivity was run using the base model at a truncation of 1E-15 with the increased failure rate. Results for the vacuum breaker sensitivity show that the CDF rises to 1.34E-8/yr. Results of the CDF for the vacuum breaker sensitivity are provided in Table 11.3-4.

Additional details of the vacuum breaker sensitivity are provided in Table 11.3-10. Some changes were shown in distribution of initiators, accident classes, drywell water level classes and top sequences for the vacuum breakers.

The vacuum breaker sensitivity shows that increased failure rates contribute to a small increase in the CDF and some changes to the Level 1 PRA model. Based on these results, the increase in CDF due to uncertainties associated with the primary vacuum breaker design and anticipated number of cycles is within reason.

11.3.1.15 System Importance

The objective of the system importance sensitivity is to evaluate impact of individual systems on the Level 1 PRA model and CDF. A total of 31 individual systems were identified and evaluated as part of the system importance sensitivity. In order to capture the impact of these 31 individual systems, a flag files was generated for each system using the basic event tops specific to that system. The TRUE flag file was used to simulate the failure of all single and common cause failures of the components within the system. From the TRUE flag files, risk achievement worth (RAW) values can be calculated. The FALSE flag file was used to simulate the success of all single and common cause failures of the components within the system and was used to calculate the Fussell-Vesely (F-V) values. Using the RAW and F-V values calculated from the system importance sensitivity, an importance ranking of each system can be obtained.

For the purpose of the system importance sensitivity, no model or database changes were required .

The individual system models were run using the base model at a truncation of 1E-14 with the additional flag files. Due to the large amount of computing time required, the truncation level of 1E-14 was considered adequate to obtain the results and provide insight necessary to allow for system rankings. Results for the system importance sensitivity are shown in Table 11.3-14.

In evaluating the CDF results obtained from the individual systems importance with the Level 1 PRA model, values for RAW and F-V were calculated and are provided in Table 11.3-14. The criteria described in Section 11.2 were applied to the RAW and F-V results to determine system importance rankings. Based on the RAW values, 20 of the 31 systems evaluated were found to be risk significant based on exceeding a RAW value of 5. A truncation level of 1E-13 was used in determining RAW values for certain systems including C10, E50, T10 and T15, higher truncations resulted in the generation of a number of cutsets for these systems that exceed the limitations of the quantification tools. Based on the F-V values, 13 of the 31 systems evaluated were found to be risk significant based on exceeding a F-V value of 0.01. The ranking of system importance based on RAW values is contained in Table 11.3-15 and rankings based on F-V values are contained in Table 11.3-16.

11.3.1.16 Demand for Passive Components

In an effort to obtain a better understanding of the impacts of passive safety systems on the Level 1 PRA model, a sensitivity was performed to evaluate the sum of CDF for both success and failure demands for certain passive components. Components identified for this sensitivity included the DPVs and PCCS systems.

In the passive components sensitivity, sequences were identified and sorted based on the success or failure of each of the individual components. In addition, sequences where more than one component failed were also identified and sorted accordingly.

The passive components sensitivity was run using the base model at a truncation of 1E-15 and the sorting tool was applied to the results. The CDF for the sequences were then calculated as shown in Table 11.3-17 along with additional details for the core damage sequences where ICS, PCCS or Pool Makeup occur.

The sensitivity results show the dominant core damage sequences involving the failure of ICS are categorized as Class I or Class III. These failures occur when high pressure makeup has failed and either one of the two occurs (1) failure to depressurization or (2) low pressure injection is unavailable. The failure of PCCS or makeup to the pools are not significant contributors to CDF.

LEVEL 2 Sensitivities

A series of sensitivities were conducted on the Level 2 PRA model. The focus of these sensitivities was to develop a better understanding and to provide insights as it relates to CDF and Level 2 release categories generated through model analysis. Based on uncertainties associated with design data, component selection, configuration and success criteria, the insights developed from the sensitivities have the potential to guide ongoing design and operational activities in the consideration of overall risk impact.

The following sections provide a more detailed discussion of the sensitivities conducted on the Level 2 PRA model. Sensitivities were grouped according to scope and methodology. The Level 2 sensitivities conducted included:

- CIS Node Placement
- Physically Unreasonable Phenomenology
- Vacuum Breaker Data

The current level 2 PRA model generates results for various release categories defined in Section 8.2.1.4 and is shown in Table 8.2-2. A detailed discussion of the model development and quantification process along with a detailed results analysis can be found in NEDO-33201 Section 8 and Appendix 8A, Rev. 2. As part of the sensitivity process, the Level 2 PRA model will provide the benchmark by which the sensitivities will be compared. A summary of the data generated from the Level 2 PRA model is provided in Table 11.3-18 and includes distribution of initiating events, accident classes and drywell water level classes, as well as top accident sequences.

The Level 2 PRA generally utilizes the metric "non-TSL" (nTSL) release as the equivalent of CDF in the Level 1 model. The nTSL frequency represents all sequences that do not result in Technical Specification Leakage (TSL), which is the success state of the Level 2 PRA. For this revision, nTSL is assumed to be equivalent to LRF

11.3.2.1 CIS Node

A Level 2 PRA model sensitivity was performed to study the effect of moving the containment isolation system (CIS) node to the first position in the event trees and the impact to LRF. The current Level 2 PRA model is based on event trees with CIS in a nodal position of 3 or 4. For the purpose of the CIS node sensitivity, the event trees were modified with the CIS node placed immediately following the initiator. This was limited to the only the low and medium event trees where CIS was credited.

To facilitate the CIS node sensitivity, the Level 2 PRA model was re-quantified using the modified event trees at a truncation of 1E-15. Results for the CIS node sensitivity showed no impact to LRF as demonstrated by no change in nTSL frequency over the PRA Level 2 base model. Results of the nTSL and CDF for the CIS node sensitivity are provided in Tables 11.3-18 and 11.3-19. The placement of the CIS node earlier in the event trees was shown to have little impact on the nTSL frequencies.

11.3.2.2 Physically Unreasonable Phenomenology

A current Level 2 PRA model contains containment failure modes that are considered "physically unreasonable" (PU). A sensitivity was performed to better understand the impact to nTSL and source terms pertaining to the omission of these PU modes from the model. These modes include ex-vessel explosion (EVE) from a medium lower drywell water level and direct containment heating (DCH).

To facilitate the PU sensitivity, a flag file was created to include the PU events in the quantification. The PU sensitivity was run using the base Level 2 model at a truncation of 1E-15 with the additional flag file. Results for the PU sensitivity showed only a small increase in the nTSL frequency over the PRA Level 2 base model. Results of the nTSL for the PU sensitivity are provided in Table 11.3-19.

Additional details of the PU sensitivity are provided in Table 11.3-18. A release frequency for DCH of 2.56E-12 was obtained for the PU sensitivity contributing 0.2% to the total non-TSL release frequency. The non-DCH release category source terms were minimally affected by the increased leakage area in their respective sequences. The DCH release category itself has a high release fraction, but its low frequency renders potential offsite consequences negligible.

The PU sensitivity confirms that no potentially significant offsite consequences are being negated by excluding PU events from the Level 2 PRA model.

11.3.2.3 Vacuum Breakers

In the vacuum breaker sensitivity, the failure rates of the vacuum breakers were increased by a factor of 10 in the database file to account for uncertainty in general reliability and anticipated number of cycles in the mission time. No other model or file changes were required for the vacuum breaker sensitivity.

The vacuum breaker sensitivity was run using the base model at a truncation of 1E-15 with the increased failure rate. Results for the vacuum breaker sensitivity showed a nTSL frequency of 2.13E-09 at a truncation of 1E-15. This value for nTSL represents a significant increase in nTSL frequency of almost 2 orders of magnitude over the base Level 2 model. Results of the nTSL for the vacuum breaker sensitivity are provided in Table 11.4-19.

Additional details of the vacuum breaker sensitivity are provided in Table 11.4-18. Other changes in release class frequencies over the base Level 2 model were shown in the classes BOC (accident class cv), FR and OPVB (accident class cdii-a). The increase in these frequencies can be attributed to the failure of steam suppression functions supported by the vacuum breakers.

The vacuum breaker sensitivity shows that increased failure rates contribute to a significant increase in the nTSL frequencies. However, the increased nTSL meets the NRC goal of 1E-06/yr for LRF. Based on these results, the uncertainties associated with the primary vacuum breaker design and anticipated number of cycles may contribute to slightly increased LRF, but the increase is reasonable. This conclusion was also supported by the Level 1 vacuum breaker sensitivity.

11.3.3 Focus Level 1

A focus evaluation and a series of sensitivities were conducted on the Level 1 PRA model. The intent of these focus sensitivities was to develop a better understanding of safety-related systems and systems included in the regulatory treatment of non-safety systems (RTNSS) program. The focused studies also provide insights related to the CDF and the Level 1 PRA. Sensitivities were grouped according to scope and methodology. Focus sensitivities were conducted on the Level 1 PRA model included:

- Level 1 Internal Event
- Level 1 Fire
- Level 1 Flood
- Level 1 High Wind

In performing the focus sensitivities, the systems credited in the Level 1 PRA model and identified as non-safety systems include the following:

- Diesels
- Condenser (N37),
- Condensate and Feedwater (N21),
- CRD Injection & FMCRD (C12),
- FAPCS (G21),
- RWCU/SDC (G31),
- FPS Injection (U43),
- DPS (C72),
- MSIV (B21),
- RCCW (P21),
- TCCW (P22),
- Plant Air (P51),
- Nitrogen (P54),
- Plant Service Water (P41),
- FMCRD groups' power (R12), and
- PIP buses A3 and B3 (R11).

11.3.3.1 Focus Level 1 Internal Events

In order to perform the focus and RTNSS sensitivities, fourteen flag files were generated (1) to fail all non-safety systems, (2) to fail all non-safety systems except those systems designated as RTNSS, and (3) to fail RTNSS systems one at a time with all other RTNSS equipment credited. The Level 1 focus sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 1 generated a CDF of 3.22E-04 with 471,592 cutsets; the RTNSS generated a CDF of 4.91E-06 with 550,770 cutsets. The results for the Level 1 focus sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The inclusion of the RTNSS systems in the model reduces CDF by approximately two orders of magnitude compared to crediting safety-related systems only. The Level 1 focus sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. CDF results for the Level 1 focus sensitivity are shown in Table 11.3-20.

Additional details of the focus sensitivity are provided in Table 11.3-21. These results showed changes to the distribution of initiators, accident classes, distribution of drywell water level classes or sequence contribution for both the focus and RTNSS sensitivities over the base model. The GEN initiator dominates the Level 1 focus PRA due to common cause failures to safety-related DCIS software, RPS hardware and safety-related inverters. The IORV initiator dominates for RTNSS due to common cause failures of all GDCS check valves or squib valves coupled with operator errors and common cause failures of all DPVs in conjunction with various operator errors.

A series of sensitivities were conducted on the RTNSS focus model to evaluate the impact of individual system failures on the CDF and the RTNSS focus model. In these sensitivities, an additional flag was added to the files to allow for a single RTNSS system to fail while all other RTNSS systems functioned normally. The Level 1 RTNSS sensitivities were run at a truncation of 1E-15 with the additional flag files. These RTNSS sensitivity results are contained in Table 11.3-21.

The Level 1 PRA model CDF is significantly impacted by the failure of the non-safety and RTNSS systems. RTNSS sensitivities showed the impact to CDF is reduced with the availability of the DPS system. Unavailability of DPS coupled with %T-GEN initiator and common cause failures of safety-related DCIS software or RPS failures are dominant contributors to CDF for RTNSS sensitivities with individual system failures.

11.3.3.2 Focus Level 1 Fire

In order to perform the Level 1 fire focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety systems and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 1 focus fire sensitivity was run using the base fire model at a truncation of 1E-15 with the additional flag files. The Level 1 focus fire generated a CDF of 1.15E-04; the RTNSS generated a CDF of 2.40E-07. The results for the focus fire sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The inclusion of the RTNSS systems in the model reduces CDF by approximately two orders of magnitude compared to crediting safety-related systems only. CDF results for the Level 1 focus fire sensitivity are shown in Table 11.3-22.

The Level 1 fire PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly reduces CDF. Based on the Level 1 fire focus sensitivities CDF results, the NRC goal of 1E-04/yr CDF is met for both the baseline Level 1 fire model and the RTNSS sensitivities. The focus fire case CDF does not meet the NRC goal. However, the fire analysis is very conservative with no credit for fire suppression or fire severity factors.

11.3.3.3 Focus Level 1 Flood

In order to perform the Level 1 flood focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety systems and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 1 focus flood sensitivity was run using the base model at a truncation of 1E-14 with the additional flag files. The focus Level 1 flood generated a CDF of 1.15E-05 with 88,884 cutsets; the RTNSS generated a CDF of 9.06E-9 with 45,642 cutsets. The results for the focus flood sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The inclusion of the RTNSS systems in the model reduces CDF by approximately three orders of magnitude compared to crediting safety-related systems only. CDF results for the focus Level 1 sensitivity are shown in Table 11.3-23.

The Level 1 flood PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly reduces CDF. Based on the Level 1 flood focus sensitivities CDF results, the NRC goal of 1E-04/yr CDF is satisfied.

11.3.3.4 Focus Level 1 High Wind

In order to perform the Level 1 high wind focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety systems and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 1 high wind focus sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 1 high wind generated a CDF of 1.94E-06 for tornados and hurricanes; the RTNSS generated a CDF of 1.76E-09 for tornados and hurricanes. The results for the Level 1 focus high wind sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The inclusion of the RTNSS systems in the model reduces the CDF by approximately three orders of magnitude compared to crediting safety-related systems only. CDF results for the Level 1 high wind focus are shown in Table 11.3-24.

The Level 1 high wind PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The Level 1 focus high winds sensitivity showed the CDF is dominated by hurricanes, which is consistent with the baseline PRA high winds model. The focus high winds sensitivity showed both the hurricane and total high wind CDF to increase by about three orders of magnitude with the failure of the non-safety related systems. The large tornado (F4/F5) scenario did not benefit from the RTNSS equipment availability due to the fact that this magnitude of wind has adversely impacts the buildings and structure housing the non-safety and RTNSS systems.

The availability of the RTNSS systems significantly minimizes Level 1 high wind CDF. Based on the Level 1 high wind focus sensitivities CDF results, the NRC goal of 1E-04/yr CDF is satisfied.

11.3.4 FOCUS Level 2

A focus evaluation and a series of sensitivities were conducted on the Level 2 PRA model. The intent of these focus sensitivities was to develop a better understanding of safety and regulatory treatment of non-safety systems (RTNSS) and to provide insights related to the total non-TSL (nTSL) frequency and the Level 2 PRA. Sensitivities were grouped according to scope and methodology. Focus sensitivities were conducted on the Level 2 PRA model included:

- Level 2 Focus
- Level 2 Fire
- Level 2 Flood
- Level 2 High Wind
- Level 2 DPS /ARI Sensitivity

In performing the focus sensitivities, the systems credited in the Level 2 PRA model and identified as non-safety systems include the following:

- Diesels (R21),
- Condenser (N37),
- Condensate and Feedwater (N21),
- CRD Injection & FMCRD (C12),
- FAPCS (G21),
- RWCU/SDC (G31),
- FPS Injection (U43),
- DPS (C72),
- MSIV (B21),
- RCCW (P21),
- TCCW (P22),
- Plant Air (P51),
- Nitrogen (P54),
- Plant Service Water (P41),
- FMCRD groups' power (R12),
- PIP buses A3 and B3 (R11),

11.3.4.1 Focus Level 2 Internal Events

In order to perform the focus and RTNSS sensitivities, fourteen flag files were generated (1) to fail all non-safety systems, (2) to fail all non-safety systems except those systems designated as RTNSS, and (3) to fail RTNSS systems one at a time with all other RTNSS equipment credited.

The Level 2 focus sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 2 generated a nTSL release frequency of 3.05E-04/yr and a CDF of 3.22E-04. However, the presence of multiple flags in the Level 2 cutset results causes a significant overestimation of release frequency because otherwise non-minimal cutsets are retained. Setting all Level 2 flags to TRUE and subsuming produces a total nTSL release of 1.18E-4/yr in the focus case.

The RTNSS generated a raw nTSL release frequency of 9.06E-08/yr. The results for the focus sensitivity showed significant impact to nTSL release with the failure of non-safety systems both with and without RTNSS. Results showing nTSL for the focus Level 2 sensitivity are shown in Table 11.3-25. These results showed changes to the release categories. Based on the Level 2 focus and RTNSS sensitivities, the NRC goal of 1E-06/yr LRF is met for RTNSS but exceed by the focus sensitivity. The focus Level 2 results are dominated by the BYP frequency as opposed to other release categories where passive safety-related systems are available. Additional details of the release categories for the Level 2 focus are provided in Table 11.3-26.

A series of sensitivities were conducted on the RTNSS to evaluate the impact of individual system failures on the nTSL release frequency, CDF and the RTNSS focus model. In these sensitivities, an additional flag was added to the files to allow for a single RTNSS system to fail while all other RTNSS systems functioned normally. The Level 2 RTNSS sensitivities were run at a truncation of 1E-15 with the additional flag files. For the sensitivities excluding DPS and ARI systems, the nTSL frequency increased by more that four orders of magnitude to ARI and greater than 5 orders of magnitude for DPS. In both cases the NRC goal for LRF was exceeded. These RTNSS sensitivity results are contained in Table 11.3-27.

The Level 2 PRA model nTSL frequency significantly impacted by the failure of the non-safety and RTNSS systems. RTNSS sensitivities showed the impact to nTSL.release is minimized with the availability of the DPS and ARI system. Due to the predominance of containment bypass frequency, the Level 2 PRA focus sensitivity does not meet the NRC goal of less than 1E-06/yr.

11.3.4.2 Focus Level 2 Fire

In order to perform the Level 2 fire focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 2 focus fire sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 2 fire generated a nTSL release frequency of 1.15E-04/yr and a CDF of 1.15E-04. The RTNSS generated a nTSL release frequency of 4.72E-08/yr and a CDF of 2.40E-07. The results for the focus sensitivity showed significant impact to nTSL release frequency with the failure of non-safety systems both with and without RTNSS. The results showed a two order of magnitude decrease in the nTSL frequency with the RTNSS systems available compared to safety-related systems only. Results for the focus Level 2 fire sensitivity are shown in Table 11.3-28.

The Level 2 fire PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly minimizes nTSL release. Based on the Level 2 fire focus sensitivities nTSL results, the NRC goal of 1E-06/yr LRF is met for RTNSS, but this goal is exceed for the focus Level 2 fire. The focus fire Level 2 nTSL is dominated by long-term containment heat removal (OPW2), in which limited equipment is available for ICS/PCCS pool makeup. Some other release categories such as OPW1 and OPVB are relatively unaffected because passive safety-related systems, which exhibit excellent reliability, are available. The RTNSS Level 2 fire results are dominated by OPW2, BYP and CCID release categories, yet the NRC goal is met with an order of magnitude margin. Additional details of the release categories for the Level 2 focus are provided in Table 11.29.

11.3.4.3 Focus Level 2 Flood

In order to perform the Level 2 flood focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 2 focus flood sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 2 flood generated a nTSL release frequency of 4.49E-04/yr and a CDF of 1.15E-05. The RTNSS Level 2 flood generated a nTSL release frequency of 1.23E-09/yr and a CDF of 9.06E-09. The results for the focus sensitivity showed significant impact to both nTSL and CDF with the failure of non-safety systems both with and without RTNSS. The results show that crediting RTNSS systems reduces the nTSL release frequency by over two orders of magnitude. Results for the focus Level 2 flood sensitivity are shown in Table 11.3-30.

The Level 2 flood PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly minimizes nTSL frequency. Based on the Level 2 flood focus sensitivities nTSL results, the NRC goal of 1E-06/y4 LRF is met for both focus and RTNSS. Additional details of the release categories for the Level 2 focus flood are provided in Table 11.3-31.

11.3.4.4 Focus Level 2 High Winds

In order to perform the Level 2 high winds focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The Level 2 focus high winds sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus Level 2 generated a nTSL release frequency of 3.26E-07/yr. The RTNSS generated a nTSL release frequency of 7.75E-11/yr. The results for the focus high winds sensitivities showed significant impact to nTSL with the failure of non-safety systems both with and without RTNSS. The results show that crediting the RTNSS systems reduces the nTSL release frequency by more than three orders of magnitude. Results for the focus Level 2 high winds sensitivity are shown in Table 11.3-32.

The Level 2 high winds PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly minimizes nTSL release frequency. Based on the Level 2 high winds focus sensitivities nTSL results, the NRC goal of 1E-06/yr LRF is met for both the focus and RTNSS Level 2 high winds sensitivities. Additional details of the release categories for the Level 2 high winds focus sensitivities are provided in Table 11.3-33.

11.3.4.5 DPS and ARI Sensitivity

The focus Level 2 models for the internal events, fire and flood did not meet the NRC goal 1E-06/yr for LRF. The focus Level 1 internal events and fire model did not satisfy the NRC goal of 1E-04/yr for CDF. Further results showed that the addition of DPS alone was not sufficient to meet the NRC LRF goal of 1E-06 as discussed in Section 11.3.4.1 for focus, Section 11.3.4.2 for fire and Section 11.3.4.3 for flood. Various sensitivity studies were conducted to establish which additional system(s) are required to reduce the nTSL frequency to below 1E-06/yr for all cases mentioned above.

The focus results for the Level 2 internal events and flood models satisfied the LRF goal with the condition that DPS and parts of the ARI system are credited in addition to the safety-related systems. Specifically, the portion of ARI that supports the automatic DPS backup to reactor trip is credited in an effort to reduce CDF and LRF.

The Level 1 internal events focus CDF was reduced from 3.22E-04/yr to 2.10E-05/yr and the focus fire CDF was reduced from 1.15E-4/yr to 2.54E-06/yr. The Level 2 focused internal events nTSL frequency was reduced from 1.18E-04/yr to 4.19E-07/yr and the Level 2 flood focus was reduced from 4.49E-06/yr to 3.74E-09/yr. These results are shown in Table 11.3-34.

Additional detailed results for the DPS & ARI sensitivity are contained in Table 11.3-35.

The raw results indicated that the Level 2 focus fire nTSL release frequency was reduced from 2.54E-06/yr to 1.71E-06/yr. This number does not meet the 1E-06/yr LRF goal, but significant conservatisms associated with the long-term containment heat removal model assure that the results are below 1E-06/yr. The conservatisms associated with release category OPW2, which comprises 95.5% of the nTSL results are shown below:

- Thermal-hydraulic calculations show that make-up to the ICS/PCCS pools is not actually required until post 72 hours, while the model requires make-up at 24 hours. Since all OPW2 cutsets involve failure to make-up, this is a significant point.
- Long-term containment heat removal uses the same success criteria for the PCCS as in the short term (4/6 loops). In reality, as few as one PCCS loop can successfully remove post-24 hours decay heat.
- The release category OPW2 (among other contained in “nTSL”) does not meet the definition of a “large” release from NUREG/CR-6595, Appendix A.1. Therefore, the OPW2 release frequency could be excluded from the LRF number for comparison to the 1E-06/yr NRC goal.

If, based on the conservatisms listed above, the OPW2 release category is removed from the focus fire Level 2 (with DPS and portions of ARI) results, the total nTSL release drops to 6.98E-08/yr.

The focus cases described here are able to meet the NRC goals of 1E-04/yr for CDF and 1E-06/yr for LRF by crediting the DPS and portions of ARI that support automatic DPS back up to reactor trip.

11.3.5 Focus Shutdown

A focus evaluation and a series of sensitivities were conducted on the shutdown PRA model. The intent of these focus sensitivities was to develop a better understanding of the importance of safety-related systems and those systems in the regulatory treatment of non-safety systems (RTNSS) program. Sensitivities were grouped according to scope and methodology. Focus sensitivities were conducted on the shutdown PRA model included:

- Shutdown Focus

- Shutdown Fire
- Shutdown Flood
- Shutdown High Wind

In performing the focus sensitivities, the systems credited in the shutdown PRA model and identified as non-safety systems include the following:

- Diesels (R21),
- CRD Injection & FMCRD (C12),
- FAPCS (G21),
- RWCU/SDC (G31),
- FPS Injection (U43),
- DPS (C72),
- RCCW (P21),
- TCCW (P22),
- Plant Air (P51),
- Nitrogen (P54),
- Plant Service Water (P41),
- FMCRD groups' power (R12), and
- PIP buses A3 and B3 (R11).

While these systems reflect the systems credited in the Level 1 PRA model, not all of these systems were credited in shutdown. However, the Level 1 PRA model focus flag file was used for simplification to conduct the shutdown focus sensitivities.

No additional assumptions were made beyond the baseline internal events shutdown PRA.

11.3.5.1 Focus Shutdown Internal Events

In order to perform the focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The shutdown focus sensitivity was run using the base shutdown model at a truncation of 1E-15 with the additional flag files. The focus shutdown generated a CDF of 1.99E-06/yr; the RTNSS generated a CDF of 1.33E-07/yr. The results for the focus sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The difference in CDF showed about an order of magnitude decrease in the CDF with the RTNSS systems available than without. The CDF results for the focus shutdown sensitivity are shown in Table 11.3-36.

The ESBWR shutdown PRA CDF is significantly impacted in non-safety related systems are not credited. The RTNSS program is fairly important for reducing the risk associated with the crediting only the safety systems, as shown by the reduction in CDF in the RTNSS case. However, the CDF reduction achieved by crediting RTNSS systems is not as significant as in the at-power cases, because the shutdown PRA already begins with a limited set of equipment for mitigating initiating events

Based on the shutdown focus sensitivities CDF results, the NRC goal of 1E-04/yr CDF is met for both the shutdown focus and RTNSS sensitivities. Since all shutdown CDF sequences are assumed to be direct LRF contributors, the LRF goal of 1E-06/yr is applicable as well. The RTNSS LRF meets the threshold, but the shutdown focus exceeds the threshold by about 1E-06/yr is applicable as well. The RTNSS LRF meets the threshold, but the shutdown focus exceeds the threshold by about 1E-06/yr.

A review of risk significant events from the RTNSS shutdown results shows the importance of the locked open, manual valve restoration failure that fails the FPS/FAPCS injection pathway. Further review shows the failure probability for this valve to be 4.84E-02, a conservative value that may be lowered with a MCR alarm.

11.3.5.2 Focus Shutdown Fire

In order to perform the shutdown fire focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The shutdown focus fire sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus shutdown fire generated a CDF of 2.54E-06; the RTNSS generated a CDF of 2.68E-07/yr. The results for the focus shutdown fire sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The RTNSS results for the focus shutdown fire sensitivity are shown in Table 11.3-37.

The availability of the RTNSS systems significantly minimizes shutdown fire CDF. Based on the shutdown fire focus sensitivities CDF results, the NRC goal of 1E-06/yr CDF is met for both the baseline fire and RTNSS sensitivities. Since all shutdown CDF sequences are assumed to be direct LRF contributors, the LRF goal of 1E-06/yr is met for the RTNSS case, but slightly exceeded in the focus sensitivity.

11.3.5.3 Focus Shutdown Flood

In order to perform the shutdown flood focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The focus shutdown flood generated a CDF of 9.69E-07; the RTNSS generated a CDF of 1.02E-07. The results for the focus shutdown flood sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The RTNSS results indicate a CDF reduction of approximately 90% compared to the focus case. The results for the focus sensitivity are shown in Table 11.3-38.

The shutdown flood PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The availability of the RTNSS systems significantly minimizes CDF. When compared to the full power PRA model, the impact of the non-safety versus RTNSS systems to the shutdown model CDF is less pronounced due to the already limited set of equipment available to mitigate the initiating events. In both the focus and RTNSS shutdown flood sensitivities, the results meet the NRC goal of 1E-04/yr per year for CDF and 1E-06/yr for LRF.

11.3.5.4 Focus Shutdown High Wind

In order to perform the shutdown high wind focus and RTNSS sensitivities, two flag files were generated (1) to fail all non-safety system and (2) to fail all non-safety systems except those systems designated as RTNSS. The shutdown high wind focus sensitivity was run using the base model at a truncation of 1E-15 with the additional flag files. The focus shutdown high wind generated a CDF of 2.52E-07 for tornados and hurricanes; the RTNSS generated a CDF of 2.77E-09 for tornados and hurricanes. The results for the focus high wind sensitivity showed significant impact to CDF with the failure of non-safety systems both with and without RTNSS. The RTNSS results indicate a CDF reduction of approximately 99% compared to the focus case. CDF results for the shutdown high wind focus are shown in Table 11.3-39.

The shutdown high wind PRA model is significantly impacted by the failure of the non-safety and RTNSS systems. The shutdown focus high winds sensitivity showed the CDF is dominated by hurricanes, which is consistent with the baseline high winds PRA model. The focus high winds sensitivity showed both the hurricane and total high wind CDF to increase by about two orders of magnitude with the failure of all non-safety related systems. The F4/F5 tornado CDFs were not shown to be sensitive to either the non-safety related failures or RTNSS due to the fact that this magnitude of wind has adversely impacted the buildings and structure housing the non-safety and RTNSS systems. In both the focus and RTNSS shutdown high wind sensitivities, the CDF results meet the NRC goal of 1E-04/yr CDF. Since all shutdown CDF sequences are assumed to be direct LRF contributors, the LRF goal of 1E-06/yr is met as well.

11.3.6 Transportation and Nearby Facilities Sensitivity

A series of sensitivities were conducted to evaluate other external events on the Level 1 PRA model. These types of external events include in this evaluation are as follows:

- Aircraft impact,
- Industrial accidents,
- Pipeline accidents,
- Hydrogen storage failures, and
- Transportation accidents

Each of the external events was evaluated using the Level 1 PRA model. To facilitate the quantification of the risk impact associated with transportation and nearby facilities, a number of assumptions and simplifications were made in support of the sensitivities and are shown in Table 11.3-40.

11.3.6.1 Aircraft Impact

An aircraft impact sensitivity was performed to evaluate the significance of this event on CDF and the Level 1 PRA model. The evaluation of the aircraft accidents including commercial, military and small private aircraft has been previously conducted within the industry. For the purpose of the aircraft impact sensitivity, a screening probability for aircraft accidents was calculated to be 1.52E-07/yr and is shown in Table 11.3-41 (ref. 11-1, 11-4 and 11-5). With the assumption that an aircraft impact event impacting the plant facility would result in a loss of preferred power (LOPP), the Level 1 PRA CDF for the aircraft impact would be 1.31E-14/yr. In the event that the aircraft impact results in more extensive damage of the plant site impacting all non-safety related components (equivalent to a focused PRA), a more conservative CDF value of 1.94E-11 is obtained.

The robust ESBWR design with its high redundant passive systems greatly help to mitigate the impact of these events. In addition, the NRC has an agreement with NORAD that enables reactor operators to quickly learn of imminent aviation threats and to swiftly place the reactor into a safe state.

11.3.6.2 Industrial Accidents

A sensitivity was conducted to evaluate the impact of industrial accidents from nearby facilities including the effects of chemical toxic releases and explosions such as blast pressure on the ESBWR facilities and supporting structures. To evaluate the impact of industrial accidents, a scenario involving the failure of both diesels due to the incapacitation of the air intakes by a chemical toxic release was postulated. The CDF for this scenario would be 2.03E-11 per year. A second, more conservative scenario was identified as the same failure of both diesels accompanied by the incapacitation of the operators and a turbine trip. The evaluation of this scenario resulted in a CDF of 9.24E-11/yr (ref 11-2).

11.3.6.3 Pipeline Accidents

The potential of pipeline accidents impacting the plant facility was found to pose insignificant risk. Scenarios associated with gas leaks traveling toward the facility with concentrations not favorable for deflagration or detonation were bounded by toxic gas releases. Other scenarios involving blast pressure or radiant heat resulting from large explosions or external fires are not expected to significantly impact the concrete ESBWR structures.

No credible accident scenarios from pipeline facilities were found with potential to impact the plant facilities. In addition, facility citing restrictions and protective systems (control room habitability system) further prevent pipeline accidents from posing any significant impact.

11.3.6.4 Hydrogen Storage Failures

On-site hydrogen storage facilities are assumed to follow the industry guidance associated with minimum separation distances between plant structures and the hydrogen storage units. In addition, DCD Section 20.2.2.2.8 for the “Hydrogen Gas Control System” provides additional guidance to ensure the hydrogen storage facilities present no impact to the ESBWR facility.

11.3.6.5 Transportation Accidents

Transportation accident can be divided into three types including marine (ship/barge), trucks or railroad. A transportation accident sensitivity was performed to evaluate the significance of each of these transportation events on CDF and the Level 1 PRA model.

11.3.6.5.1 Marine Accidents

A sensitivity was conducted to evaluate the impact of marine accidents on the ESBWR facilities and supporting structures. To evaluate the impact of marine accidents, a scenario involving the release of toxic chemicals to the atmosphere was postulated. The CDF for this scenario would be 1.05E-12 per year and is shown in Table 11.3-42 (ref 11-6). A second scenario was identified as an explosion that impacts the service water system resulted in a CDF of 1.03E-12/yr. Facility citing restrictions are expected to further prevent vehicle accidents from posing any significant impact.

11.3.6.5.2 Vehicle Accidents

A sensitivity was conducted to evaluate the impact of transportation accidents on the ESBWR facilities and supporting structures. For vehicle accidents, a scenario involving the release of toxic chemicals to the atmosphere was postulated. These scenarios are highly dependent upon the proximity of trucking routes and nature of the release. For a toxic chemical release, a CDF for this scenario would be 1.42E-13/yr and is shown in Table 11.3-43 (ref 11-3 & 11-6).

11.3.6.5.3 Railroad Accidents

The evaluation of the railroad accidents was conducted to determine the impact to the ESBWR facilities and supporting structures. For the purpose of the railroad accident sensitivity, a scenario in which toxic chemicals are released resulting in the incapacitation of equipment and/or personnel was postulated. The impact from this railroad accident was calculated to be 8.40E-13/yr and is shown in Table 11.3-44 (ref. 11-6). Facility citing restrictions are expected to further prevent railroad accidents from posing any significant impact.

11.3.7 Fire Sensitivity

Besides the focus fire studies included in the above sections, a series of sensitivities were conducted to determine the impact to CDF and LRF in the full-power and shutdown fire PRA models from the uncertainties in the model assumptions. The full-power fire model sensitivity studies are grouped as follows:

- Plant partitioning
- Fire risk in transition modes
- Fire ignition frequencies
- Separation criteria
- Fire barrier failure probabilities

The shutdown fire model sensitivity studies are grouped as follows:

- Fire barrier failure probabilities
- Separation criteria
- Initiating event frequencies and basic event probabilities

11.3.7.1 Plant Partitioning for Full-Power Fire Model

Plant partitioning for fire modeling is based on the fire area definitions in DCD Appendix 9A. Fire risk insights have been communicated to the design engineers in the process of fire PRA model development. One major risk insight is that DPS cabinet(s) cannot be located in N-DCIS room 3301 that also houses control cabinets for nonsafety- related systems. A fire in room 3301 could result in train A failure of all nonsafety-related systems. It also results in failure of feedwater and condensate system.

In DCD Appendix 9A, rooms 3140 and 3301 are included in fire area F3140. Changes have been requested from PRA to assign different fire areas for those rooms, which have been reflected in the fire model assumptions.

This plant partitioning fire sensitivity case was conducted to show the risk impact should the fire area definitions differ from the current assumptions.

If the DPS room is not separated from room 3301, the fire risk associated with the room 3301 will be the dominant risk contributor. The increase of CDF is about 5.80E-8/yr (or about 712% of total baseline fire CDF). The increase in LRF is not as significant as CDF since the majority of the increase comes from the TSL sequences. The increase in LRF is about 8.12E-10/yr (or 168% of total baseline fire LRF).

If room 3301 is not separated from room 3140, moderate risk increase is calculated. The fire risk associated with the room 3301 will have an increase in CDF of about 1.33E-9/yr (or about 14% of total baseline fire CDF). The increase in LRF is not as significant as CDF since the majority of the increase comes from the TSL sequences. The increase in LRF is about 1.66E-11/yr (or 3% of total baseline fire LRF).

In summary, DPS is critical in mitigating the fire risks, which warrants the separation of the DPS cabinet(s) from other cabinets in room 3301. The risk increases associated with the merging rooms 3301 and 3140 into one single fire area are moderate. In both cases, the resulting total fire risks are still at least three orders of magnitudes lower than the threshold values (1.E-4/yr for CDF and 1.E-6/yr for LRF).

11.3.7.2 Fire Risk in Transition Modes

Under the full-power (mode 1) condition, the drywell and containment fire area F1170 is inerted. Therefore, the fire risk associated with a fire in fire area F1170 during full-power condition (Mode 1) is not evaluated. A special fire scenario is assumed for fire area F1170 in Mode 2, 3 or 4.

Technical Specification treatment of systems in Mode 2, 3 or 4 is the same for all credited systems in Mode 1. The plant is assumed to respond to a transient in these modes just as it will in Mode 1. Therefore, the Mode 1 PRA model is assumed to be applicable to all modes 1 through 4.

In Mode 2, 3, or 4, the containment will have a short period when it is de-inerted. It is assumed that the de-inerted period is 48 hours per refueling cycle. For sensitivity study purpose, it is conservatively assumed that the containment could have a fire that result in a plant trip during this period. It should be noted that the fire ignition sources inside the containment are limited since all the control cables inside the containment are normally de-energized. There is no other ignition source except transient loads, which are highly unlikely to exist in this fire area in Modes 1 through 4.

The fire ignition frequency for fire area F1170 is only applicable to a short period when the containment is de-inerted during Modes 1 though 4 (assumed to be 48 hours per refueling cycle). Including cables as ignition sources, an averaged fire frequency of 1.58E-6 /yr is calculated for fire area F1170. Since the cables will be typically de-energized, a less conservative F1170 fire ignition frequency based on transient bin (#7) only is 2.05E-7 /yr.

In this sensitivity study, a fire-induced inadvertent opening of relief valve initiating event is assumed for F1170. This is conservative since the hot shorts of the cables are unlikely under de-energized condition. All the fire-susceptible components located inside the drywell and containment are assumed to be damaged by the postulated fire, which is physically unreasonable. The upper drywell is well separated from the lower drywell although they are connected. The upper drywell is spacious and divisional separation of safety-related components and control cables are ensured by design requirements. A single fire that can induce failure to all components in the containment/drywell area is physically unreasonable.

Nevertheless, this physically unreasonable scenario is constructed for sensitivity study purpose and to demonstrate the importance of separation criteria for the components and their associated cables inside the upper and lower drywells.

With an averaged fire frequency of 1.58E-6 /yr, the fire CDF from F1170 is calculated to be 1.53E-9/yr (or 19% of the total baseline fire CDF). With the conservative assumption on the failure of all components in the containment/drywell area, all F1170 CDF is LRF (release category CCID with GDCS deluge system failed). This leads to a contribution of LRF of 1.53E-9/yr from F1170 (or 317% of the total baseline fire LRF).

A review of the cutset file shows that about 60% of the cutsets have event “R10-LOSP-EPRI,” which models the consequential LOPP. Since the plant is already in a transition to shutdown mode, the grid is prepared for the loss of the output from the nuclear power plant. Therefore, this failure is not applicable to this fire sequence. With the adjustment, the increase in CDF due to F1170 is 6.16E-10/yr (or 8% of total baseline fire CDF). The LRF increase due to F1170 is also 6.16E-10/yr (or 127% of total baseline fire LRF).

With an averaged fire frequency of 2.05E-7 /yr, the fire CDF and LRF from F1170 are both calculated to be 7.895E-11/yr (or 1% of total baseline fire CDF and 16% of total baseline total fire LRF).

Since the total baseline fire CDF and LRF values are at least three orders of magnitudes below the thresholds values (1.E-04/yr for CDF and 1.E-06/yr for LRF), the increases due to F1170 are not significant.

11.3.7.3 Fire Ignition Frequencies for Full-Power Fire Model

The following cases are constructed for the sensitivity studies on fire ignition frequencies for full-power fire models.

- All fire initiating event frequencies increased by a factor of 2;
- All fire initiating event frequencies reduced by a factor of 2;
- The main control room fire initiating event (%F3270) includes main control boards, which results in a new frequency of 5.97E-3/yr;
- In the ignition source data sheets, recounts Bin 15 number based on the assumption that all high energy cabinets (480V and higher) would have 4 vertical sections and each counted as one cabinet.

The first case is not credible since the total fire frequency for the plant would be about 0.45/yr, which exceeds the total fire frequency of 0.299/yr in NUREG/CR-6850. The fire CDF and LRF values are increased to 1.63E-08/yr and 9.67E-10/yr, respectively. With such conservative fire ignition frequencies, the fire CDF and LRF values are still about four orders of magnitudes below the NRC thresholds (1E-4/yr for CDF and 1E-6/yr for LRF).

The second case may reflect the actual ESBWR plant fire ignition frequencies more closely. The ESBWR plant has less active components than the traditional plants. Since the fire ignition frequency calculations are basically partitioning the fire ignition source bins, it is reasonable to assume that the non-PRA components that are located in the screened fire areas would significant reduce the fire ignition frequencies calculated in the fire analysis. This case results in a total fire CDF of 4.07E-09/yr and a total fire LRF of 2.42E-10/yr.

The third case demonstrates that the fire risk increase is negligible with the main control boards bin included in the MCR fire ignition frequency calculation. In the baseline fire ignition frequency calculation, the main control room (MCR) fire ignition frequency (%F3270) does not include the main control boards since the ESBWR MCR is totally different from the traditional plant design. Only display units are included in the MCR and all other control cabinets are in the DCIS rooms. Based on the new calculation for this sensitivity case, a fire ignition frequency of 5.97E-3/yr is obtained for %F3270, which is about 60% higher than the baseline value. This results in an increase in total fire CDF of 2.10E-11/yr (or 0.3%) and an increase in total fire LRF of 4.04E-12/yr (or 0.8%), which is negligible.

The high energy switchgears (480V and higher) have been identified for Bin 16 counts. It is assumed in the fourth sensitivity case that each high energy switchgear (480V and above) would be counted as 4 cabinets in Bin 15. There are 44 high energy switchgears identified in Bin 15 counts. Therefore, 132 additional cabinet counted are added to the subject fire areas. This change leads to the redistribution of the fire ignition frequencies. As a result, the total fire CDF is reduced by 3.0E-10/yr (or 3.7%) from the baseline CDF to 7.84E-09/yr. The total LRF is also reduced by 1.51E-11/yr (or 3.1%) to 4.68E-10/yr. This demonstrates that the fire ignition frequency calculations without counting the additional high energy switchgear cabinets are slightly more conservative.

11.3.7.4 Separation Criteria for Full-Power Fire Model

This sensitivity case is constructed to investigate the sensitivity of fire risk to separation criteria on the nonsafety-related systems. Turbine building general area (fire area F4100) is investigated specifically since the simplified cable routing conservatively assumes that the majority of cables in the turbine building have to pass through this area. The baseline case for F4100 scenario assumes that a fire in F4100 would not result in the failure associated with cable routing for the RCCW and PSW systems. This is a reasonable assumption since these two systems are RTNSS and no single fire should impact both trains. In this sensitivity study, the following cases are constructed:

- Case 1: Assume that a fire in F4100 will induce failure to both trains of RCCW and PSW systems.
- Case 2: Assume that the instrument air (IA) system cables are also protected. A fire in F4100 will not induce failure to RCCW, PSW or IA systems.

- Case 3: Assume that a fire in F4100 will not induce failure to train A of RCCW and PSW systems.
- Case 4: Assume that a fire in F4100 will not induce failure to train B of RCCW and PSW systems.

The CDF increases for the above four cases are as follows:

- Case 1: 2.60E-09/yr (or 32.0% of the baseline total fire CDF)
- Case 2: 0.00E+00/yr (no change from the baseline total fire CDF)
- Case 3: 2.90E-11/yr (or 0.4% of the baseline total fire CDF)
- Case 4: 3.02E-11/yr (or 0.4% of the baseline total fire CDF)

The LRF increases for the above four cases are as follows:

- Case 1: 6.58E-10/yr (or 136.2% of the baseline total fire LRF)
- Case 2: 0.00E+00/yr (no change from the baseline total fire LRF)
- Case 3: 2.29E-12/yr (or 0.5% of the baseline total fire LRF)
- Case 4: 2.39E-12/yr (or 0.5% of the baseline total fire LRF)

The results clearly demonstrate the importance of the RTNSS requirements for RCCW and PSW systems to ensure separation criteria. The separation criteria applied to instrument air system has negligible impact on the full-power fire model. It should be noted that even without the separation criteria implemented for RCCW and PSW systems, the fire risk CDF and LRF are still three orders of magnitudes lower than the NRC thresholds (1E-04/yr for CDF and 1E-06/yr for LRF).

11.3.7.5 Fire Barrier Failure Probability for Full-Power Fire Model

This sensitivity case is constructed to investigate the sensitivity of fire risk to the failure probabilities of fire barriers. Fire propagation scenarios have been modeled for the full-power Level 1 and Level 2 fire models. For risk-significant fire areas, typically the exposing area and exposed areas are reversed to construct two fire propagation scenarios. Some fire propagation cases do not have their reversed scenarios. These cases are not significant risk contributors. The inclusion of some cases is simply to demonstrate that these postulated fire propagation scenarios are not risk significant (especially the ones change the corresponding initiating event from general transient to T-IORV). It is not intended to postulate all potential fire propagation scenarios.

To report the importance of these fire barriers, a recovery rule file has been used to add the fire barrier failure events to the merged cutset files.

Based on the baseline full-power fire CDF results, the fire barrier importance measures are reported in Table 11.3-45, which shows two risk important fire barriers based on the full-power CDF cutsets:

- Fire barrier between fire areas FDPS and F3301 (DPS room and N-DCIS room 3301)
- Fire barrier between fire areas F9150 and F9160 (the cable tunnels)

Fire areas FDPS and F3301 are separated by walls and a fire door since the DPS room is enclosed by room 3301. The most vulnerable fire barrier is the fire door. Fire areas F9150 and F9160 are cable tunnels that are mostly separated by walls except at the access point. It is impossible for a fire to start at the access point and propagate to both cable tunnels since there should not have much combustible along the path to fuel the fire propagation.

Based on the baseline full-power fire LRF (nTSL releases) results, the fire barrier importance measures are reported in Table 11.3-46. The fire propagation scenarios have more significant impact on the LRF results since they defeat more redundancy and result in more severe release categories instead of the TSL release. Almost a quarter of total LRF is contributed from the fire propagation scenarios. Table 11.3-46 above shows the following risk important fire barriers based on LRF cutsets:

- Fire barrier between fire areas F9160 and F9150 (the cable tunnels),
- Fire barrier between fire areas F1321 and F1220 (Div II electrical equipment room and Div II battery room),
- Fire barrier between fire areas F1341 and F1160 (Div IV electrical equipment room and the non-divisional commodity chase D that are connected to RWCU/SDC valve room B),
- Fire barrier between fire areas F1230 and F1220 (Div II and III battery rooms),
- Fire barrier between fire areas F1240 and F1220 (Div II and IV battery rooms), and
- Fire barrier between fire areas FDPS and F3301 (DPS room and N-DCIS room 3301),
- Fire barrier between fire areas F1220 and F1162 (Div II battery room and the non-divisional commodity chase B that are connected to RWCU/SDC heat exchanger room).

To perform online maintenance, some of the fire doors may be open for access or other purposes. This is not modeled in the baseline ESBWR fire PRA model. The risk increases associated with the open fire doors will be controlled by the plant's risk management program of 10CFR50.65(a)(4) when the plant is in operation.

This sensitivity study also investigates the potential fire risk increases associated with the risk important fire barriers. It should be noted that the risk important fire barriers based on the CDF cutsets are a subset of the risk important fire barriers based on LRF cutsets.

Tables 11.3-47 and 11.3-48 show the risk impact when the fire barriers are assumed to be failed and with a failure probability of 0.1. The calculations with fire barrier failed are based on the RAW values. The calculations for failure probability of 0.1 are performed by increasing probability of the subject fire barrier failure event in the cutset files.

Tables 11.3-49 and 11.3-50 indicate that the risk increases associated with several fire barrier failures are significant. However, even with the most limiting case (breached fire barrier between the cable tunnels), the fire risk is still at least two orders of magnitudes below the NRC threshold values (1E-04/yr for CDF and 1E-06/yr for LRF). Note the results in the above tables do not take credit for fire suppression and fire severity factors. If a screening value of 0.1 is used for these two additional factors, the most limiting fire CDF and LRF will be at least four orders of magnitudes lower than the NRC thresholds.

Tables 11.3-47 and 11.3-48 indicate that the risk increases associated with several fire barrier failures are significant. However, even with the most limiting case (breached fire barrier between the cable tunnels), the fire risk is still at least two orders of magnitudes below the NRC threshold values (1E-4/yr for CDF and 1E-6/yr for LRF). Note the results in the above tables do not take credit for fire suppression and fire severity factors. If a screening value of 0.1 is used for these two additional factors, the most limiting fire CDF and LRF will be at least four orders of magnitudes lower than the NRC thresholds.

The risk importance measures for the fire barriers will be used to implement design requirements to mitigate their fire risk impact.

11.3.7.6 Fire Barrier Failure Probability for Shutdown Fire Model

This sensitivity case is constructed to investigate the sensitivity of the shutdown fire risk to the failure probabilities of fire barriers. Based on the baseline shutdown fire CDF results, the fire barrier importance measures are reported in Table 11.4-49, which shows two risk important fire barriers:

- Fire barrier between fire areas F1152 and F1162 (two RWCU/SDC pump rooms)
- Fire barriers between fire areas F3301 and F3302 (two N-DCIS rooms)

As discussed in the qualitative screening task for shutdown fire (Section 12.6.2), the fire propagation scenario for fire areas F1152 and F1162 is extremely conservative since a fire has to pass through multiple normally closed non-fire doors, two access tunnels, two corridor areas and the fire door separating the two fire areas. This postulated fire propagation is highly unlikely. Fire barrier between F3301 and F3302 has a RAW value greater than 2.0. However, its FV value is very low.

During an outage, some of the fire doors may be open for access or other purposes. This is not modeled in the baseline ESBWR fire PRA model. The risk increases associated with the open fire doors will be controlled by the plant’s risk management program of 10CFR50.65(a)(4).

Table 11.4-50 shows the shutdown fire risk increases by setting the fire barrier failure probabilities to either 1.0 or 0.1. The calculations with a failure probability of 0.1 are performed for the screening purpose. A fire watch will be posted when the maintenance is performed with the fire door open. Whether the fire watch is a roving watch or a continuous watch with capability to communicate to the control room cannot be defined at this time since the ESBWR plant is in design certification phase and no detailed procedures are available. However, a screen value of 0.1 is sufficient to demonstrate the potential risk impact of the fire barrier failure associated with a fire watch.

For shutdown fire analysis, all CDF sequences are assumed to be contributors to LRF. However, even for the LRF threshold of 1E-6/yr, the most limiting fire barrier failure is at least one order of magnitude lower. Note the results in the above tables do not take credit of fire suppression and fire severity factors. If a screening value of 0.1 is used for these two additional factors, the most limiting fire CDF and LRF will be at least three orders of magnitudes lower than the NRC thresholds.

Moreover, for fire propagation between F3301 and F3302, the screen value of 0.1 for the failure of a fire watch is still very conservative. Between these two fire areas, there is another fire area F3100. Opening fire doors from F3301 and F3302 to F3100 at the same time should not be allowed under any circumstance. With one fire door open and the other one intact, the failure probability for the modeled fire barrier would be 7.4E-3 without credit of a fire watch. This will lead to a shutdown CDF of 2.77E-8/yr, or a 2% increase.

The risk importance measures for the fire barriers will be used to implement design requirements to mitigate their fire risk impact.

11.3.7.7 Separation Criteria for Shutdown Fire Model

This sensitivity case is constructed to investigate the sensitivity of the shutdown fire risk to the separation criteria, especially in the turbine building general area (F4100). Almost two third of the total shutdown CDF is coming from the postulated fire in this fire area. With the RTNSS requirements, RCCW and PSW cables are assumed to be separate and protected or routed outside of fire area F4100.

Without the separation criteria for RTNSS systems, the shutdown fire risk in fire area F4100 would result in an increase of 8.52E-8/yr (or 314% of the baseline shutdown fire CDF). This case clearly demonstrates the necessity of separation requirements for the RTNSS systems.

In contrast, if the instrument air system cables are routed outside fire area F4100 or protected with 3-hour fire barriers, a fire in F4100 will not result in a shutdown initiating event, which then can be qualitatively screened. In this case, the shutdown fire CDF will be reduced to 8.15E-9/yr.

Similarly, separation criteria for PSW trains should also be implemented in fire area F7300 since PSW system is RTNSS. With two PSW trains separated, only a fire big enough to propagate and damage all PSW components would result in a shutdown initiating event. Assuming a probability of 0.1 for the fire propagation, the F7300 initiating event frequencies are updated as follows:

%F7300sensitivity= ½ * %F7300baseline * 0.1

Table 11.3-51 shows the results with the modified F7300 initiating event frequencies.

With the assumed separation criteria implemented for fire area F7300 and exclude the F4100 contribution by assuming that the instrument air system cable will meet separation criteria, the shutdown fire CDF can be further reduced to 1.00E-9/yr.

In summary, the separation criteria required for the ESBWR plant design is extremely important to shutdown fire risk. Without taking credit for the separation and protection of RCCW and PSW cables in the turbine building general area (F4100), the shutdown fire risk increases by 8.52E-8/yr (or 314% from the baseline shutdown fire CDF). On the other hand, when the separation criteria is also applied to the instrument air systems and the plant service water area (F7300), the shutdown fire CDF can be reduced to 1.00E-9/yr, which is five orders of magnitudes below the NRC CDF threshold (1E-4/yr) and three orders of magnitudes below the NRC LRF threshold (1E-6/yr) by assuming all shutdown fire CDF contributes to LRF.

11.3.7.8 Initiating Event Frequencies and Basic Event Probabilities for Shutdown Fire Model

This sensitivity case is constructed to investigate the sensitivity of the shutdown fire risk to the initiating event frequencies and some basic event failure probabilities. To demonstrate the conservatism in the baseline shutdown fire model, the shutdown fire ignition frequency for fire area F4100 (turbine building general area) and the failure probability of basic event G21-BV_-RE-F334 are investigated.

In the baseline shutdown fire model, 50% of turbine building fire during shutdown is assumed to be applicable to the turbine building general area (fire area F4100), this is conservative since the turbine building has more than 30 fire areas. However, F4100 does cover large areas in the turbine building.

For sensitivity study, assuming that 25% of turbine building fire during shutdown is applicable to the turbine building general area (fire area F4100), the total shutdown fire CDF reduction would be 9.49E-09/yr (or 35% of the baseline shutdown fire CDF).

In the baseline shutdown fire CDF cutset file, basic event G21-BV_-RE-F334 (MISPOSITION OF VALVE F334) has a FV value of 0.736, which is the most risk important basic event. The failure probability for this event is 4.84E-02 with a test interval greater than 8640 hours.

It has been proposed to add monitoring and alarm to this valve, so the valve position will be monitored continuously. With this design change, the type code for the postulated valve F334 failure should be "MANUAL VALVE PLUGS/TRANSFERS CLOSED" with a failure rate of 3E-08/hour. That results in a failure probability of 7.2E-07 for 24 hours. This would be consistent with other normally locked open manual valves with alarm and indication in the main control room.

With a probability of 7.2E-07 for basic event G21-BV_-RE-F334, the shutdown fire CDF is reduced to 7.162E-9/yr (or a reduction of 73% from the baseline shutdown fire CDF).

By removing conservatism in both F4100 fire ignition frequency and the basic event G21-BV_-RE-F334 probability as discussed above, a new shutdown fire CDF is calculated as 4.755E-09/yr (or a reduction of 82.5% from the baseline shutdown fire CDF).

In summary, the shutdown fire PRA model is very conservative with some conservatism inherited from the shutdown PRA model. By removing conservatism associated with the F4100 fire ignition frequency and / or the failure probability for basic event G21-BV_-RE-F334 (MISPOSITION OF VALVE F334), the shutdown fire CDF value can be reduced significantly.

Table 11.3-1
Level 1 Sensitivity – Base Model - Detailed Model Results

Initiator Distribution	Level 1 Base Model
BOC	3.05E-10
LOCA	1.06E-09
LOPP	1.41E-09
FDW	2.28E-09
DHR	4.58E-10
IORV	4.45E-09
GEN	2.24E-09
Total	**1.22E-08**
Class Distribution	Level 1 Base Model
cdi	46.12%
cdii	0.35%
cdiii	36.99%
cdiv	15.35%
cdv	1.20%
Drywell Water Level Classes	Level 1 Base Model
DWL-L	55.70%
DWL-M	0.82%
DWL-H	5.00%
Other	38.48%
Top Sequences	Level 1 Base Model
AT-T-FDW013	3.00%
AT-T-FDW015	0.92%
AT-T-GEN021	7.20%
AT-T-GEN023	10.70%
AT-T-GEN026	2.03%
AT-T-IORV009	1.30%
AT-T-LOPP013	5.57%
BOC-FDWA027	0.64%
LL-S050	0.69%
LL-S-FDWB045	4.30%
T-FDW050	9.35%

Table 11.3-1

Level 1 Sensitivity – Base Model - Detailed Model Results

Top Sequences	Level 1 Base Model
T-FDW060	0.72%
T-FDW061	2.66%
T-GEN067	1.38%
T-IORV017	5.39%
T-IORV018	7.39%
T-IORV063	16.90%
T-IORV065	5.70%
T-LOPP050	3.51%
T-LOPP061	1.57%

Table 11.3-2

Level 1 Sensitivity – Human Reliability – CDF

Truncation	Level 1 Base Model		ALL_T		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF (%)	RAW
1.00E-13	8028	1.066E-08	8028	6.245E-07	5.76E+01	58.58
1.00E-14	45518	1.180E-08	45518	6.259E-07	5.20E+01	53.04
1.00E-15	173798	1.220E-08	173255	6.265E-07	5.04E+01	51.35

Truncation	Level 1 Base Model		ALL_F		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF	FV
1.00E-13	8028	1.066E-08	8030	2.570E-09	-7.59E-01	0.759
1.00E-14	45518	1.180E-08	45528	2.832E-09	-7.60E-01	0.760
1.00E-15	173798	1.220E-08	1773307	2.906E-09	-7.62E-01	0.762

Truncation	Level 1 Base Model		PRE_T		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF	RAW
1.00E-13	8028	1.066E-08	8028	3.595E-07	3.27E+01	33.72
1.00E-14	45518	1.180E-08	45518	3.609E-07	2.96E+01	30.58
1.00E-15	173798	1.220E-08	173255	3.614E-07	2.86E+01	29.62

Truncation	Level 1 Base Model		PRE_F		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF	FV
1.00E-13	8028	1.066E-08	8296	6.292E-09	-4.10E-01	0.410
1.00E-14	45518	1.180E-08	47264	6.845E-09	-4.20E-01	0.420
1.00E-15	173798	1.220E-08	181528	7.040E-09	-4.23E-01	0.423

Truncation	Level 1 Base Model		POST_T		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF	RAW
1.00E-13	8028	1.066E-08	8497	5.304E-08	3.98E+00	4.98
1.00E-14	45518	1.180E-08	48383	5.474E-08	3.64E+00	4.64
1.00E-15	173251	1.220E-08	188605	5.537E-08	3.54E+00	4.54

Truncation	Level 1 Base Model		POST_F		Results	
	# Cutsets	CDF	# Cutsets	CDF	Diff CDF	FV
1.00E-13	8028	1.066E-08	8028	4.482E-09	-5.80E-01	0.580
1.00E-14	45518	1.180E-08	45518	5.027E-09	-5.74E-01	0.574
1.00E-15	173251	1.220E-08	173255	5.220E-09	-5.72E-01	0.572

Table 11.3-3

Level 1 Sensitivity – Human Reliability – Detailed Model Results

Initiator Distribution	Base Model	ALL F	ALL T	POST F	POST T	PRE F	PRE T
BOC	3.05E-10	1.90E-10	1.84E-09	2.19E-10	9.93E-10	2.70E-10	1.10E-09
LOCA	1.06E-09	2.10E-10	2.53E-08	4.39E-10	4.02E-09	7.37E-10	1.65E-08
LOPP	1.41E-09	5.27E-10	9.11E-09	9.38E-10	3.97E-09	9.35E-10	9.46E-09
FDW	2.28E-09	2.40E-10	3.26E-08	9.66E-10	9.10E-09	1.51E-09	3.05E-08
DHR	4.58E-10	2.72E-10	7.14E-09	2.93E-10	1.98E-09	3.53E-10	2.20E-09
IORV	4.45E-09	7.74E-11	5.08E-07	8.98E-10	2.49E-08	1.58E-09	2.90E-07
GEN	2.24E-09	1.39E-09	4.15E-08	1.47E-09	1.04E-08	1.65E-09	1.17E-08
Total	**1.22E-08**	2.91E-09	6.26E-07	5.22E-09	5.54E-08	7.05E-09	3.61E-07
Class Distribution	Base Model	ALL F	ALL T	POST F	POST T	PRE F	PRE T
cdi	46.12%	5.39%	68.11%	29.52%	54.64%	41.54%	73.38%
cdii	0.35%	0.26%	0.99%	0.41%	13.16%	0.19%	0.25%
cdiii	36.99%	25.49%	30.48%	31.67%	27.92%	29.66%	25.77%
cdiv	15.35%	64.37%	0.31%	35.86%	3.38%	26.56%	0.53%
cdv	1.20%	4.49%	0.12%	2.54%	0.89%	2.05%	0.07%
Drywell Water Level Classes	Base Model	ALL F	ALL T	POST F	POST T	PRE F	PRE T
DWL-L	55.70%	68.21%	67.13%	60.75%	52.66%	60.98%	72.06%
DWL-M	0.82%	0.21%	0.49%	0.74%	0.73%	0.82%	0.49%
DWL-H	5.00%	1.44%	0.80%	3.96%	4.67%	6.31%	1.40%
Other	38.48%	30.15%	31.57%	34.56%	41.94%	31.89%	26.06%
Top Sequences	Level 1 Base Model	ALL F	ALL T	POST F	POST T	PRE F	PRE T
AT-T-FDW012	NA	NA	NA	NA	0.84%	NA	NA
AT-T-FDW013	3.00%	2.72%	0.52%	7.01%	0.66%	1.12%	0.90%
AT-T-FDW015	0.92%	3.86%	NA	2.15%	NA	1.59%	NA
AT-T-GEN020	NA	NA	NA	NA	9.81%	NA	NA
AT-T-GEN021	7.20%	2.69%	6.04%	2.81%	7.73%	3.28%	2.06%
AT-T-GEN023	10.70%	44.90%	0.21%	25.00%	2.36%	18.50%	0.36%
AT-T-GEN024	NA	1.05%	NA	NA	NA	NA	NA
AT-T-GEN026	2.03%	8.51%	NA	4.75%	NA	3.51%	NA
AT-T-IORV008	NA	NA	NA	NA	1.84%		NA
AT-T-IORV009	1.30%	NA	1.13%	NA	1.44%	NA	0.37%
AT-T-IORV011	NA	0.91%	NA	NA	NA	NA	NA
AT-T-LOPP013	5.57%	15.70%	NA	13.00%	1.23%	6.47%	NA
AT-T-LOPP015	NA	1.15%	NA	0.64%	NA	NA	NA
AT-T-SW004	NA	0.90%	NA	NA	NA	NA	NA
BOC-FDWA027	0.64%	2.64%	NA	1.51%	NA	1.09%	NA

Table 11.3-3

Level 1 Sensitivity – Human Reliability – Detailed Model Results

Top Sequences	Level 1 Base Model	ALL F	ALL T	POST F	POST T	PRE F	PRE T
BOC-FDWA029	NA	0.88%	NA	NA	NA	NA	NA
BOC-FDWB054	NA	0.77%	NA	NA	NA	NA	NA
BOC-RWCU015	NA	NA	NA	NA	0.56%	NA	NA
BOC-RWCU051	NA	1.51%	NA	0.84%	NA	NA	NA
LL-S047	NA	NA	0.72%	NA	NA	NA	0.62%
LL-S050	0.69%	2.92%	NA	1.62%	NA	1.20%	NA
LL-S-FDWA013	NA	NA	0.40%	0.90%	0.69%	NA	NA
LL-S-FDWB045	4.30%	NA	0.40%	2.33%	4.52%	5.73%	0.69%
ML-L011	NA	NA	NA	NA	0.54%	NA	NA
ML-L013	NA	2.45%	NA	1.36%	1.01%	NA	NA
ML-L013	NA	NA	NA	NA	NA	NA	NA
ML-L013	NA	NA	NA	NA	NA	NA	NA
ML-L014	NA	0.65%	NA	NA	NA	NA	NA
RVR-014	NA	0.57%	NA	NA	NA	NA	NA
SL-L068	NA	NA	0.21%	NA	NA	NA	NA
SL-S017	NA	NA	NA	NA	NA	NA	1.15%
SL-S018	NA	NA	NA	NA	NA	NA	0.38%
SL-S063	NA	NA	1.34%	NA	0.70%	NA	NA
SL-S063	NA	NA	NA	NA	NA	NA	NA
SL-S065	NA	NA	0.45%	NA	NA	NA	NA
T-FDW003	NA	NA	0.48%	NA	NA	NA	NA
T-FDW050	9.35%	NA	2.60%	5.06%	9.87%	12.10%	4.51%
T-FDW060	0.72%	NA	NA	1.69%	NA	NA	1.52%
T-FDW061	2.66%	NA	1.12%	NA	3.34%	4.10%	0.67%
T-GEN004	NA	NA	0.30%	NA	NA	NA	NA
T-GEN021	NA	NA	NA	0.95%	NA	NA	1.16%
T-GEN022	NA	NA	NA	NA	NA	0.75%	0.39%
T-GEN067	1.38%	NA	1.13%	NA	2.09%	2.25%	NA
T-GEN069	NA	NA	0.49%	NA	0.74%	0.87%	NA
T-IORV017	5.39%	0.85%	NA	12.30%	NA	NA	51.50%
T-IORV018	7.39%	NA	NA	4.06%	NA	4.40%	17.20%
T-IORV063	16.90%	NA	60.00%	NA	31.50%	12.80%	8.40%
T-IORV065	5.70%	NA	20.00%	NA	10.50%	4.32%	2.82%
T-LOPP050	3.51%	NA	0.83%	1.85%	3.89%	4.09%	1.44%
T-LOPP061	1.57%	1.06%	0.37%	1.55%	1.43%	1.79%	NA

Table 11.3-4

Level 1 Sensitivity - CDF Results

Truncation	Level 1 Base Model		CCF		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8028	1.907E-11	5.58E+02
1.00E-14	45518	1.180E-08	45518	2.090E-11	5.64E+02
1.00E-15	173798	1.220E-08	173255	2.185E-11	5.57E+02

Truncation	Level 1 Base Model		SLCS		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	7914	9.298E-09	1.46E-01
1.00E-14	45518	1.180E-08	45318	1.043E-08	1.31E-01
1.00E-15	173798	1.220E-08	173005	1.084E-08	1.25E-01

Truncation	Level 1 Base Model		SRV CCFs		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8028	1.066E-08	0.00E+00
1.00E-14	45518	1.180E-08	45518	1.180E-08	0.00E+00
1.00E-15	173798	1.220E-08	173255	1.220E-08	0.00E+00

Truncation	Level 1 Base Model		SPC/LPCI Pumps		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8296	1.073E-08	6.57E-03
1.00E-14	45518	1.180E-08	47264	1.190E-08	8.47E-03
1.00E-15	173798	1.220E-08	181528	1.232E-08	9.84E-03

Truncation	Level 1 Base Model		Turbine Bypass		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8028	1.066E-08	0.00E+00
1.00E-14	45518	1.180E-08	45518	1.180E-08	0.00E+00
1.00E-15	173798	1.220E-08	173255	1.220E-08	0.00E+00

Truncation	Sens_LOCA		Sens_LOCA_x2		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8497	1.191E-08	1.17E-01
1.00E-14	45518	1.180E-08	48383	1.313E-08	1.13E-01
1.00E-15	173251	1.220E-08	188605	1.357E-08	1.12E-01

Table 11.3-4

Level 1 Sensitivity - CDF Results

Truncation	Sens_LOCA		Sens_LOCA_ICS		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8028	1.066E-08	0.00E+00
1.00E-14	45518	1.180E-08	45518	1.180E-08	0.00E+00
1.00E-15	173251	1.220E-08	173255	1.220E-08	0.00E+00
Truncation	Level 1 Base Model		CRD Injection		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8030	1.066E-08	0.00E+00
1.00E-14	45518	1.180E-08	45528	1.180E-08	0.00E+00
1.00E-15	173798	1.220E-08	1773307	1.220E-08	0.00E+00
Truncation	Level 1 Base Model		Accumulator		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	202392	5.416E-06	5.07E+02
Truncation	Level 1 Base Model		Vacuum Breaker		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8241	1.167E-08	9.47E-02
1.00E-14	45518	1.180E-08	48786	1.289E-08	9.24E-02
1.00E-15	173798	1.220E-08	203617	1.336E-08	9.51E-02

Table 11.3-5

Level 1 Sensitivity – Common Cause Factors – Detailed Model Results

Initiator Distribution	Level 1 Base Model	CCF
BOC	3.05E-10	5.08E-12
LOCA	1.06E-09	1.64E-11
LOOP	1.41E-09	0.00E+00
FDW	2.28E-09	0.00E+00
DHR	4.58E-10	3.99E-14
IORV	4.45E-09	3.14E-13
GEN	2.24E-09	0.00E+00
Total	**1.22E-08**	2.18E-11

Class Distribution	Level 1 Base Model	CCF
cdi	46.12%	75.03%
cdii	0.35%	1.70%
cdiii	36.99%	0.00%
cdiv	15.35%	0.00%
cdv	1.20%	23.27%

Drywell Water Level Classes	Level 1 Base Model	CCF
DWL-L	55.70%	0.00%
DWL-M	0.82%	0.00%
DWL-H	5.00%	75.10%
Other	38.48%	24.90%

Top Sequences	Level 1 Base Model	CCF
AT-LOCA004	NA	0.00%
AT-T-FDW013	3.00%	NA
AT-T-FDW015	0.92%	NA
AT-T-GEN021	7.20%	NA
AT-T-GEN023	10.70%	NA
AT-T-GEN026	2.03%	NA
AT-T-IORV009	1.30%	NA
AT-T-LOPP013	5.57%	NA
BOC-FDWA027	0.64%	NA
BOC-RWCU049	NA	14.20%
BOC-RWCU015	NA	8.00%
BOC-RWCU046	NA	1.09%
LL-S050	0.69%	NA
LL-S-FDWB012	NA	0.08%
LL-S-FDWB045	4.30%	NA
RVR-014	NA	75.10%
T-FDW050	9.35%	NA
T-FDW060	0.72%	NA
T-FDW061	2.66%	NA
T-GEN067	1.38%	NA
T-IORV015	NA	0.76%
T-IORV017	5.39%	NA
T-IORV018	7.39%	NA
T-IORV030	NA	0.05%
T-IORV031	NA	0.63%
T-IORV063	16.90%	NA
T-IORV065	5.70%	NA
T-LOPP050	3.51%	NA
T-LOPP061	1.57%	NA
T-SW002	NA	0.18%

Table 11.3-6

Level 1 Sensitivity – Squib Valves – CDF Results

Truncation	Base Level 1 Model		All SQV x10		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	22897	4.887E-08	3.58E+00
1.00E-14	45518	1.180E-08	102776	5.140E-08	3.36E+00
1.00E-15	173798	1.220E-08	445888	5.239E-08	3.29E+00
Truncation	Base Level 1 Model		All SQV x5		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	16224	2.727E-08	1.56E+00
1.00E-14	45518	1.180E-08	77018	2.918E-08	1.47E+00
1.00E-15	173798	1.220E-08	302972	2.985E-08	1.45E+00
Truncation	Level 1 Base Model		SLCS SQV		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8121	1.243E-08	1.66E-01
1.00E-14	45518	1.180E-08	45645	1.357E-08	1.50E-01
1.00E-15	173798	1.220E-08	173396	1.398E-08	1.46E-01
Truncation	Level 1 Base Model		ADS SQV		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	16896	3.138E-08	1.94E+00
1.00E-14	45518	1.180E-08	780015	3.330E-08	1.82E+00
1.00E-15	173798	1.220E-08	331178	3.403E-08	1.79E+00
Truncation	Level 1 Base Model		INJ SQV		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	13936	2.638E-08	1.47E+00
1.00E-14	45518	1.180E-08	70143	2.813E-08	1.38E+00
1.00E-15	173798	1.220E-08	287552	2.878E-08	1.36E+00
Truncation	Level 1 Base Model		EQU SQV		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	8028	1.066E-08	0.00E+00
1.00E-14	45518	1.180E-08	45527	1.180E-08	0.00E+00
1.00E-15	173798	1.220E-08	173318	1.220E-08	0.00E+00

Table 11.3-7

Level 1 Sensitivity - Squib Valves – Detailed Model Results

Initiator Distribution	Base Model	ALL_x5	ALL_x10	ADS_X10	SLCS_X10	INJ_X10	EQU_x10
BOC	3.05E-10	7.17E-10	1.25E-09	8.21E-10	3.24E-10	7.10E-10	3.05E-10
LOCA	1.06E-09	2.36E-09	4.00E-09	1.61E-09	1.06E-09	3.44E-09	1.06E-09
LOOP	1.41E-09	2.70E-09	4.38E-09	2.90E-09	1.45E-09	2.84E-09	1.41E-09
FDW	2.28E-09	5.80E-09	1.03E-08	6.36E-09	2.42E-09	6.04E-09	2.28E-09
DHR	4.58E-10	7.13E-10	1.08E-09	7.14E-10	6.80E-10	6.03E-10	4.58E-10
IORV	4.45E-09	1.44E-08	2.69E-08	1.88E-08	4.49E-09	1.26E-08	4.47E-09
GEN	2.24E-09	3.13E-09	4.49E-09	2.84E-09	3.57E-09	2.58E-09	2.24E-09
Total	**1.22E-08**	2.98E-08	5.24E-08	3.40E-08	1.40E-08	2.88E-08	1.22E-08
Class Distribution	Base Model	ALL_x5	ALL_x10	ADS_X10	SLCS_X10	INJ_X10	EQU_x10
cdi	46.12%	45.18%	44.48%	19.81%	40.31%	77.10%	46.13%
cdii	0.35%	0.14%	0.08%	0.12%	0.30%	0.14%	0.34%
cdiii	36.99%	45.77%	48.16%	74.11%	32.31%	15.68%	36.98%
cdiv	15.35%	8.39%	6.95%	5.50%	26.03%	6.50%	15.34%
cdv	1.20%	0.52%	0.33%	0.45%	1.05%	0.57%	1.20%
Drywell Water Level Classes	Base Model	ALL_x5	ALL_x10	ADS_X10	SLCS_X10	INJ_X10	EQU_x10
DWL-L	55.70%	48.29%	46.32%	23.24%	61.30%	74.32%	55.72%
DWL-M	0.82%	0.70%	66.00%	29.00%	72.00%	1.19%	82.00%
DWL-H	5.00%	4.63%	4.48%	1.79%	4.36%	8.14%	500.00%
Other	38.48%	46.39%	48.54%	74.58%	33.62%	16.35%	38.47%
Top Sequences	Base Model	ALL_x5	ALL_x10	ADS_X10	SLCS_X10	INJ_X10	EQU_x10
AT-T-FDW013	3.00%	1.23%	0.70%	1.07%	2.62%	1.27%	3.00%
AT-T-FDW015	0.92%	NA	NA	NA	1.76%	3.05%	0.92%
AT-T-GEN021	7.20%	2.95%	1.68%	2.58%	6.29%	NA	7.20%
AT-T-GEN023	10.70%	6.25%	5.47%	3.83%	20.50%	4.53%	10.70%
AT-T-GEN026	2.03%	0.83%	NA	0.73%	1.77%	0.86%	2.03%
AT-T-IORV009	1.30%	NA	NA	NA	1.14%	NA	1.30%
AT-T-LOPP013	5.57%	2.28%	1.30%	2.00%	4.87%	2.36%	5.57%
BOC-FDWA027	0.64%	0.62%	0.60%	NA	0.56%	1.10%	0.64%
BOC-FDWA029	NA	NA	0.51%	0.78%	NA	NA	NA
LL-S050	0.69%	NA	NA	NA	0.61%	NA	0.69%
LL-S-FDWA013	NA	NA	NA	NA	NA	0.65%	NA
LL-S-FDWB045	4.30%	4.10%	4.00%	1.54%	3.75%	7.28%	4.30%
ML-L011	NA	NA	NA	NA	NA	0.81%	NA

Table 11.3-7

Level 1 Sensitivity - Squib Valves – Detailed Model Results

Top Sequences	Base Model	ALL_x5	ALL_x10	ADS_X10	SLCS_X10	INJ_X10	EQU_x10
SL-S017	NA	NA	NA	NA	NA	0.82%	NA
SL-S018	NA	NA	NA	0.58%	NA	NA	NA
T-FDW050	9.35%	8.94%	8.74%	3.35%	8.17%	15.90%	9.36%
T-FDW060	0.72%	1.48%	1.70%	2.62%	0.63%	NA	0.72%
T-FDW061	2.66%	5.07%	5.77%	8.88%	2.32%	1.13%	2.66%
T-GEN021	NA	NA		NA	NA	0.71%	NA
T-GEN022	NA	1.24%	1.43%	2.20%	NA	NA	NA
T-GEN067	1.38%	1.33%	1.32%	NA	1.20%	2.39%	1.38%
T-GEN069	NA	1.03%	1.15%	1.77%	NA	NA	NA
T-IORV017	5.39%	5.19%	5.10%	1.93%	4.70%	9.28%	5.39%
T-IORV018	7.39%	15.20%	17.40%	26.80%	6.45%	3.13%	7.39%
T-IORV063	16.90%	16.20%	15.80%	6.06%	14.80%	28.80%	16.90%
T-IORV065	5.70%	11.70%	13.40%	20.60%	4.98%	2.42%	5.70%
T-LOPP050	3.51%	3.43%	3.41%	1.26%	3.06%	6.20%	3.51%
T-LOPP060	NA	0.56%	0.65%	1.01%	NA	NA	NA
T-LOPP061	1.57%	2.20%	2.39%	3.68%	1.37%	0.66%	1.57%

Table 11.3-8

Level 1 Sensitivity – Test and Maintenance Unavailability – CDF results

Truncation	Level 1 Base Model		TM		Results	
	# Cutsets	CDF	# Cutsets	CDF	Difference	RAW
1.00E-13	8028	1.066E-08	6656	9.793E-09	-8.13E-02	0.92
1.00E-14	45518	1.180E-08	37598	1.075E-08	-8.90E-02	0.91
1.00E-15	173798	1.220E-08	137842	1.107E-08	-9.26E-02	0.91
Truncation	Level 1 Base Model		0_1xTM		Results	
	# Cutsets	CDF	# Cutsets	CDF	Difference	FV
1.00E-13	8028	1.066E-08	6814	9.842E-09	-7.67E-02	0.077
1.00E-14	45518	1.180E-08	38904	1.084E-08	-8.14E-02	0.081
1.00E-15	173798	1.220E-08	145561	1.118E-08	-8.36E-02	0.084
Truncation	Level 1 Base Model		10xTM		Results	
	# Cutsets	CDF	# Cutsets	CDF	Difference	RAW
1.00E-13	8028	1.066E-08	16994	2.293E-08	1.15E+00	2.15
1.00E-14	45518	1.180E-08	90761	2.518E-08	1.13E+00	2.13
1.00E-15	173798	1.220E-08	418780	2.613E-08	1.14E+00	2.14

Table 11.3-9
Level 1 Sensitivity – Test and Maintenance Unavailability – Detailed Model Results

Initiator Distribution	Base Model	TM	0_1xTM	10xTM
BOC	3.05E-10	3.05E-10	3.05E-10	3.17E-10
LOCA	1.06E-09	1.01E-09	1.02E-09	1.67E-09
LOOP	1.41E-09	1.27E-09	1.28E-09	3.09E-09
FDW	2.28E-09	2.27E-09	2.27E-09	2.42E-09
DHR	4.58E-10	4.49E-10	4.50E-10	5.73E-10
IORV	4.45E-09	3.62E-09	3.70E-09	1.51E-08
GEN	2.24E-09	2.19E-09	2.18E-09	2.95E-09
Total	**1.22E-08**	1.11E-08	1.12E-08	2.61E-08
Class Distribution	Base Model	TM	0_1xTM	10xTM
cdi	46.12%	45.39%	45.47%	49.86%
cdii	0.35%	0.36%	0.36%	2.02%
cdiii	36.99%	36.02%	36.10%	40.16%
cdiv	15.35%	16.91%	16.76%	7.38%
cdv	1.20%	1.33%	1.31%	0.58%
Drywell Water Level Classes	Base Model	TM	0_1xTM	10xTM
DWL-L	55.70%	56.08%	56.04%	54.01%
DWL-M	0.82%	0.79%	0.79%	0.92%
DWL-H	5.00%	5.49%	5.45%	2.37%
Other	38.48%	37.64%	37.72%	42.70%
Top Sequences	Level 1 Base Model	TM	0_1xTM	10xTM
AT-T-FDW013	3.00%	3.20%	3.18%	1.82%
AT-T-FDW015	0.92%	1.01%	1.00%	NA
AT-T-GEN021	7.20%	7.55%	7.51%	4.99%
AT-T-GEN023	10.70%	11.80%	11.70%	4.99%
AT-T-GEN026	2.03%	2.23%	2.21%	1.08%
AT-T-IORV009	1.30%	1.36%	1.36%	0.91%
AT-T-LOPP013	5.57%	5.13%	5.18%	6.50%
BOC-FDWA027	0.64%	0.71%	0.70%	NA
SL-S017	NA	NA	NA	0.75%
T-FDW050	9.35%	10.30%	10.20%	4.39%
T-FDW060	0.72%	0.79%	0.79%	NA

Table 11.3-9

Level 1 Sensitivity – Test and Maintenance Unavailability – Detailed Model Results

Top Sequences	Level 1 Base Model	TM	0_1xTM	10xTM
T-FDW061	2.66%	2.93%	2.90%	1.26%
T-GEN067	1.38%	1.39%	1.39%	1.21%
T-GEN069	NA	NA	NA	0.64%
T-IORV013	NA	NA	NA	0.83%
T-IORV017	5.39%	4.78%	4.84%	8.70%
T-IORV018	7.39%	6.56%	6.64%	11.60%
T-IORV027	NA	NA	NA	0.62%
T-IORV063	16.90%	15.00%	15.20%	26.40%
T-IORV065	5.70%	5.06%	5.12%	8.91%
T-LOPP050	3.51%	3.75%	3.72%	2.64%
T-LOPP061	1.57%	1.57%	1.56%	1.89%

Table 11.3-10

Level 1 Sensitivity – Test and Maintenance Unavailability – Detailed Model Results

Initiator Distribution	Level 1 Base Model	SLCS	SRVCCF	SPC/LPCI	TB	CRD	VB
BOC	3.05E-10	2.90E-10	3.05E-10	3.05E-10	3.05E-10	3.05E-10	3.08E-10
LOCA	1.06E-09	1.05E-09	1.06E-09	1.06E-09	1.06E-09	1.06E-09	1.82E-09
LOOP	1.41E-09	1.37E-09	1.41E-09	1.41E-09	1.41E-09	1.41E-09	1.48E-09
FDW	2.28E-09	2.17E-09	2.28E-09	2.33E-09	2.28E-09	2.28E-09	2.42E-09
DHR	4.58E-10	2.87E-10	4.58E-10	4.62E-10	4.58E-10	4.58E-10	4.63E-10
IORV	4.45E-09	4.42E-09	4.47E-09	4.46E-09	4.47E-09	4.45E-09	4.68E-09
GEN	2.24E-09	1.22E-09	2.24E-09	2.28E-09	2.24E-09	2.24E-09	2.25E-09
Total	**1.22E-08**	1.08E-08	1.22E-08	1.23E-08	1.22E-08	1.22E-08	1.34E-08
Class Distribution	Level 1 Base Model	SLCS	SRVCCF	SPC/LPCI	TB	CRD	VB
cdi	46.12%	51.95%	46.13%	45.84%	46.13%	46.12%	42.50%
cdii	0.35%	0.38%	0.34%	1.13%	0.34%	0.35%	2.74%
cdiii	36.99%	41.65%	36.98%	36.64%	36.98%	36.99%	33.80%
cdiv	15.35%	4.66%	15.35%	15.19%	15.35%	15.35%	14.01%
cdv	1.20%	1.35%	1.20%	1.19%	1.20%	1.20%	6.95%
Drywell Water Level Classes	Level 1 Base Model	SLCS	SRVCCF	SPC/LPCI	TB	CRD	VB
DWL-L	55.70%	50.13%	55.71%	55.35%	55.71%	55.70%	51.21%
DWL-M	0.82%	0.92%	0.82%	0.81%	0.82%	0.82%	0.75%
DWL-H	5.00%	5.62%	5.00%	4.96%	5.00%	5.00%	4.56%
Other	38.48%	43.32%	38.47%	38.88%	38.47%	38.48%	43.48%
Top Sequences	Level 1 Base Model	SLCS	SRVCCF	SPC/LPCI	TB	CRD	VB
AT-T-FDW013	3.00%	3.38%	3.00%	2.97%	3.00%	3.00%	2.74%
AT-T-FDW015	0.92%	NA	0.92%	0.91%	0.92%	0.92%	0.84%
AT-T-GEN021	7.20%	8.11%	7.20%	7.13%	7.20%	7.20%	6.57%
AT-T-GEN023	10.70%	0.90%	10.70%	10.60%	10.70%	10.70%	9.76%
AT-T-GEN026	2.03%	2.29%	2.03%	2.01%	2.03%	2.03%	1.85%
AT-T-IORV009	1.30%	1.47%	1.30%	1.29%	1.30%	1.30%	1.19%
AT-T-LOPP013	5.57%	6.28%	5.57%	5.52%	5.57%	5.57%	5.09%
BOC-FDWA027	0.64%	0.73%	0.64%	0.64%	0.64%	0.64%	NA
LL-S050	0.69%	0.78%	0.69%	0.69%	0.69%	0.69%	NA
LL-S-FDWB045	4.30%	4.84%	4.30%	4.27%	4.30%	4.30%	3.92%
ML-L013	NA	NA	NA	NA	NA	NA	5.33%
T-FDW050	9.35%	10.50%	9.35%	9.29%	9.36%	9.35%	8.54%

Table 11.3-10

Level 1 Sensitivity – Test and Maintenance Unavailability – Detailed Model Results

T-FDW052	NA	NA	NA	NA	NA	NA	0.85%
T-FDW060	0.72%	0.81%	0.72%	0.72%	0.72%	0.72%	NA
T-FDW061	2.66%	2.99%	2.66%	2.63%	2.66%	2.66%	2.43%
T-GEN067	1.38%	1.55%	1.38%	1.36%	1.38%	1.38%	1.26%
T-IORV015	NA	NA	NA	NA	NA	NA	0.69%
T-IORV017	5.39%	6.07%	5.39%	5.39%	5.39%	5.39%	4.92%
T-IORV018	7.39%	8.33%	7.39%	7.34%	7.39%	7.39%	6.75%
T-IORV063	16.90%	19.10%	16.90%	16.80%	16.90%	16.90%	15.40%
T-IORV065	5.70%	6.42%	5.70%	5.65%	5.70%	5.70%	5.21%
T-LOPP050	3.51%	3.95%	3.51%	3.50%	3.51%	3.51%	3.20%
T-LOPP061	1.57%	1.76%	1.57%	1.55%	1.57%	1.57%	1.43%

Table 11.3-11

Level 1 Sensitivity – Component Type Code Data – CDF Results

Type Code	System Name	Baseline Value	Sens. Value (x10)	Truncation	Results		
					# Cutsets	CDF	Difference
MTS CO	Manual Transfer Switch Spuriously Opens	1.00E-06	1.00E-05	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8031	1.066E-08	0.0E+00
				1.00E-14	45490	1.181E-08	-5.9E-04
NMO CC	Nitrogen Motor Operated Valve Fails to Open	1.00E-04	1.00E-03	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8031	1.066E-08	0.0E+00
				1.00E-14	45551	1.180E-08	-1.7E-04
NMO OC	Nitrogen Motor Operated Valve Fails to Close	1.00E-07	1.00E-06	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8028	1.066E-08	0.0E+00
				1.00E-14	45518	1.180E-08	-8.5E-05
NMO OO	Nitrogen Motor Operated Valve Transfers Closed	1.00E-04	1.00E-03	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8028	1.066E-08	0.0E+00
				1.00E-14	45518	1.180E-08	-8.5E-05
NPO CC	Nitrogen Piston Operated Valve Fails to Close	1.00E-04	1.00E-03	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8030	1.066E-08	0.0E+00
				1.00E-14	45549	1.180E-08	-1.7E-04
NPO OC	Nitrogen Piston Operated Valve Fails to Open	1.00E-07	1.00E-06	1.00E-12	1131	8.699E-09	0.0E+00
				1.00E-13	8028	1.066E-08	0.0E+00
				1.00E-14	45518	1.180E-08	-8.5E-05
				Truncation	No. Cutsets	Result - CDF	
		Baseline CDF		1.00E-12	1131	8.699E-09	
				1.00E-13	8028	1.066E-08	
				1.00E-14	45518	1.180E-08	

Table 11.3-12
Level 1 Sensitivity – LOCA – Detailed Model Results

Initiator Distribution	Base LOCA Model	LOCA_x2	LOCA_ICS
BOC	3.05E-10	6.16E-10	3.05E-10
LOCA	1.06E-09	2.12E-09	1.06E-09
LOOP	1.41E-09	1.41E-09	1.41E-09
FDW	2.28E-09	2.28E-09	2.28E-09
DHR	4.58E-10	4.60E-10	4.58E-10
IORV	4.47E-09	4.47E-09	4.47E-09
GEN	2.24E-09	2.24E-09	2.24E-09
Total	**1.22E-08**	1.36E-08	1.22E-08
Class Distribution	Base LOCA Model	LOCA_x2	LOCA_ICS
Cdi	46.13%	48.44%	46.13%
Cdii	0.34%	0.35%	0.34%
Cdiii	36.98%	34.44%	36.98%
Cdiv	15.35%	14.72%	15.35%
Cdv	1.20%	2.06%	1.20%
Drywell Water Level Classes	Base LOCA Model	LOCA_x2	LOCA_ICS
DWL-L	55.71%	52.82%	55.71%
DWL-M	0.82%	1.50%	0.82%
DWL-H	5.00%	8.86%	5.00%
Other	38.47%	36.81%	38.47%
Top Sequences	Base LOCA Model	LOCA_x2	LOCA_ICS
AT-T-FDW013	3.00%	2.77%	3.00%
AT-T-FDW015	0.92%	NA	0.92%
AT-T-GEN021	7.20%	6.53%	7.20%
AT-T-GEN023	10.70%	9.70%	10.70%
AT-T-GEN026	2.03%	1.84%	2.03%
AT-T-IORV009	1.30%	1.17%	1.30%
AT-T-LOPP013	5.57%	5.01%	5.57%
BOC-FDWA027	0.64%	1.16%	0.64%
LL-S050	0.69%	1.25%	0.69%
LL-S-FDWB045	4.30%	7.73%	4.30%
ML-L011	NA	0.86%	NA
ML-L013	NA	1.05%	NA

Table 11.3-12

Level 1 Sensitivity – LOCA – Detailed Model Results

T-FDW050	9.36%	8.41%	9.36%
T-FDW060	0.72%	NA	0.72%
T-FDW061	2.66%	2.39%	2.66%
T-GEN067	1.38%	1.24%	1.38%
T-IORV017	5.39%	4.84%	5.39%
T-IORV018	7.39%	6.65%	7.39%
T-IORV063	16.90%	15.20%	16.90%
T-IORV065	5.70%	5.13%	5.70%
T-LOPP050	3.51%	3.16%	3.51%
T-LOPP061	1.57%	1.41%	1.57%

Table 11.3-13
Level 1 Sensitivity – Accumulator – Detail Model Results

Initiator Distribution	Level 1 Base Model @ 1E-13	ACC
BOC	2.44E-10	2.29E-08
LOCA	9.55E-10	1.93E-09
LOOP	1.03E-09	2.28E-09
FDW	2.20E-09	8.70E-07
DHR	4.07E-10	2.38E-06
IORV	3.75E-09	3.77E-08
GEN	2.12E-09	2.10E-06
Total	**1.07E-08**	5.42E-06
Class Distribution	Level 1 Base Model @ 1E-13	ACC
cdi	46.56%	0.11%
cdii	0.25%	99.75%
cdiii	34.53%	0.10%
cdiv	17.38%	0.03%
cdv	1.27%	0.00%
Drywell Water Level Classes	Level 1 Base Model @ 1E-13	ACC
DWL-L	57.52%	0.13%
DWL-M	0.77%	0.00%
DWL-H	5.67%	0.01%
Other	36.05%	99.86%
Top Sequences	Level 1 Base Model @ 1E-13	ACC
AT-T-FDW013	3.19%	0.01%
AT-T-FDW015	1.04%	NA
AT-T-GEN021	7.00%	0.01%
AT-T-GEN023	12.20%	0.02%
AT-T-GEN026	2.24%	NA
AT-T-IORV009	1.40%	NA
AT-T-LOPP013	4.18%	0.01%
BOC-FDWA027	0.72%	NA
LL-S007	NA	0.01%
LL-S050	0.80%	NA
LL-S-FDWB045	4.91%	0.01%
SL-S023	NA	0.01%

Table 11.3-13

Level 1 Sensitivity – Accumulator – Detail Model Results

T-FDW003	NA	3.82%
T-FDW050	10.50%	0.02%
T-FDW060	0.81%	NA
T-FDW061	2.94%	0.01%
T-GEN004	NA	57.80%
T-GEN027	NA	0.01%
T-GEN067	1.43%	NA
T-IORV017	4.62%	NA
T-IORV018	6.81%	0.01%
T-IORV023	NA	0.58%
T-IORV063	16.80%	0.05%
T-IORV065	5.39%	0.04%
T-LOPP008	NA	0.02%
T-LOPP050	3.41%	0.01%
T-LOPP061	1.21%	NA
T-SW002	NA	37.50%
T-SW015	NA	0.01%

Table 11.3-14

Level 1 Sensitivity – System Importance – CDF, RAW and FV Results

	Truncation	No. Cutsets	Result - CDF
Baseline CDF	1.00E-12	1131	8.70E-09
	1.00E-13	8028	1.07E-08
	1.00E-14	45518	1.18E-08

System ID	System Name	Truncation	Results						Risk Significance[1]	
			# Cutsets	CDF (T)	# Cutsets	CDF (F)	RAW	FV	RAW	FV
B21	Automatic Depressurization System	1.00E-12	88780	8.49E-05	536	6.24E-09	9760.89	0.283	yes	yes
		1.00E-13	236573	8.50E-05	3414	7.06E-09	7970.92	0.338	yes	yes
		1.00E-14	668843	8.50E-05	21014	7.59E-09	7201.69	0.357	yes	yes
B32	Isolation Condenser System	1.00E-12	1132	8.70E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8031	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45550	1.18E-08	45518	1.18E-08	1.00	0.000	no	no
C12	Control Rod Drive System	1.00E-12	462314	5.77E-02	634	5.89E-09	6632946	0.323	yes	yes
		1.00E-13	1417616	5.77E-02	4803	7.05E-09	5410131	0.339	yes	yes
		1.00E-14	error[2]	error	30950	7.83E-09	---	0.336	---	yes
C62	Nonsafety DCIS	1.00E-12	5002	4.84E-06	1109	8.25E-09	556.16	0.052	yes	yes
		1.00E-13	22823	4.84E-06	7893	1.02E-08	454.32	0.045	yes	yes
		1.00E-14	83680	4.84E-06	45107	1.13E-08	410.51	0.042	yes	yes
C63	Safety Related DCIS	1.00E-12	28504	5.03E-05	990	6.12E-09	5785.26	0.296	yes	yes
		1.00E-13	137001	5.04E-05	7343	7.94E-09	4723.92	0.255	yes	yes
		1.00E-14	669606	5.04E-05	40859	8.97E-09	4268.90	0.240	yes	yes
C71	Reactor Protection System	1.00E-12	23456	2.13E-04	1123	8.66E-09	24538.45	0.005	yes	no
		1.00E-13	108135	2.13E-04	7977	1.06E-08	20027.20	0.005	yes	no
		1.00E-14	429733	2.14E-04	45244	1.17E-08	18093.22	0.005	yes	no
C72	Diverse Protection System	1.00E-12	45994	2.26E-06	1102	8.43E-09	259.23	0.031	yes	yes
		1.00E-13	194238	2.30E-06	7838	1.04E-08	215.76	0.029	yes	yes
		1.00E-14	771509	2.32E-06	43941	1.15E-08	196.44	0.030	yes	yes

Table 11.3-14

Level 1 Sensitivity – System Importance – CDF, RAW and FV Results

C74	Safety System Logic & Control	1.00E-12	871	3.64E-07	1127	8.66E-09	41.86	0.004	yes	no
		1.00E-13	6847	3.66E-07	8019	1.06E-08	34.31	0.003	yes	no
		1.00E-14	40261	3.67E-07	45490	1.18E-08	31.09	0.003	yes	no
E50	Gravity Driven Cooling System	1.00E-12	109772	1.22E-05	743	4.61E-09	1402.80	0.470	yes	yes
		1.00E-13	544533	1.23E-05	5087	5.86E-09	1156.66	0.450	yes	yes
		1.00E-14	error	error	26843	6.53E-09	---	0.447	---	yes
G21	Feedwater & Auxiliary Pool Cooling System	1.00E-12	3337	4.04E-08	1002	7.64E-09	4.65	0.122	no	yes
		1.00E-13	21781	4.58E-08	6999	9.34E-09	4.30	0.124	no	yes
		1.00E-14	92068	4.80E-08	38388	1.03E-08	4.07	0.127	no	yes
G31	Reactor Water Cleanup/ Shutdown Cooling System	1.00E-12	63432	4.09E-03	1131	8.70E-09	470605.82	0.000	yes	no
		1.00E-13	187270	4.09E-03	8018	1.07E-08	384033.77	0.000	yes	no
		1.00E-14	512570	4.09E-03	45441	1.18E-08	346932.20	0.000	yes	no
N21	Condensate & Feedwater System	1.00E-12	3463	3.35E-07	1087	8.54E-09	38.52	0.018	yes	yes
		1.00E-13	14032	3.38E-07	7739	1.04E-08	31.72	0.021	yes	yes
		1.00E-14	66502	3.40E-07	44067	1.15E-08	28.79	0.022	yes	yes
N37	Turbine Bypass System	1.00E-12	1132	8.70E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8036	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45537	1.18E-08	45518	1.18E-08	1.00	0.000	no	no
N71	Circulating Water System	1.00E-12	1132	8.70E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8036	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45537	1.18E-08	45518	1.18E-08	1.00	0.000	no	no
P21	Reactor Component Cooling Water System	1.00E-12	2312	1.48E-07	1059	8.51E-09	17.01	0.022	yes	yes
		1.00E-13	9916	1.50E-07	6045	1.00E-08	14.07	0.059	yes	yes
		1.00E-14	33947	1.51E-07	29581	1.07E-08	12.78	0.090	yes	yes
P22	Turbine Component Cooling Water System	1.00E-12	3463	3.35E-07	987	8.09E-09	38.52	0.070	yes	yes
		1.00E-13	14032	3.38E-07	7327	9.88E-09	31.73	0.073	yes	yes
		1.00E-14	66525	3.40E-07	41770	1.09E-08	28.79	0.073	yes	yes
P41	Plant Service Water System	1.00E-12	4488	4.76E-06	1043	8.41E-09	546.70	0.034	yes	yes
		1.00E-13	20246	4.76E-06	7295	1.02E-08	446.51	0.044	yes	yes
		1.00E-14	73936	4.76E-06	39339	1.12E-08	403.56	0.053	yes	yes
P51	Service Air System	1.00E-12	1234	1.02E-08	1131	8.70E-09	1.17	0.000	no	no

Table 11.3-14

Level 1 Sensitivity – System Importance – CDF, RAW and FV Results

		1.00E-13	8454	1.23E-08	8028	1.07E-08	1.15	0.000	no	no
		1.00E-14	47533	1.34E-08	45511	1.18E-08	1.14	0.000	no	no
P52	Instrument Air System	1.00E-12	3256	1.28E-07	1131	8.70E-09	14.68	0.000	yes	no
		1.00E-13	13499	1.31E-07	8028	1.07E-08	12.25	0.000	yes	no
		1.00E-14	65267	1.32E-07	45504	1.18E-08	11.20	0.000	yes	no
P54	High Pressure Nitrogen Supply System	1.00E-12	1150	8.73E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8122	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45969	1.19E-08	45518	1.18E-08	1.00	0.000	no	no
R10	Electrical Power Distribution System	1.00E-12	43394	9.22E-07	864	7.32E-09	105.94	0.159	yes	yes
		1.00E-13	150500	9.55E-07	5017	8.54E-09	89.62	0.199	yes	yes
		1.00E-14	574314	9.68E-07	24519	9.13E-09	82.07	0.227	yes	yes
R11	Medium Voltage Distribution System	1.00E-12	5565	4.84E-06	1126	8.68E-09	556.62	0.002	yes	no
		1.00E-13	25635	4.85E-06	8015	1.06E-08	454.78	0.002	yes	no
		1.00E-14	94506	4.85E-06	45396	1.18E-08	411.02	0.002	yes	no
R12	Low Voltage Distribution System	1.00E-12	5565	4.84E-06	1331	8.70E-09	556.62	0.000	yes	no
		1.00E-13	25635	4.84E-06	8028	1.07E-08	454.22	0.000	yes	no
		1.00E-14	94506	4.85E-06	45504	1.18E-08	411.02	0.000	yes	no
R16	Direct Current Power Supply	1.00E-12	13501	2.02E-05	1131	8.70E-09	2318.66	0.000	yes	no
		1.00E-13	34713	2.02E-05	8024	1.07E-08	1892.12	0.000	yes	no
		1.00E-14	95495	2.02E-05	45502	1.18E-08	1709.32	0.000	yes	no
R21	Standby On Site AC Power Supply	1.00E-12	1100	2.35E-08	919	8.24E-09	2.70	0.052	no	yes
		1.00E-13	6297	2.51E-08	5616	9.54E-09	2.36	0.105	no	yes
		1.00E-14	23565	2.57E-08	32668	1.04E-08	2.17	0.123	no	yes
T10	Containment System	1.00E-12	278084	5.24E-03	1125	8.61E-09	602368.09	0.010	yes	no
		1.00E-13	1317013	5.24E-03	7993	1.06E-08	491557.22	0.008	yes	no
		1.00E-14	error	error	45299	1.17E-08	---	0.008	---	no
T15	Passive Containment Cooling System	1.00E-12	232916	8.62E-06	1131	8.70E-09	991.16	0.000	yes	no
		1.00E-13	1206753	8.91E-06	8026	1.07E-08	835.48	0.000	yes	no
		1.00E-14	error	error	45460	1.18E-08	---	0.000	---	no
T23	Suppression Pool System	1.00E-12	1206	9.25E-09	1131	8.70E-09	1.06	0.000	no	no
		1.00E-13	8575	1.14E-08	8028	1.07E-08	1.07	0.000	no	no
		1.00E-14	48641	1.26E-08	45518	1.18E-08	1.07	0.000	no	no

Table 11.3-14

Level 1 Sensitivity – System Importance – CDF, RAW and FV Results

T31	Containment Inerting System	1.00E-12	1131	8.70E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8029	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45542	1.18E-08	45518	1.18E-08	1.00	0.000	no	no
U40	Reactor Building HVAC	1.00E-12	1150	8.73E-09	1131	8.70E-09	1.00	0.000	no	no
		1.00E-13	8122	1.07E-08	8028	1.07E-08	1.00	0.000	no	no
		1.00E-14	45967	1.19E-08	45518	1.18E-08	1.00	0.000	no	no
U43	Fire Protection System	1.00E-12	2103	1.59E-08	1129	8.70E-09	1.83	0.000	no	no
		1.00E-13	15927	1.97E-08	7979	1.07E-08	1.85	0.000	no	no
		1.00E-14	78513	2.16E-08	44863	1.18E-08	1.83	0.003	no	no

Notes:

1 Risk significance based on a Fussell-Vesely importance value > 0.01 and/or a risk achievement worth (RAW) value > 5.

2 Values reported as error result from scenarios generating a number of cutsets in excess of the memory limitations of the model

Table 11.3-15

Level 1 Sensitivity – System Importance - RAW system Ranking

System ID	System Name	Truncation	Results					
			# Cutsets	CDF (T)	# Cutsets	CDF (F)	RAW	Ranking
C12	Control Rod Drive System	1.00E-12	462314	5.77E-02	634	5.89E-09	5410131*	1
T10	Containment System	1.00E-12	278084	5.24E-03	1125	8.61E-09	491557.22*	2
G31	Reactor Water Cleanup/ Shutdown Cooling System	1.00E-12	63432	4.09E-03	1131	8.70E-09	346932.20	3
C71	Reactor Protection System	1.00E-12	23456	2.13E-04	1123	8.66E-09	18093.22	4
B21	Automatic Depressurization System	1.00E-12	6672	1.73E-06	1131	8.70E-09	7201.69	5
C63	Safety Related DCIS	1.00E-12	22031	3.70E-07	1131	8.70E-09	4268.90	6
R16	Direct Current Power Supply	1.00E-12	13501	2.02E-05	1131	8.70E-09	1709.32	7
E50	Gravity Driven Cooling System	1.00E-12	109772	1.22E-05	743	4.61E-09	1156.66*	8
T15	Passive Containment Cooling System	1.00E-12	232916	8.62E-06	1131	8.70E-09	835.46*	9
R11	Medium Voltage Distribution System	1.00E-12	5565	4.84E-06	1126	8.68E-09	411.02	10 tie
R12	Low Voltage Distribution System	1.00E-12	5565	4.84E-06	1331	8.70E-09	411.02	10 tie
C62	NonSafety DCIS	1.00E-12	22031	3.70E-07	1131	8.70E-09	410.51	12
P41	Plant Service Water System	1.00E-12	4488	4.76E-06	1043	8.41E-09	403.56	13
C72	Diverse Protection System	1.00E-12	45994	2.26E-06	1102	8.43E-09	196.44	14
R10	Electrical Power Distribution System	1.00E-12	43394	9.22E-07	864	7.32E-09	82.07	15
C74	Safety System Logic & Control	1.00E-12	871	3.64E-07	1127	8.66E-09	31.09	16
N21	Condensate & Feedwater System	1.00E-12	3463	3.35E-07	1087	8.54E-09	28.79	17 tie
P22	Turbine Component Cooling Water System	1.00E-12	3463	3.35E-07	987	8.09E-09	28.79	17 tie
P21	Reactor Component Cooling Water System	1.00E-12	2312	1.48E-07	1059	8.51E-09	12.78	19

Table 11.3-15

Level 1 Sensitivity – System Importance - RAW system Ranking

P52	Instrument Air System	1.00E-12	3256	1.28E-07	1131	8.70E-09	11.20	20
*	Based on E-13 trunction results							

Table 11.3-16

Level 1 Sensitivity – System Importance – FV System Ranking

System ID	System Name	Results	
		FV	Ranking
E50	Gravity Driven Cooling System	0.447	1
B21	Automatic Depressurization System	0.357	2
C12	Control Rod Drive System	0.336	3
C63	Safety Related DCIS	0.240	4
R10	Electrical Power Distribution System	0.227	5
G21	Feedwater & Auxiliary Pool Cooling System	0.127	6
R21	Standby On Site AC Power Supply	0.123	7
P21	Reactor Component Cooling Water System	0.090	8
P22	Turbine Component Cooling Water System	0.073	9
P41	Plant Service Water System	0.053	10
C62	Non Safety DCIS	0.240	11
C72	Diverse Protection System	0.030	12
N21	Condensate & Feedwater System	0.022	13

Table 11.3-17

Level 1 Sensitivity – Passive Component Demand – CDF and FV Results

$$CDF*FV_{(dpv\_f)}=1.22E\text{-}08/yr \times 2.12E\text{-}01 = 2.59E\text{-}09/yr$$

$$CDF*[FV_{(dpv\_all) - FV(dpv\_f)]}=1.22E\text{-}08/yr \times (6.12E\text{-}01 - 2.12E\text{-}01) = 4.88E\text{-}09/yr$$

$$CDF*FV_{(dhr\_all)}=1.22E\text{-}08/yr \times 2.35E\text{-}01 = 2.87E\text{-}09/yr$$

Sequences	Demand Sensitivity	
	FV	CDF
ICS Failures	2.35E+02	2.86E-09
Both ICS and PCCS failures	3.04E-05	3.71E-13
PCCS or Pool Makeup Failures	2.14E-05	2.61E-12
TOTAL	2.35E-01	2.87E-09

Sequences	Demand Sensitivity	
	FV	CDF
ICS Failures due to Pool Makeup	3.90E-06	4.76E-14
PCCS only Failure	2.10E-04	2.56E-12
TOTAL	2.14E-05	2.61E-12

Table 11.3-18

Level 2 Sensitivity – Base Model and Sensitivity Detailed Model Results

Release Category	Level 2 Base Model	CIS	PU	VB
	Freq.	Freq.	Freq.	Freq.
TSL	1.12E-08	1.12E-08	1.124E-08	1.123E-08
FR	2.34E-13	2.34E-13	2.342E-13	1.656E-11
OPW2	7.78E-14	7.78E-14	7.769E-14	7.767E-14
OPW1	3.21E-11	3.21E-11	3.206E-11	3.216E-11
OPVB	1.57E-11	1.57E-11	1.571E-11	3.779E-10
BYP	5.63E-11	5.63E-11	5.639E-11	5.957E-11
CCIW	9.92E-11	9.92E-11	9.944E-11	9.981E-11
CCID	9.02E-13	9.03E-13	9.024E-13	9.020E-13
EVE	6.10E-10	6.10E-10	6.096E-10	6.097E-10
DCH	0.00E+00	0.00E+00	2.556E-12	0.000E+00
BOC	1.47E-10	1.47E-10	1.468E-10	9.292E-10
TOTAL	1.22E-08	1.22E-08	1.221E-08	1.336E-08
nTSL	9.62E-10	9.62E-10	9.638E-10	2.126E-09
Initiator Distribution	Level 2 Base Model	CIS	PU	VB
	FV	FV	FV	FV
%BOC-FDWA	1.37E-03	1.37E-03	1.70E-03	1.43E-03
%BOC-FDWB	2.17E-03	2.17E-03	1.70E-03	1.07E-03
%BOC-IC	0.00E+00	0.00E+00	0.00E+00	3.05E-04
%BOC-MS	6.78E-04	6.77E-04	1.00E-02	2.86E-02
%BOC-RWCU	6.43E-02	6.43E-02	3.40E-03	3.13E-02
%ISLOCA	0.00E+00	0.00E+00	0.00E+00	2.35E-02
%LL-S	7.53E-03	7.53E-03	3.39E-04	2.78E-01
%LL-S-FDWA	5.20E-02	5.20E-02	5.55E-06	3.51E-01
%LL-S-FDWB	5.73E-01	5.73E-01	5.55E-06	7.92E-03
%ML-L	9.80E-02	9.80E-02	7.55E-05	2.87E-04
%ML-L-RWCU	0.00E+00	0.00E+00	0.00E+00	1.85E-03
%RVR	1.78E-02	1.78E-02	1.00E-10	7.99E-02
%SL-L	1.82E-04	1.82E-04	1.43E-04	2.10E-02
%SL-L-RWCU	0.00E+00	0.00E+00	0.00E+00	9.85E-03
%SL-S	1.12E-03	1.12E-03	6.33E-04	1.18E-01
%T-FDW	3.66E-02	3.66E-02	1.17E-01	2.27E-02
%T-GEN	4.47E-02	4.46E-02	1.18E+00	1.80E-03
%T-IA	1.97E-02	1.97E-02	1.02E-02	1.17E-02
%T-IORV	5.06E-02	5.06E-02	2.83E-02	4.83E-03
%T-LOPP-GR	1.21E-02	1.21E-02	1.86E-02	4.03E-03
%T-LOPP-PC	8.81E-04	8.81E-04	2.07E-03	2.06E-03
%T-LOPP-SC	6.14E-03	6.14E-03	1.04E-02	6.14E-03
%T-LOPP-WR	2.34E-03	2.34E-03	4.83E-03	2.34E-03
%T-PCS	8.75E-03	8.73E-03	1.97E-01	8.73E-03
%T-SW	1.01E-03	1.01E-03	9.70E-04	1.01E-03

Table 11.3-19

Level 2 Sensitivity – Base Model and Sensitivity – nTSL Results

Truncation	Base Level 2 Model		Focus Level 2		% Difference	
	nTSL	CDF	nTSL	CDF	nTSL	CDF
1.00E-15	9.62E-10	1.220E-08	3.05E-04	3.22E-04	3.17+05%	2.64E+-1%
Truncation	Base Level 2 Model		RTNSS Level 2		% Difference	
	nTSL	CDF	nTSL	CDF	nTSL	CDF
1.00E-15	9.62E-10	1.220E-08	9.06E-08	4.91E-06	9317.88%	40145.90%
Truncation	Level 2 - Base		CIS		% Difference	
	nTSL	CDF	nTSL	CDF	nTSL	CDF
1.00E-15	9.62E-10	1.22E-08	9.62E-10	1.22E-08	0.00%	0.00%
Truncation	Level 2 - Base		PU		% Difference	
	nTSL	CDF	nTSL	CDF	nTSL	CDF
1.00E-15	9.62E-10	1.22E-08	9.64E-10	1.22E-08	0.21%	0.00%
Truncation	Level 2 - Base		VB		% Difference	
	nTSL	CDF	nTSL	CDF	nTSL	CDF
1.00E-15	9.62E-10	1.22E-08	2.13E-09	1.34E-08	121.41%	9.84%

Table 11.3-20

Focus Level 1 – CDF Results

Truncation	Level 1 Base Model		Level 1 Focus		% Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	52255	3.22E-04	3.02E+04
1.00E-14	45518	1.180E-08	146352	3.22E-04	2.73E+04
1.00E-15	173798	1.220E-08	471592	3.22E-04	2.64E+04
Truncation	Level 1 Base Model		Level 1 RTNSS		% Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	8028	1.066E-08	37951	4.91E-06	4.60E+02
1.00E-14	45518	1.180E-08	142840	4.91E-06	4.15E+02
1.00E-15	173798	1.220E-08	550770	4.91E-06	4.01E+02
Truncation	Level 1 Focus		Level 1 RTNSS		% Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-13	52255	3.22E-04	37951	4.91E-06	-9.85E-01
1.00E-14	146352	3.22E-04	142840	4.91E-06	-9.85E-01
1.00E-15	471592	3.22E-04	550770	4.91E-06	-9.85E-01

Table 11.3-21

Focus Level 1 – Detailed Model Results

Initiator Distribution	Level 1 Base Model	Level 1 Focus	Level 1 RTNSS
BOC	3.05E-10	3.62E-06	2.83E-09
LOCA	1.06E-09	1.01E-06	2.62E-07
LOPP	1.41E-09	4.56E-06	4.01E-09
FDW	2.28E-09	1.69E-05	1.16E-08
DHR	4.58E-10	3.88E-05	2.14E-08
IORV	4.45E-09	2.61E-05	4.48E-06
GEN	2.24E-09	2.31E-04	1.27E-07
Total	**1.22E-08**	3.22E-04	4.91E-06
Class Distribution	Level 1 Base Model	Level 1 Focus	Level 1 RTNSS
cdi	46.12%	4.85%	62.98%
cdii	0.35%	0.03%	0.13%
cdiii	36.99%	60.21%	36.53%
cdiv	15.35%	34.79%	0.35%
cdv	1.20%	0.12%	0.02%
Drywell Water Level Classes	Level 1 Base Model	Level 1 Focus	Level 1 RTNSS
DWL-L	55.70%	39.59%	62.11%
DWL-M	0.82%	0.06%	1.20%
DWL-H	5.00%	0.01%	0.06%
Other	38.48%	60.34%	36.62%
Top Sequences	Level 1 Base Model	Level 1 Focus	Level 1 RTNSS
AT-T-FDW013	3.00%	0.31%	NA
AT-T-FDW015	0.92%	NA	NA
AT-T-FDW016	NA	0.05%	NA
AT-T-GEN021	7.20%	NA	0.81%
AT-T-GEN023	10.70%	0.00%	NA
AT-T-GEN026	2.03%	33.20%	0.30%
AT-T-IORV009	1.30%	NA	0.15%
AT-T-IORV014	NA	1.08%	NA
AT-T-LOPP013	5.57%	0.09%	NA
BOC-FDWA027	0.64%	NA	NA
BOC-FDWA029	NA	0.05%	NA
BOC-FDWB054	NA	0.05%	0.05%
BOC-MS067	NA	0.38%	NA
BOC-RWCU051	NA	0.11%	NA
LL-S047	NA	0.06%	0.69%

Table 11.3-21

Focus Level 1 – Detailed Model Results

Top Sequences	Level 1 Base Model	Level 1 Focus	Level 1 RTNSS
LL-S050	0.69%	NA	NA
LL-S-FDWB045	4.30%	NA	NA
ML-L011	NA	NA	0.69%
SL-L022	NA	NA	0.29%
SL-L068	NA	NA	0.21%
SL-S017	NA	0.09%	1.29%
SL-S018	NA	NA	0.43%
SL-S063	NA	NA	0.94%
SL-S065	NA	0.31%	0.32%
T-FDW050	9.35%	NA	NA
T-FDW060	0.72%	NA	NA
T-FDW061	2.66%	4.05%	NA
T-GEN021	NA	0.04%	0.24%
T-GEN022	NA	NA	0.30%
T-GEN067	1.38%	NA	0.64%
T-GEN069	NA	48.40%	0.59%
T-IORV017	5.39%	3.96%	15.80%
T-IORV018	7.39%	1.32%	19.20%
T-IORV063	16.90%	0.65%	42.00%
T-IORV065	5.70%	4.32%	14.20%
T-LOPP050	3.51%	NA	NA
T-LOPP061	1.57%	NA	NA

Table 11.3-22

Focus Level 1 – Fire Sensitivity Results

Truncation	Level 1 Base Fire	Level 1 Focus Fire	Difference
	CDF	CDF	
1.00E-13	7.366E-09	1.15E-04	1.56E+04
1.00E-14	7.803E-09	1.15E-04	1.47E+04
1.00E-15	8.058E-09	1.15E-04	1.43E+04
Truncation	Level 1 Base Fire	Level 1 RTNSS Fire	Difference
	CDF	CDF	
1.00E-13	7.366E-09	2.35E-07	3.08E+01
1.00E-14	7.803E-09	2.38E-07	2.95E+01
1.00E-15	8.058E-09	2.40E-07	2.87E+01

Table 11.3-23

Focus Level 1 – Flood Sensitivity Results

Truncation	Level 1 Base Flood		Level 1 Focus Flood		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-14	45518	1.622E-09	88884	1.15E-05	7.11E+03
Truncation	Level 1 Base Flood		Level 1 Focus RTNSS		Difference
	# Cutsets	CDF	# Cutsets	CDF	
1.00E-14	45518	1.622E-09	45642	8.90E-09	4.49E+00

Table 11.3-24

Focus Level 1 – High Wind Sensitivity Results

Truncation	Scenario	Level 1 Base High Wind		Level 1 Focus High Wind		Difference
		# Cutsets	CDF	# Cutsets	CDF	
1.00E-14	Tornado F2/F3	42	4.64E-13	609	8.91E-10	1.92E+03
1.00E-14	Tornado F4/F5	144	4.83E-11	146	4.84E-11	4.14E-04
1.00E-14	Hurricane	10235	1.29E-09	23583	1.93E-06	1.50E+03
	TOTAL		1.34E-09		1.94E-06	1.44E+03
Truncation	Scenario	Level 1 Base High Wind		Level 1 RTNSS High Wind		Difference
		# Cutsets	CDF	# Cutsets	CDF	
1.00E-14	Tornado F2/F3	42	4.64E-13	44	4.67E-13	5.17E-03
1.00E-14	Tornado F4/F5	144	4.83E-11	146	4.84E-11	4.14E-04
1.00E-14	Hurricane	10235	1.29E-09	5775	1.71E-09	3.24E-01
	TOTAL		1.34E-09		1.76E-09	3.12E-01

Table 11.3-25

Focus Level 2 – nTSL Results

Truncation	Level 2 Model			Focus Fire Level 2			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.62E-10	7.90E-02	1.220E-08	1.15E-04	1.00	1.15E-04	1.20E+05	1.17E+01	9.43E+03
Truncation	Level 2 Fire Model			RTNSS Fire Level 2			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	4.83E-10	6.00E-02	8.060E-09	4.72E-08	0.197	2.40E-07	9.67E+01	2.28E+00	2.88E+01
Truncation	Focus Fire Level 2			RTNSS Fire Level 2			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	1.15E-04	1.00	1.15E-04	4.72E-08	0.197	2.40E-07	-1.00E+00	-8.03E-01	-9.98E-01

Table 11.3-26

Focus Level 2 – Detailed Model Results

Release Category	Level 2 Base	Level 2 Focus	Level 2 RTNSS
TSL	1.12E-08	2.045E-05	4.819E-06
FR	2.34E-13	NA	3.364E-10
OPW2	7.78E-14	4.797E-04	9.560E-10
OPW1	3.21E-11	2.750E-08	4.942E-10
OPVB	1.57E-11	1.568E-08	4.950E-09
BYP	5.63E-11	1.173E-04	2.987E-08
CCIW	9.92E-11		4.896E-08
CCID	9.02E-13	4.797E-14	9.638E-10
EVE	6.10E-10	1.123E-07	3.115E-09
DCH	0.00E+00		
BOC	1.47E-10	3.791E-07	9.483E-10
Total	1.22E-08	3.220E-04	4.910E-06
nTSL	9.62E-10	1.179E-04	9.060E-08
CCFP	7.90E-02	3.660E-01	1.845E-02

Table 11.3-27

Focus Level 2 – RTNSS Sensitivity Results

Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o DPS		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	1.16E-04	0.403	2.87E-04
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o ARI		
	# Cutsets	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	1.83E-05	0.793	2.31E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/ scram		
	# Cutsets	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	1.59E-06	0.069	2.31E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/ MSIV		
	# Cutsets	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	6.38E-07	0.028	2.31E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o FDW RB		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	1.02E-07	0.019	5.24E-06
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o PIP		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	4.13E-07	0.02	2.11E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o DG A&B		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	9.19E-08	0.019	4.96E-06
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o FAPCS		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	3.42E-07	0.016	2.10E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o FPS Pool		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	1.29E-07	0.026	4.95E-06
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o RCCW		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	3.48E-07	0.017	2.10E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o TCCW		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF

Table 11.3-27

Focus Level 2 – RTNSS Sensitivity Results

1.00E-15	9.06E-08	0.018	4.91E-06	9.06E-08	0.018	4.91E-06
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o PSW		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	3.48E-07	0.017	2.10E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o CWS NI		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	3.48E-07	0.017	2.10E-05
Truncation	Level 2 Focus RTNSS			Level 2 Focus w/o CWS BOP		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	4.91E-06	9.06E-08	0.018	4.91E-06

Table 11.3-28

Focus Level 2 – Fire Sensitivity – nTSL Results

Truncation	Fire Level 2 Model			Focus Level 2 Fire			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	4.83E-10	0.060	8.060E-09	1.15E-04	1.000	1.15E-04	2.38E+05	1.57E+01	1.43E+04
Truncation	Fire Level 2 Model			RTNSS Level 2 Fire			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	4.83E-10	0.060	8.060E-09	4.72E-08	0.197	2.40E-07	9.67E+01	2.28E+00	2.88E+01
Truncation	Focus Level 2 Fire			RTNSS Level 2 Fire			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	1.15E-04	1.000	1.15E-04	4.72E-08	0.197	2.40E-07	-1.00E+00	-8.03E-01	-9.98E-01

Table 11.3-29 Focus Level 2 – Fire Sensitivity –Detailed Model Results			
Release Category	Level 2 Base Fire	Level 2 Focus Fire	Level 2 RTNSS Fire
TSL	1.31E-09	2.29E-07	1.93E-07
FR	1.29E-14	NA	2.10E-11
OPW2	7.95E-13	1.13E-04	2.12E-08
OPW1	1.07E-13	6.39E-10	2.15E-11
OPVB	2.21E-14	3.67E-10	1.11E-10
BYP	7.30E-12	1.37E-06	1.15E-08
CCIW	1.25E-11	2.73E-07	2.02E-09
CCID	1.49E-13	1.68E-07	1.23E-08
EVE	NA	NA	NA
DCH	NA	NA	NA
BOC	4.41E-12	1.54E-11	2.30E-11
Total	1.34E-09	1.15E-04	2.40E-07
nTSL	4.83E-10	1.15E-04	4.72E-08
CCFP	6.00E-02	9.98E-01	1.97E-01

Table 11.3-30

Focus Level 2 – Flood sensitivity – nTSL Results

Truncation	Level 2 Base Flood			Level 2 Focus Flood			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	2.07E-10	1.28E-01	1.620E-09	4.49E-06	0.389	1.15E-05	2.17E+04	2.04E+00	7.10E+03
Truncation	Level 2 Base Flood			Level 2 RTNSS Flood			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	2.07E-10	1.28E-01	1.620E-09	1.23E-09	0.136	9.06E-09	4.94E+00	6.25E-02	4.59E+00
Truncation	Level 2 Focus Flood			Level 2 RTNSS Flood			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	4.49E-06	0.389	1.15E-05	1.23E-09	0.136	9.06E-09	-3.65E+03	-6.50E-01	-9.99E-01

Table 11.3-31

Focus Level 2 – Flood Sensitivity – Detailed Model Results

Release Category	Level 2 Base Flood	Level 2 Focus Flood	Level 2 RTNSS Flood
TSL	1.31E-09	7.05E-06	7.83E-09
FR	1.29E-14	NA	NA
OPW2	7.95E-13	1.68E-09	4.60E-10
OPW1	1.07E-13	3.73E-12	1.44E-12
OPVB	2.21E-14	2.00E-12	1.84E-12
BYP	7.30E-12	4.49E-09	7.66E-10
CCIW	1.25E-11	NA	NA
CCID	1.49E-13	NA	NA
EVE	NA	NA	NA
DCH	NA	NA	NA
BOC	NA	NA	NA
Total	4.41E-12	1.15E-04	9.06E-09
nTSL	2.07E-10	4.49E-06	1.23E-09
CCFP	1.28E-01	3.89E-01	1.36E-01

Table 11.3-32

Focus Level 2 – High Wind Sensitivity – nTSL Results

Scenario	Truncation	Level 2 Base High Wind		Level 2 Focus High Wind		Difference	
		nTSL	CDF	nTSL	CDF	nTSL	CDF
Tornado F2/F3	1.00E-15	0	4.00E-13	8.99E-10	8.92E-10	NA	2.23E+03
Tornado F4/F5	1.00E-15	9.00E-12	4.86E-11	4.88E-11	4.84E-11	4.42E+00	-4.12E-03
Hurricane	1.00E-15	2.10E-11	1.29E-09	3.25E-07	1.93E-06	1.55E+04	1.50E+03
TOTAL		3.00E-11	1.34E-09	3.26E-07	1.94E-06	1.09E+04	1.45E+03
Scenario	Truncation	Level 2 Base High Wind		Level 2 RTNSS High Wind		Difference	
		nTSL	CDF	nTSL	CDF	nTSL	CDF
Tornado F2/F3	1.00E-15	0	4.00E-13	2.26E-15	4.67E-13	NA	1.68E-01
Tornado F4/F5	1.00E-15	9.00E-12	4.86E-11	9.40E-12	4.84E-11	4.44E-02	-4.12E-03
Hurricane	1.00E-15	2.10E-11	1.29E-09	6.81E-11	1.71E-09	2.24E+00	3.26E-01
TOTAL		3.00E-11	1.34E-09	7.75E-11	1.76E-09	1.58E+00	3.13E-01

Table 11.3-33

Focus Level 2 – High Wind Sensitivity – Detailed Model Results

Release Category	Level 2 Base Wind	Level 2 Focus Wind	Level 2 RTNSS Wind
TSL	1.31E-09	1.61E-06	1.68E-09
FR	1.29E-14	NA	7.64E-14
OPW2	7.95E-13	1.24E-09	1.06E-11
OPW1	1.07E-13	2.13E-12	1.07E-13
OPVB	2.21E-14	9.26E-13	2.20E-14
BYP	7.30E-12	3.25E-07	4.75E-11
CCIW	1.25E-11	8.26E-12	1.47E-11
CCID	1.49E-13	NA	1.55E-13
EVE	NA	NA	NA
DCH	NA	NA	NA
BOC	4.41E-12	2.94E-12	4.41E-12
Total	1.34E-09	1.94E-06	1.76E-09
nTSL	3.00E-11	3.26E-06	7.75E-11
CCFP	2.20E-02	1.68E-01	4.40E-02

Table 11.3-34

Focus Level 2 – DPS and ARI Sensitivity – nTSL Results

Truncation	Level 2 Focus			Level 2 Focus w/DPS & ARI			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	3.22E-04	4.19E-07	0.020	2.10E-05	3.62E+00	1.11E-01	-9.35E-01
Truncation	Level 2 Focus			Level 2 Focus Fire w/DPS &ARI			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	3.22E-04	6.98E-08	0.028	2.54E-06	-2.30E-01	5.56E-01	-9.92E-01
Truncation	Level 2 Focus			Level 2 Focus Flood w/DPS &ARI			Difference		
	nTSL	CCFP	CDF	nTSL	CCFP	CDF	nTSL	CCFP	CDF
1.00E-15	9.06E-08	0.018	3.22E-04	3.74E-09	0.118	3.15E-08	-9.59E-01	5.56E+00	-1.00E+00

Table 11.3-35

Focus Level 2 – DPS and ARI Sensitivity – Detailed Model Results

Release Category	Level 2 Base	Level 2 Focus	Level 2 Focus w/DPS & ARI
TSL	1.12E-08	1.72E-05	2.06E-05
FR	2.34E-13	NA	5.89E-09
OPW2	7.78E-14	1.83E-04	6.26E-08
OPW1	3.21E-11	2.77E-08	2.77E-08
OPVB	1.57E-11	1.58E-08	1.57E-08
BYP	5.63E-11	1.18E-04	8.33E-08
CCIW	9.92E-11	3.22E-06	2.22E-07
CCID	9.02E-13	6.41E-08	4.23E-09
EVE	6.10E-10	1.12E-07	5.25E-09
DCH	0.00E+00		
BOC	1.47E-10	3.80E-07	1.74E-09
Total	1.22E-08	3.22E-04	2.10E-05
nTSL	9.62E-10	3.05E-04	4.19E-07
CCFP	0.079	0.946	0.020
Release Category	Level 2 Base Fire	Level 2 Focus Fire	Level 2 Focus Fire w/DPS & ARI
TSL	1.31E-09	2.29E-07	8.31E-07
FR	1.29E-14	NA	5.34E-12
OPW2	7.95E-13	1.13E-04	1.63E-09
OPW1	1.07E-13	6.39E-10	5.39E-10
OPVB	2.21E-14	3.67E-10	3.36E-10
BYP	7.30E-12	1.37E-06	3.72E-08
CCIW	1.25E-11	2.73E-07	NA
CCID	1.49E-13	1.68E-07	3.86E-08
EVE	NA	NA	NA
DCH	NA	NA	NA
BOC	4.41E-12	1.54E-11	2.31E-11
Total	1.34E-09	1.15E-04	2.54E-06
nTSL	4.83E-10	1.15E-04	1.71E-06
CCFP	0.060	0.998	0.672
Release Category	Level 2 Base Flood	Level 2 Focus Flood	Level 2 Focus Flood w/DPS & ARI
TSL	1.31E-09	7.05E-06	2.78E-08
FR	1.29E-14	NA	4.45E-13

Table 11.3-35

Focus Level 2 – DPS and ARI Sensitivity – Detailed Model Results

Release Category	Level 2 Base Flood	Level 2 Focus Flood	Level 2 Focus Flood w/DPS & ARI
OPW2	7.95E-13	1.68E-09	2.29E-09
OPW1	1.07E-13	3.73E-12	7.44E-12
OPVB	2.21E-14	2.00E-12	4.01E-12
BYP	7.30E-12	4.49E-09	1.17E-09
CCIW	1.25E-11	NA	2.57E-10
CCID	1.49E-13	NA	2.50E-12
EVE	NA	NA	NA
DCH	NA	NA	NA
BOC	NA	NA	NA
Total	4.41E-12	1.15E-04	3.15E-08
nTSL	2.07E-10	4.49E-06	3.74E-09
CCFP	0.128	0.389	0.118

Table 11.3-36

Focus Shutdown – CDF Results

Truncation	Shutdown Base	Shutdown Focus	Difference
	CDF	CDF	
1.00E-13	9.20E-09	1.98E-06	2.14E+02
1.00E-14	9.31E-09	1.99E-06	2.13E+02
1.00E-15	9.37E-09	1.99E-06	2.11E+02
Truncation	Shutdown Base	RTNSS Shutdown	% Difference
	CDF	CDF	
1.00E-13	9.20E-09	1.32E-07	1.33E+01
1.00E-14	9.31E-09	1.33E-07	1.33E+01
1.00E-15	9.37E-09	1.33E-07	1.32E+01
Truncation	Shutdown Focus	RTNSS Shutdown	% Difference
	CDF	CDF	
1.00E-13	1.98E-06	1.32E-07	-1.40E+01
1.00E-14	1.99E-06	1.33E-07	-1.40E+01
1.00E-15	1.99E-06	1.33E-07	-1.40E+01

Table 11.3-37

Focus Sensitivity – Fire Sensitivity – CDF Results

Truncation	Base Shutdown Fire	Focus Shutdown Fire	Difference
	CDF	CDF	
1.00E-13	9.20E-09	1.98E-06	2.14E+02
1.00E-14	9.31E-09	1.99E-06	2.13E+02
1.00E-15	9.37E-09	1.99E-06	2.11E+02
Truncation	Base Shutdown Fire	RTNSS Shutdown Fire	Difference
	CDF	CDF	
1.00E-13	9.20E-09	1.32E-07	1.33E+01
1.00E-14	9.31E-09	1.33E-07	1.33E+01
1.00E-15	9.37E-09	1.33E-07	1.32E+01
Truncation	Focus Shutdown Fire	RTNSS Shutdown Fire	Difference
	CDF	CDF	
1.00E-13	1.98E-06	1.32E-07	-9.33E-01
1.00E-14	1.99E-06	1.33E-07	-9.33E-01
1.00E-15	1.99E-06	1.33E-07	-9.33E-01

Table 11.3-38

Focus Shutdown – Flood Sensitivity – CDF Results

Truncation	Base Shutdown Flood CDF	Focus Shutdown Flood CDF	Difference
1.00E-13	9.20E-09	1.98E-06	2.14E+02
1.00E-14	9.31E-09	1.99E-06	2.13E+02
1.00E-15	9.37E-09	1.99E-06	2.11E+02
Truncation	Base Shutdown Flood CDF	RTNSS Shutdown Flood CDF	Difference
1.00E-13	9.20E-09	1.32E-07	1.33E+01
1.00E-14	9.31E-09	1.33E-07	1.33E+01
1.00E-15	9.37E-09	1.33E-07	1.32E+01
Truncation	Focus Shutdown Fire CDF	RTNSS Shutdown Fire CDF	Difference
1.00E-13	1.98E-06	1.32E-07	-1.40E+01
1.00E-14	1.99E-06	1.33E-07	-1.40E+01
1.00E-15	1.99E-06	1.33E-07	-1.40E+01

Table 11.3-39

Focus Shutdown – High Wind Sensitivity – CDF Results

Truncation	Scenario	Base Shutdown High Wind	Focus Shutdown High Wind	Difference
		CDF	CDF	
1.00E-15	Tornado F2/F3	1.20E-11	7.01E-11	4.84E+00
1.00E-15	Tornado F4/F5	1.20E-12	4.61E-12	2.84E+00
1.00E-15	Hurricane	1.18E-09	2.52E-07	2.13E+02
	TOTAL	1.19E-09	2.52E-07	2.11E+02
Truncation	Scenario	BaseShutdown High Wind	RTNSS Shutdown High Wind	Difference
		CDF	CDF	
1.00E-15	Tornado F2/F3	1.20E-11	2.77E-11	1.31E+00
1.00E-15	Tornado F4/F5	1.20E-12	4.61E-12	2.84E+00
1.00E-15	Hurricane	1.18E-09	2.74E-09	1.33E+00
	TOTAL	1.19E-09	2.77E-09	1.33E+00
Truncation	Scenario	Focus Shutdown High Wind	RTNSS Shutdown High Wind	Difference
		CDF	CDF	
1.00E-15	Tornado F2/F3	7.01E-11	2.77E-11	-1.53E+00
1.00E-15	Tornado F4/F5	4.61E-12	4.61E-12	0.00E+00
1.00E-15	Hurricane	2.52E-07	2.74E-09	-9.10E+01
	TOTAL	2.52E-07	2.77E-09	-8.99E+01

Table 11.3-40

Transportation Sensitivity - Assumptions

External Event	Assumption
Aircraft Impact	Accident rate for aircraft is 4.0E-10 per mile.
	A total of approximately 980,000 flights per year (Atlanta Hartsfield Jackson International Airport, 2006)
Transportation	Accident conditional release probability of 0.09 for trucks, 0.2 for rail and 0.023 for barges.
	A total of four major highways are within an approximate width of 9 miles.
All Industrial Accidents	A 10 mile diameter area of interest for chemical storage. Materials stored or situated at a distance of greater than 5 miles from the plant site need not be considered. (RG 1.78)
General Citing	ESBWR facilities occupy approximately 10% of total site or 0.014 square miles.

Table 11.3-41

Transportation Sensitivity – Aircraft Impacts

Probability		$\frac{Accidentrate * \# flights * facilityarea}{widthairway}$	
Accident Rate for Aircraft	=	4.00E-10	per mile
Number of flights	=	980,000	
Area of ESBWR facility	=	0.014	sq. mi.
Airway width	=	9	mi
Frequency		1.52E-07	per year
Scenario 1	Aircraft impact results in station blackout		
Frequency		1.52E-07	per year
Level 1 PRA CCDP	=	8.61E-08	per year
CDF	=	1.31E-14	per year
Scenario 2	Aircraft impact results in station blackout and loss of non-safety systems		
Frequency		1.52E-07	per year
Level 1 PRA CCDP	=	1.27E-04	per year
CDF	=	1.94E-11	per year

Table 11.3-42

Transportation Sensitivity – Marine Accidents

Probability	$ReleaseFrequency * CCDP$		
Scenario 1	Explosion from barge.ship results in complete loss of service water		
	Frequency	1.13E-04	per year
Level 1 PRA CCDP	=	9.33E-09	per year
CDF	=	1.05E-12	per year
Scenario 2	Marine accident resulting in release of toxic materials		
	Chemical Release Rate	1.00E-02	per year
Level 1 PRA CCDP	=	9.33E-09	per year
CDF	=	1.03E-12	per year

Table 11.3-43

Transportation Sensitivity – Vehicle Accidents

Probability	=	$\text{Re}\,leaseFrequency * CCDP$	
Scenario 1	Toxic chemical release from vehicle accident		
	Frequency	1.52E-05	per year
Level 1 PRA CCDP	=	9.33E-09	per year
CDF	=	1.42E-13	per year

Table 11.3-44

Transportation Sensitivity – Railroad Accidents

Probability	=	$\mathrm{Re}\, leaseFrequency * CCDP$	
Scenario 1	Toxic chemical release from railcar accident		
	Frequency	9.00E-05	per year
Level 1 PRA CCDP	=	9.33E-09	per year
CDF	=	8.40E-13	per year

Table 11.3-45 Fire Sensitivity – Fire Barrier Importance Based on Full-Power CDF Cutsets			
Event Name (see note)	**Probability**	**FV**	**RAW**
FB_F1210_F1150	2.70E-03	9.13E-05	1.03
FB_F1220_F1162	2.70E-03	4.15E-04	1.15
FB_F1220_F1203	1.20E-03	1.55E-04	1.13
FB_F1230_F1152	2.70E-03	2.92E-05	1.01
FB_F1230_F1210	7.40E-03	2.58E-04	1.03
FB_F1230_F1220	7.40E-03	1.56E-03	1.21
FB_F1230_F1262	1.20E-03	9.86E-06	1.01
FB_F1240_F1160	2.70E-03	3.20E-04	1.12
FB_F1240_F1210	7.40E-03	2.51E-04	1.03
FB_F1240_F1220	7.40E-03	1.53E-03	1.2
FB_F1311_F1150	2.70E-03	6.06E-04	1.22
FB_F1311_F1210	2.70E-03	6.79E-04	1.25
FB_F1321_F1162	2.70E-03	5.80E-04	1.21
FB_F1321_F1203	7.40E-03	4.87E-03	1.65
FB_F1321_F1220	2.70E-03	2.18E-03	1.8
FB_F1331_F1152	2.70E-03	3.46E-04	1.13
FB_F1331_F1203	7.40E-03	4.17E-03	1.56
FB_F1331_F1230	2.70E-03	3.62E-04	1.13
FB_F1331_F1311	7.40E-03	3.67E-03	1.49
FB_F1341_F1160	2.70E-03	2.64E-03	1.98
FB_F1341_F1240	2.70E-03	3.55E-04	1.13
FB_F1341_F1311	7.40E-03	3.66E-03	1.49
FB_F1341_F1321	7.40E-03	3.61E-03	1.48
FB_F3110_F3100	7.40E-03	3.22E-04	1.04
FB_F3110_F3270	2.70E-03	1.17E-04	1.04
FB_F3120_F3101	7.40E-03	3.19E-04	1.04
FB_F3120_F3270	1.20E-03	5.18E-05	1.04
FB_F3130_F3101	7.40E-03	9.92E-07	1
FB_F3130_F3110	1.20E-03	1.22E-04	1.1
FB_F3140_F3100	7.40E-03	9.92E-07	1
FB_F3140_F3120	1.20E-03	1.21E-04	1.1
FB_F3301_F3100	7.40E-03	1.90E-04	1.03
FB_F3301_F3101	2.70E-03	6.76E-05	1.02
FB_F3301_F3110	1.20E-03	2.44E-04	1.2
FB_F3301_F3130	1.20E-03	8.34E-05	1.07
FB_F3301_F3270	1.20E-03	2.98E-05	1.02

Table 11.3-45

Fire Sensitivity – Fire Barrier Importance Based on Full-Power CDF Cutsets

FB_F3302_F3100	7.40E-03	2.10E-04	1.03
FB_F3302_F3110	1.20E-03	3.21E-04	1.27
FB_F3302_F3130	1.20E-03	1.47E-04	1.12
FB_F3302_F3270	1.20E-03	3.26E-05	1.03
FB_F3302_F9150	1.20E-03	4.93E-04	1.41
FB_F4100_F1770	1.20E-03	1.03E-03	1.86
FB_F4100_F4250	7.40E-03	1.28E-03	1.17
FB_F4100_F4260	7.40E-03	5.68E-04	1.08
FB_F4100_F4350	7.40E-03	5.55E-04	1.07
FB_F4100_F4360	7.40E-03	5.55E-04	1.07
FB_F4100_F4550	7.40E-03	5.64E-04	1.08
FB_F4100_F4560	7.40E-03	5.64E-04	1.08
FB_F4100_F4651	7.40E-03	5.55E-04	1.07
FB_F4100_F4661	7.40E-03	5.55E-04	1.07
FB_F4103_F4100	7.40E-03	8.31E-04	1.11
FB_F5550_F5100	7.40E-03	3.55E-04	1.05
FB_F5550_F5350	1.20E-03	5.46E-05	1.05
FB_F5550_F5650	2.70E-03	1.26E-04	1.05
FB_F5560_F5100	7.40E-03	6.36E-04	1.09
FB_F5560_F5360	1.20E-03	8.82E-06	1.01
FB_F5560_F5660	2.70E-03	2.11E-05	1.01
FB_F9160_F9150	1.20E-03	2.84E-02	24.64
FB_FDPS_F3301	7.40E-03	5.32E-02	8.13
	Total FV	**0.125**	

Table 11.3-46

Fire Sensitivity – fire Barrier Importance Based on Full-Power LRF Cutsets

Event Name (see note)	Probability	FV	RAW
FB_F1210_F1150	2.70E-03	3.95E-05	1.01
FB_F1220_F1162	2.70E-03	7.26E-03	3.68
FB_F1220_F1203	1.20E-03	2.71E-03	3.25
FB_F1230_F1152	2.70E-03	1.16E-05	1
FB_F1230_F1210	7.40E-03	4.52E-03	1.6
FB_F1230_F1220	7.40E-03	2.73E-02	4.66
FB_F1230_F1262	1.20E-03	0.00E+00	1
FB_F1240_F1160	2.70E-03	4.17E-03	2.54
FB_F1240_F1210	7.40E-03	4.39E-03	1.58
FB_F1240_F1220	7.40E-03	2.68E-02	4.58
FB_F1311_F1150	2.70E-03	6.46E-05	1.02
FB_F1311_F1210	2.70E-03	3.00E-04	1.11
FB_F1321_F1162	2.70E-03	5.35E-05	1.02
FB_F1321_F1203	7.40E-03	8.42E-04	1.11
FB_F1321_F1220	2.70E-03	3.81E-02	15.05
FB_F1331_F1152	2.70E-03	2.31E-04	1.09
FB_F1331_F1203	7.40E-03	7.47E-04	1.1
FB_F1331_F1230	2.70E-03	1.69E-05	1.01
FB_F1331_F1311	7.40E-03	4.99E-03	1.67
FB_F1341_F1160	2.70E-03	3.40E-02	13.55
FB_F1341_F1240	2.70E-03	1.69E-05	1.01
FB_F1341_F1311	7.40E-03	4.98E-03	1.66
FB_F1341_F1321	7.40E-03	4.90E-03	1.65
FB_F3110_F3100	7.40E-03	5.64E-05	1.01
FB_F3110_F3270	2.70E-03	2.07E-05	1.01
FB_F3120_F3101	7.40E-03	5.59E-05	1.01
FB_F3120_F3270	1.20E-03	9.16E-06	1.01
FB_F3130_F3101	7.40E-03	0.00E+00	1
FB_F3130_F3110	1.20E-03	1.78E-05	1.01
FB_F3140_F3100	7.40E-03	0.00E+00	1
FB_F3140_F3120	1.20E-03	1.78E-05	1.01
FB_F3301_F3100	7.40E-03	1.16E-05	1
FB_F3301_F3101	2.70E-03	0.00E+00	1
FB_F3301_F3110	1.20E-03	3.23E-05	1.03
FB_F3301_F3130	1.20E-03	0.00E+00	1
FB_F3301_F3270	1.20E-03	0.00E+00	1

Table 11.3-46

Fire Sensitivity – fire Barrier Importance Based on Full-Power LRF Cutsets

Event Name (see note)	Probability	FV	RAW
FB_F3302_F3100	7.40E-03	1.30E-05	1
FB_F3302_F3110	1.20E-03	3.47E-05	1.03
FB_F3302_F3130	1.20E-03	0.00E+00	1
FB_F3302_F3270	1.20E-03	0.00E+00	1
FB_F3302_F9150	1.20E-03	2.10E-03	2.74
FB_F4100_F1770	1.20E-03	2.01E-04	1.16
FB_F4100_F4250	7.40E-03	1.98E-03	1.26
FB_F4100_F4260	7.40E-03	7.17E-04	1.1
FB_F4100_F4350	7.40E-03	7.17E-04	1.1
FB_F4100_F4360	7.40E-03	7.17E-04	1.1
FB_F4100_F4550	7.40E-03	7.17E-04	1.1
FB_F4100_F4560	7.40E-03	7.17E-04	1.1
FB_F4100_F4651	7.40E-03	7.17E-04	1.1
FB_F4100_F4661	7.40E-03	7.17E-04	1.1
FB_F4103_F4100	7.40E-03	1.08E-03	1.14
FB_F5550_F5100	7.40E-03	1.49E-05	1
FB_F5550_F5350	1.20E-03	0.00E+00	1
FB_F5550_F5650	2.70E-03	2.41E-06	1
FB_F5560_F5100	7.40E-03	5.59E-05	1.01
FB_F5560_F5360	1.20E-03	0.00E+00	1
FB_F5560_F5660	2.70E-03	3.86E-06	1
FB_F9160_F9150	1.20E-03	5.98E-02	50.72
FB_FDPS_F3301	7.40E-03	1.22E-02	2.63
	Total FV	**0.249**	

Table 11.3-47
Fire Sensitivity – full Power fire CDF Sensitivity Results for Fire Barrier Failure Probabilities

Fire Barrier	FV_CDF	Base CDF Contribution	RAW_CDF	CDF if Failed (Prob =1)	%CDF Increase if Failed	CDF if Prob = 0.1	CDF Increase if Prob = 0.1
FB_F9160_F9150	2.84E-02	2.288E-10	24.64	1.985E-07	2364%	2.690E-08	234%
FB_F1321_F1220	2.18E-03	1.757E-11	1.8	1.450E-08	80%	8.690E-09	8%
FB_F1341_F1160	2.64E-03	2.127E-11	1.98	1.595E-08	98%	8.825E-09	10%
FB_F1230_F1220	1.56E-03	1.257E-11	1.21	9.750E-09	21%	8.215E-09	2%
FB_F1240_F1220	1.53E-03	1.233E-11	1.2	9.670E-09	20%	8.212E-09	2%
FB_FDPS_F3301	5.32E-02	4.287E-10	8.13	6.551E-08	713%	1.342E-08	67%
FB_F1220_F1162	4.15E-04	3.344E-12	1.15	9.267E-09	15%	8.333E-09	3%

Table 11.3-48
Fire Sensitivity – Full-Power fire LRF Sensitivity results for Fire Barrier Failure Probabilities

Fire Barrier	FV_LRF	Base LRF Contribution	RAW_LRF	LRF if Failed (Prob =1)	%LRF Increase if Failed	LRF if Prob =0.1	LRF Increase if Prob = 0.1
FB_F9160_F9150	5.98E-02	2.754E-11	50.72	2.336E-08	4972%	2.725E-09	492%
FB_F1321_F1220	3.81E-02	1.755E-11	15.05	6.931E-09	1405%	1.092E-09	137%
FB_F1341_F1160	3.40E-02	1.566E-11	13.55	6.240E-09	1255%	1.024E-09	122%
FB_F1230_F1220	2.73E-02	1.257E-11	4.66	2.146E-09	366%	6.176E-10	34%
FB_F1240_F1220	2.68E-02	1.234E-11	4.58	2.109E-09	358%	6.145E-10	33%
FB_FDPS_F3301	1.22E-02	5.618E-12	2.63	1.211E-09	163%	5.304E-10	15%
FB_F1220_F1162	7.26E-03	3.343E-12	3.68	1.695E-09	268%	5.808E-10	26%

Table 11.3-49 Fire Sensitivity – Fire Barrier Importance Based on Shutdown CDF Cutsets			
Event Name (see note)	**Probability**	**FV**	**RAW**
FB_F1152_F1162	7.40E-03	1.56E-02	3.09
FB_F3301_F3302	1.10E-04	3.45E-04	4.13
FB_F4250_F4260	1.20E-03	1.14E-03	1.94
FB_F4350_F4360	1.20E-03	1.35E-04	1.11
FB_F5550_F5560	1.60E-04	1.23E-04	1.77
FB_F9150_F9160	1.20E-03	5.29E-05	1.04

Note: The fire barriers are named as "FB_FXXXX_FYYYY." The first two letters "FB" denotes fire barrier. "FXXXX" and "FYYYY" denote the two fire areas connected by the subject fire barrier.

Table 11.3-50

Fire Sensitivity – Shutdown fire CDF Sensitivity Results for Fire Barrier Failure Probabilities

Fire Barrier	FV_CDF	Base CDF Contribution	RAW_CDF	CDF if Failed (Prob =1)	%CDF Increase if Failed	CDF if Prob = 0.1	CDF Increase if Prob = 0.1
FB_F1152_F1162	1.56E-02	4.231E-10	3.09	8.380E-08	209%	3.242E-08	20%
FB_F3301_F3302	3.45E-04	9.356E-12	4.13	1.120E-07	313%	3.560E-08	31%
FB_F4250_F4260	1.14E-03	3.092E-11	1.94	5.261E-08	94%	2.965E-08	9%
FB_F4350_F4360	1.35E-04	3.661E-12	1.11	3.010E-08	11%	3.590E-08	32%
FB_F5550_F5560	1.23E-04	3.336E-12	1.77	4.800E-08	77%	2.919E-08	8%
FB_F9150_F9160	5.29E-05	1.435E-12	1.04	2.820E-08	4.0%	2.724E-08	0.4%

Table 11.3-51

Fire Sensitivity – Shutdown fire CDF Sensitivity results for Fire Area F7300

Shutdown Fire Scenarios	Baseline Initiating Event Frequency	Baseline CCDP	Baseline CDF	Initiating Event Frequency for Sensitivity	Shutdown Fire CDF for Sensitivity
F7300_M5	1.42E-04	1.60E-06	2.282E-10	7.12E-06	1.14E-11
F7300_M5O	3.56E-05	1.59E-06	5.649E-11	1.78E-06	2.82E-12
F7300_M6U	4.45E-05	1.62E-04	7.232E-09	2.23E-06	3.62E-10
F7300 Total	**2.23E-04**		**7.517E-09**	**1.11E-05**	**3.76E-10**

OTHER SENSITIVITIES

In addition to the sensitivities provide herein Section 11, several other sensitivities were conducted. Table 11.4-1 provides a listing and location for these additional sensitivities.

Table 11.4-1

Other Sensitivities

Sensitivity Title	Section
Shutdown LOCA Frequency	Section 12
Shutdown DW Hatch – 50% Failure Rate	Section 12
Shutdown DW Hatch – 1% Failure Rate	Section 12
Shutdown DW Hatch – Closed M5	Section 12
Shutdown Operator Actions True	Section 12
Shutdown Operator Actions Equal 1.00E-3	Section 12
Offsite Consequences Sensitivity to MET Conditions, Release Elevation, Release Energetics, and Mission Time	Section 10

11.5 UNCERTAINTY ANALYSIS

An uncertainty analysis was conducted for the Level 1 PRA model. The purpose of the uncertainty analysis is to show point estimate CDF calculated elsewhere is an appropriate representation of the plant risk given the input.

The following assumptions were associated with the uncertainty analysis:

- Lognormal distribution was assumed for all basic events;
- An error factor of 5 was assumed for all human error probabilities;
- An error factor of 10 was assumed for all common cause events; and
- A lognormal distribution and error factors of ten were assumed for the CCF special common cause events.

These results show that the CDF distribution is below the NRC goals of 1E-04 for CDF and that numerical uncertainty presents no impact to the Level 1 PRA mode,

A Latin Hypercube sampling method was used to perform the calculation and generate a CDF density function and cumulative function. The uncertainty distribution and error factors are captured in the type code (TC) table of the modified Level 1 PRA database. The database was modified so that common cause failure events can be associated with the corresponding failure rate in the type code table of the database. A sample size of 30,000 was used to generate these functions and associated results. The point estimate CDF of 1.14E-08/yr was generated based on the sample size. Graphical results, as well as the uncertainty values (mean, 5%, 50%, 95%) for the uncertainty are shown in Figure 11.5-1 and 11.5-2.

These results show that the CDF distribution is below the NRC goals of 1E-04 for CDF and that numerical uncertainty presents no impact to the Level 1 PRA mode,

Table 11.5-1

Uncertainty Analysis – Density Function

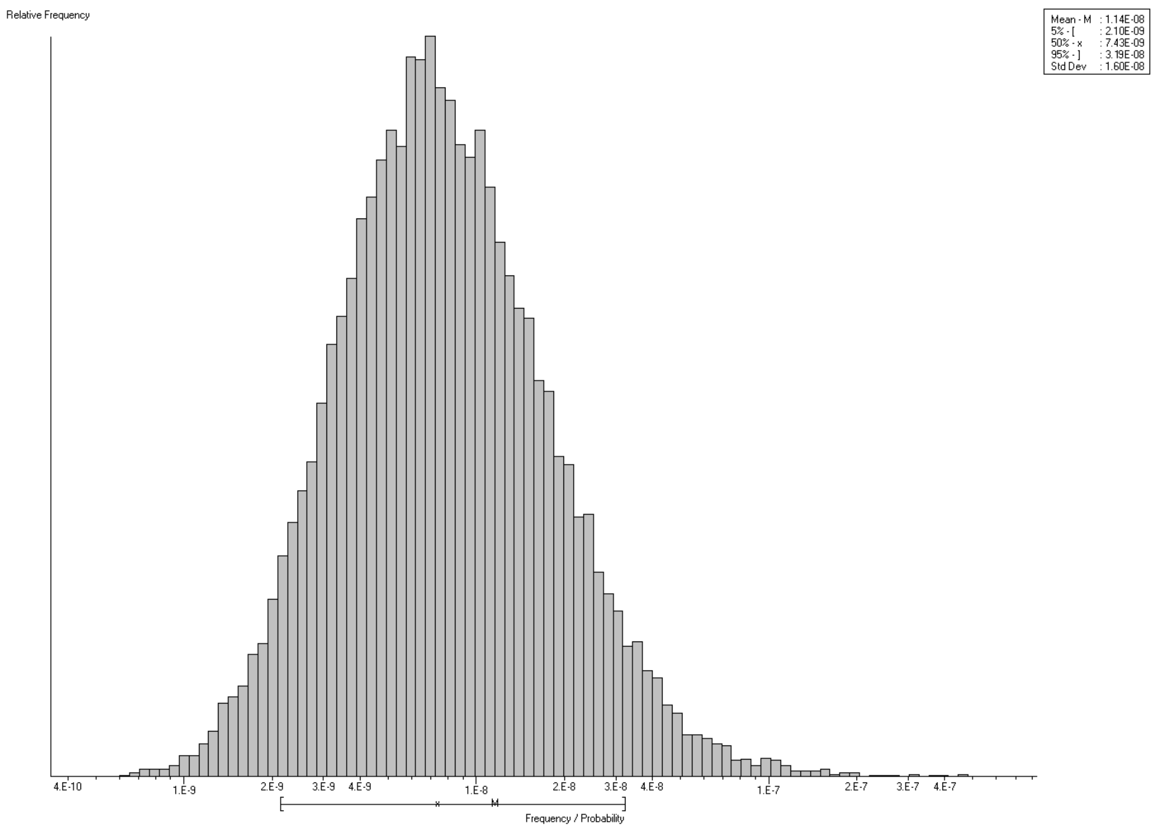
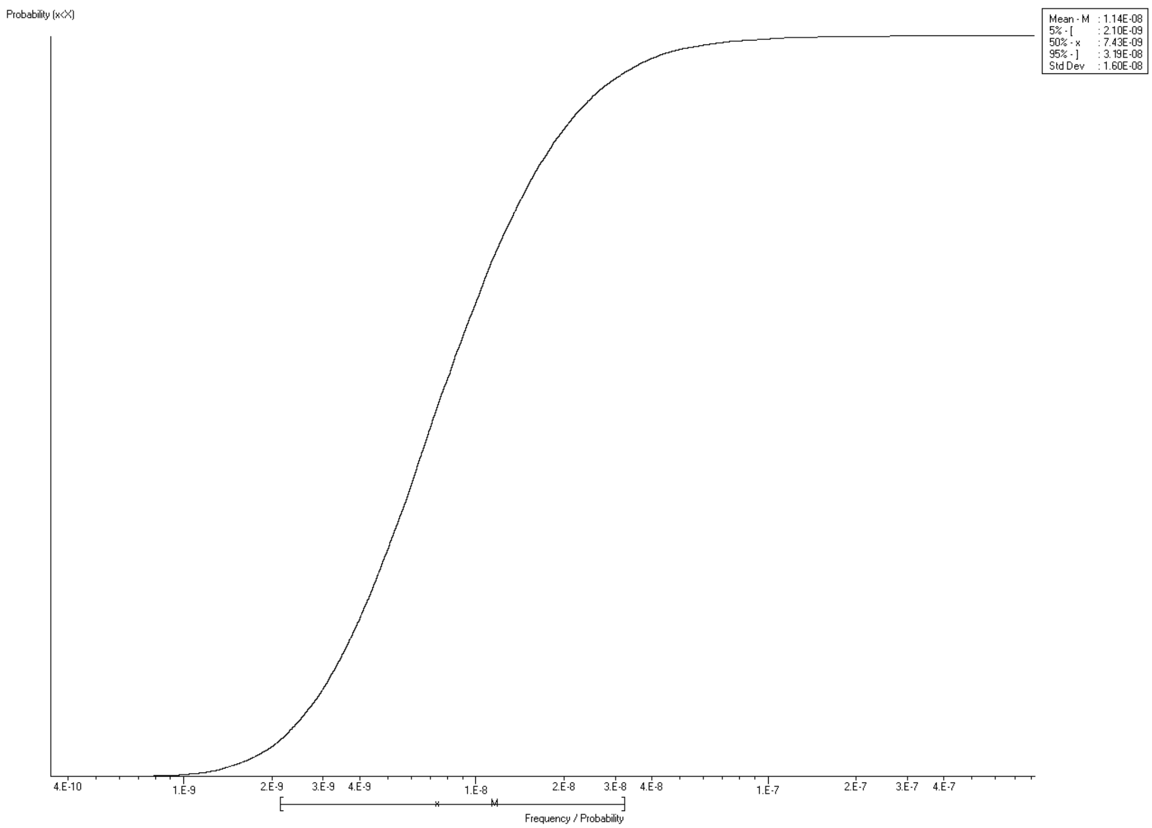


Table 11.5-2

Uncertainty Analysis – Cumulative function



11.6 CONCLUSIONS & INSIGHTS

- The ESBWR core damage frequency (CDF) is dominated by common cause failure (CCF). The non-CCF CDF is primarily a result of irrecoverable vessel or line failures, or break outside containment RWCU combined with failure of low-pressure injection.
- The PRA model conservatively assumes that a single failure on either train of SLC caused core damage if the control rods fail to insert (ATWS). The CDF would be reduced significantly if either train of SLC is able to mitigate ATWS scenarios.
- Accumulator failures can significantly increase the CDF, which warrants future consideration for providing alarm/indication for the accumulator pressure and operator response to low pressure to mitigate the risk of accumulator failures.
- Pre-initiators have more significant impact on the RAW value than post initiators. This is primarily due to the large number of potential latent failures. The post-initiator HRA screening values are relatively high. As expected, the post-initiator HRA values have a high FV, but a relatively lower impact on RAW
- Changes to squib valve failure data, particularly when used for the ADS and GDCS functions, have significant impact due to their contribution to passive safety features.
- Relocation of the CIS node to the first position in the Containment Event Trees (CET) has a negligible impact on Level 2 results.
- Vacuum breaker and back-up valve failure rates do not have significant impact on CDF, but have significant impact on Level 2 results. Steam suppression failures generally lead to core damage states against which mitigation is not credited in the PRA..
- The risk associated with accidents in nearby facilities including industrial accidents, military accidents, pipeline or hydrogen storage, and transportation accident low and do not warrant further evaluation. The risk is low primarily due to robust design of the ESBWR, and the passive nature of the highly redundant systems.
- The ESBWR Level 1 PRA core damage frequency is significantly impacted if the non-safety related systems are not credited. If credit is taken for all the RTNSS systems, the focused Level 1 PRA results can be reduced significantly. Crediting the Diverse Protection System (DPS) as the only non-safety related system, the impact to CDF can also be significantly minimized.
- Crediting the DPS and ARI functions along with the safety-related systems, the ESBWR LRF can be significantly reduced to satisfy the NRC goal of 1E-06/yr for LRF in the internal events, fire, and flooding Level 2 PRA models.
- The ESBWR High Winds core damage frequency is dominated by hurricanes in all cases (Baseline, Focus, and RTNSS). Even if all non-safety related systems credited in the Level 1 High Winds PRA are assumed to be unavailable, the analyses results still meet the NRC goal of 1E-04/yr for CDF.
- The ESBWR Level 1 full-power Fire PRA CDF is significantly impacted if non-safety-related systems are not credited. The CDF does not meet the NRC goal of CDF less than 1E-04/yr. However, the fire analysis is very conservative in that it takes no credit for fire

suppression and fire severity factors. The fire CDF without credit for the non-safety related systems will meet the threshold value by removing some of these conservatisms.

- The ESBWR Level 2 PRA results are significantly impacted if non-safety related systems are not credited. The LRF does not meet the NRC goal of 1E-06/yr and CCFP < 10%. The Diverse Protection System (DPS) and Alternate Rod Insertion (ARI) system can significantly reduce LFR as part of the RTNSS program.
- The ESBWR Level 2 flooding PRA results are significantly impact if non-safety related systems are not credited. The LRFNRC goal of 1E-06/yr and CCFP < 10%. If credit is taken for RTNSS systems, the flooding Level 2 results can nearly meet the ESBWR design goals.

11.7 REFERENCES

11-1 USA Today Online. "FAA: Atlanta's Airport is Nation's Busiest". Posted January 4th, 2007 by Daniel Yee.

11-2 Regulatory Guide 1.78, "Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release". December 2001.

11-3 Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants". February 1978.

11-4 NRC Review Standard RS-200. "Processing Applications for Early Site Permits".

11-5 NUREG-1840. "Safety Evaluation of Early Site Permit Application in the Matter of System Energy Resources, Inc., a Subsidiary of Entergy Corporation, for the Grand Gulf Early Site Permit Site". April 2006.

11-6 NUREG/CR-6642. "Recommendations for Revision of Regulatory Guide 1.78", November 1999.

Table 11-3 Results of the 72-Hour Mission Time Sensitivity Analysis (Deleted)

Table 11-4 Sensitivity Analysis Results Compilation (Deleted)

Table 11-5 Focused Level 2 Node Probabilities (Deleted)

Table 11-4 Focused Level 2 End State Frequencies (Deleted)

Table 11-5 Top 50 Cutsets for RTNSS Sensitivity Analysis (Deleted)

Figure 11-1. Uncertainty Distribution Level 1, Internal Events (Deleted)

Figure 11-2. Cumulative Distribution Function Level 1, Internal Events (Deleted)

Figure 11-3. Class III without LOPP CPET for RTNSS Sensitivity (Deleted)

Figure A.11-1. Class II CCV for Transients, Except Loss of Service Water and Power (Deleted)

Figure A.11-2. Class II CCV for Loss of Service Water (Deleted)

Figure A.11-3. Class II CCV for Loss of Preferred Power (Deleted) (A)

Figure A.11-4. Class II CCV for Loss of Preferred Power (B) (Deleted)

Figure A.11-5. Class II CCV for Large LOCA (Deleted)

Figure A.11-6. Class II CCV for Large LOCA in Feedwater Line A (Deleted)

Figure A.11-7. Class II CCV for Large LOCA in Feedwater Line B (Deleted)

Figure A.11-8. Class II CCV for Medium Liquid LOCA (Deleted)

Figure A.11-9. Class II CCV for Medium Liquid LOCA in RWCU (Deleted)

Figure B.11-1. General Transient (Deleted)

Figure B.11-2. Transient with PCS Unavailable (Deleted)

Figure B.11-2a. Transient with PCS Unavailable after BOC in IC or MS (Deleted)

Figure B.11-3. Loss of Feedwater Transient (Deleted)

Figure B.11-4. Loss of Service Water System (Deleted)

Figure B.11-5. Loss of Preferred Power Transient (Deleted)

Figure B.11-6. Inadvertent Opening of a Relief Valve (Deleted)

Figure B.11-7. ATWS from General Transient (Deleted)

Figure B.11-7a. ATWS from Loss of Preferred Power (Deleted)

Figure B.11-8. ATWS from Transient Loss of PCS (Deleted)

Figure B.11-8a. ATWS from Loss of PCS after BOC in IC or MS (Deleted)

Figure B.11-9. ATWS from Transient with Loss of Feedwater System (Deleted)

Figure B.11-10. ATWS from Transient with Loss of Service Water System (Deleted)

Figure B.11-11. ATWS from Inadvertent Opening of a Relief Valve (Deleted)

Figure B.11-11a. ATWS from Small LOCA above Reactor Core (Deleted)

Figure B.11-12. Large Steam Breaks (above L3) other than Feedwater Lines (Deleted)

Figure B.11-13. Large Steam Breaks (above L3) in FDW (A) Line (Deleted)

Figure B.11-14. Large Steam Breaks (above L3) in FDW (B) Line (Deleted)

Figure B.11-15. Small Steam Breaks (above L3) (Deleted)

Figure B.11-16. Medium Liquid Breaks (below L3) other than RWCU/SDC Lines (Deleted)

Figure B.11-17. Medium Liquid Breaks (below L3) in RWCU/SDC Lines (Deleted)

Figure B.11-18. Small Liquid LOCA (below L3) other than RWCU/SDC Lines (Deleted)

Figure B.11-19. Small Liquid LOCA (below L3) in RWCU/SDC Lines (Deleted)

Figure B.11-20. Reactor Vessel Rupture (Deleted)

Figure B.11-20a. Reactor Vessel Rupture after Loss of Preferred Power (Deleted)

Figure B.11-21. Steam Break Outside Containment in Main Steam Lines (Deleted)

Figure B.11-22. Steam Break Outside Containment in FDW A Line (Deleted)

Figure B.11-23. Steam Break Outside Containment in FDW B Line (Deleted)

Figure B.11-24. Large Steam Break Outside Containment in IC Lines (Deleted)

Figure B.11-25. Large Liquid Break Outside Containment in RWCU/SDC Lines (Deleted)