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Loss of Essential Service Water in LWRs (GI-153)

Scoping Study

Prepared by
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Sandia National Laboratories
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ABSTRACT

The contribution of essential service water (ESW) system failure to core damage frequency has long been a concern of the NRC. The objective of this study is to assess the safety significance of the loss of ESW systems in LWRs relative to core damage frequency (CDF) and perform a limited value/impact analysis of potential modifications to solve ESW vulnerabilities using a prototypical (pilot) plant. Previous studies indicate that service water systems contribute from <1% to 65% of the total internal CDF. For the pilot plant analyzed, common ESW vulnerabilities are failure of standby service water pumps to start, backflow through check valves for cross-tied pumps, and failure of normally closed isolation valves in diesel generator cooling loops to open on demand. For the potential modifications evaluated for the pilot plant, the results showed that they could reduce the CDF by as much as 33 percent. However, the dollars per person REM measures resulting from various groups of these modifications significantly exceeded the current criteria of $1000. The results, since they only apply to the pilot plant, are not typical of all LWRs. Due to the importance of service water to CDF and the plant specific nature of ESW systems, there could be plants for which there would be cost-effective modifications. Additional analysis would be required to identify them.

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EXECUTIVE SUMMARY

The reliability of essential service water (ESW) systems and related problems has been a concern of the Nuclear Regulatory Commission (NRC) and the nuclear industry for many years. Operational experience shows significant failures such as fouling mechanisms, single failures and other design deficiencies, flooding, multiple equipment failures, and operator or procedural errors. The objectives of this study are to assess the safety significance of the loss of ESW systems in light water reactors (LWRs) and the corresponding contributions to core damage frequencies (CDF), and to perform a limited value/impact study on a prototypical plant.

A review of the contribution to CDF of ESW system failures for internal events only, in 20 PRAs shows that the average contribution is:

PWRs "old"	12%	BWRs	"old"	36%
PWRs "new"	7%	BWRs	"new"	15%

There were wide variations in the contribution made by service water for the eleven plant PRAs considered in this study. The variation was from <1% to 65%, indicating that the impact of service water systems on plant risk is plant-specific. The reasons for the broad range found are the degree of dependency a plant has on service water, the reliability of the service water systems themselves, and, to some extent, the differences in the NRC-sponsored PRAs in terms of modeling assumptions and scope of each PRA program.

The service water system dominant failure modes found from the review of the eleven NRC-sponsored PRAs tend to have some commonality between the plants even though the service water system configuration for each plant reviewed is unique. Two common service water faults found were the dependency of the service water system on motor-operated or air-operated isolation valves to open on demand to supply cooling water to safety related loads and failure of the standby service water pumps to start. Two subtle failure modes identified in the NUREG/CR-4550 program were found to be dominant failure modes for three of the plants reviewed. These subtle failures are (1) the failure to isolate nonessential cooling water loads; and (2) pump discharge check valve back flow failing cross-tied pumps.

The prototypical or pilot plant was selected relative to several criteria including the following:

1. One of the NRC sponsored PRAs with relatively current methods and fault trees in a computer format, e.g., IRRAS.

2. The PRA results indicate ESW systems are a significant contributor to CDF.

3. The plant represents a large group of units.

4. The ESW system is representative of a large group of ESW systems and the analysis includes common failures found at other plants.

The plant selected was a BWR 4 MK I analyzed in NUREG-1150 and described in detail in NUREG/CR-4550.

The pilot plant study has several limitations and assumptions. External events are discussed but not included in the quantitative analysis. The service water system analyzed is referred to as the Emergency Service Water (ESW) system. Failure of this system as an initiating event was not important at the pilot plant due to the dominance of loss of offsite power and was therefore not included in the quantitative analysis. However, such an initiator could be important at other plants. The ESW and Emergency Heat Sink (EHS) are dominant contributors to the blackout sequences at the pilot plant due to the dependence of other systems, such as the emergency diesel generators and room cooling, on these systems. The mapping from plant damage states to consequences was taken from NUREG/CR-4551 without detailed reanalysis, and the costs of the modifications proposed were extrapolated from TAP A-45 (Decay Heat Removal) without contact with the utility or detailed drawings. Costs were increased from the TAP A-45 estimates using the consumer price index (CPI) from 1985 to 1992 but the value/impact analysis still uses the $1000/person-REM.

The pilot plant analysis was accomplished by identifying ESW vulnerabilities and developing modifications to address them. The effects of one or more of these modifications were then incorporated into the service water fault trees by changing the appropriate event frequencies. As a result, only requantification was required. This procedure was carried out using the dominant cut sets from the NUREG/CR-4550 results as included in the available IRRAS model. There were three dominant accident sequences including service water that were significant as shown in the following table:

Accident Sequence	Sequence CDF[1] (/RX yr)	Sequence % of Total CDF	ESW Contribution	ESW % of Total CDF
T1-BNU11	1.64E-06	36.4	8.39E-07	19
T1-P1BNU11	1.31E-07	2.9	7.34E-08	2
T1-BU11NU21	1.25E-07	2.7	5.88E-08	1

[1]Mean values

These are all station blackout sequences to which the service water systems contribute as described earlier. In addition, these sequences include almost all the cut sets considered in the entire internal analysis. All these sequences fell into the same plant damage state.

Five service water vulnerabilities were identified from these accident sequences as shown below.

The inputs to the value/impact analysis and the results for the $/person REM measure are shown on the next page.

While the $/person REM are high relative to the currently used criteria of $1000/person REM, the results from TAP A-45 were also generally high. The pilot plant may be better than many other plants in the US nuclear industry relative to service water vulnerabilities. Furthermore, if external events were included in the quantitative analysis the value/impact measure could become more favorable.

Vulnerability	Description	% Contribution to Total CDF
1	Operator fails to operate the emergency heat sink (EHS).	14
2	Failure to restore ESW components after maintenance.	1
3	Pump discharge check valve failures fail cross-tied ESW pumps.	4
4	ESW pump hardware faults.	<1
5	Failure of ESW to cool the EDGs due to AOV failures.	2

There were seven modifications developed to address these vulnerabilities. One consisted of additional operator training, revised procedures, and additional alarms. Another was increased testing frequency. The remainder were various hardware additions or modifications.

These modifications can address one or more vulnerabilities so they were grouped into five alternatives for the system analysis and value/impact analysis.

In any case, the methods were demonstrated and the ESW systems were assessed to be significant contributors to CDF; e.g., 22 percent at the pilot plant.

In summary, although this study looked at only one plant in any detail, it verified the concern relating to the reliability of ESW. The study also showed that the impact of service water on plant risk is plant specific.

Alternative	ΔCDF	Percent Improvement in CDF	Risk (ΔDose) Person REM/R yr.	Results for Offsite and Onsite costs $/Person REM
1	4.80E-07	10.3	1.07	134K
2	5.80E-07	12.4	1.29	158K
3	1.54E-06	33.0	3.44	45K
4	1.46E-06	31.3	3.26	283K
5	1.06E-06	22.7	2.36	529K

For the plant considered, modifications to reduce the vulnerabilities were developed. However, the cost of implementing the modifications was found to be high in terms of the benefit provided. Other plants would need to be analyzed to determine if this is a generic conclusion.

1.0 Introduction and Methodology

1.1 Historical Background

The reliability of the essential service water (ESW) system and related problems have been a concern of the NRC and the nuclear industry for years. The NRC concerns have been expressed in research reports,[1,2] bulletins,[3,4] generic letters,[5] and generic issues.[6,7,8] A comprehensive review and evaluation of operating experience related to service water systems[9] conducted by the NRC further indicate the safety significance of the ESW system. The study (NUREG-1275) identified a total of 980 operational events in which the service water system was involved, with twelve of these operational events representing a complete loss of the ESW system. The causes of failures and degradations include various fouling mechanisms (sediment deposition, biofouling, corrosion and erosion, foreign material and debris intrusion); single failures and other design deficiencies; flooding; multiple equipment failures; and operator or procedural errors.

Recently, another ESW related study, Generic Issue 130, "Essential Service Water Pump Failures at Multi-Plant Sites," was completed. Preliminary results of this study[1] indicate that the problems associated with the ESW system would be a significant contributor to the frequency of core damage in the seven multi-plant sites identified in the scope of the study. The generic safety insights gained from this study indicated that the issue of ESW adequacy should be expanded to include all US LWRs. This issue will include all potential causes for the ESW system unavailability except those which have been considered to be resolved by implementing the resolutions stated in Generic letter No. 89-13[5] (such as biofouling).

1.2 Safety Significance

The ESW system at a nuclear power plant supplies cooling water to transfer heat from various safety-related and non-safety related systems and equipment to the ultimate heat sink of the plant. It is an open-cycle system which takes suction from the ultimate heat sink, e.g., ocean, bay, river, lake, pond or cooling towers, removes heat via heat exchangers from the various structures, systems and components it serves, and discharges the water back to the ultimate heat sink. The ESW system is known by different names at various light water reactor plants. In pressurized water reactor (PWR) plants, it may be referred to as the essential service water (ESW) system, the emergency equipment cooling water (EECW) system, the essential raw cooling water (ERCW) system, the salt water cooling (SWC) system, the nuclear service water (NSW) system, or others. In boiling water reactor (BWR) plants, it may be referred to as the emergency cooling water (ECW) system, the standby service water (SSW) system, the plant service water (PSW) system, the residual heat removal service water (RHRSW) system, or others.

The ESW system, which is a support system like electrical power, is needed in every phase of plant operations. Under accident conditions, the ESW system supplies cooling water to systems and components that are important to safe plant shutdown or to mitigating the consequences of the accident. Under normal operating conditions the ESW system provides component and room cooling (mainly via the component cooling water system). During a subsequent shutdown period, it also ensures that residual heat is removed from the reactor core. The ESW system may also supply makeup water to the fire protection system, cooling towers and water treatment systems at the plant.

The design and operational characteristics of the ESW system are different for PWRs and BWRs. In addition, the design and operational characteristics differ significantly from plant-to-plant within each of these reactor types. The success criteria associated with the functions of an ESW system are also plant-specific. A complete loss of the ESW system could potentially lead to a core-melt accident, posing a significant risk to the public.

Safety concerns include: partial or complete loss of ESW system functions resulting from common causes, degradation of the ESW system, design deficiencies, and procedural or maintenance errors. The ESW system can combine normal and emergency service water functions. In plants where the ESW performs this dual function, loss of ESW results in shutdown and a challenge to the safety system with failure or degradation of a critical support system. In other plants there are separate normal and emergency service water systems so that an ESW failure initiating event is not a concern unless there is some potential common cause failure between these "independent" service water systems.

1.3 Objective

The objective of this study is to assess the safety significance of the loss of ESW systems in LWRs and the corresponding contributions to core damage frequency (CDF), and to perform limited value/impact and sensitivity studies on a selected prototypical (pilot) plant. A second phase to the program may use the pilot plant analysis as an example to extend the analysis to cover all plant types in the US LWR industry.

1.4 Specific Tasks

There were two technical tasks identified in this study:

Task 1 - Evaluate the Importance of Service Water System Failures to Core Damage Frequency

The objective of this task is to evaluate the safety importance of service water using core damage frequency (CDF) contribution as a measure, and NRC-sponsored PRAs as the benchmark. Dominant accident sequences involving service water failures will be identified and examined for specific component faults or related failures, e.g., human errors or test and maintenance unavailability leading to core damage. Several candidate plants will be identified from IREP (Interim Reliability Evaluation Program), TAP A-45, NUREG-1150, and the LaSalle PRA. These PRAs cover 15 different plants and all NSSS vendors including older and newer vintages. ASEP (Accident Sequence Evaluation Program) service water models will be reviewed to evaluate potential groups in terms of types of vulnerabilities. In addition, various sources will be reviewed to evaluate operational experience of service water systems.

Task 2 - Perform a Best-Estimate Scoping Study of Plant Risk Due to Service Water Vulnerabilities, Including Value/Impact and Sensitivity Studies on a Selected Prototypical Plant

A prototypical (pilot) plant will be selected on the basis of the results from Task 1, the availability of useful PRA information, and the contribution of service water failures to CDF. A best-estimate calculation of CDF due to service water will then be performed on this plant, using generic input where appropriate. Service water failures found in Task 1 will be correlated with service water (SW) events in the dominant accident sequences of the selected plant PRA. Both internal and external events will be included. Sensitivity studies will be performed to determine the effect of important SW related events. Alternatives to improve or eliminate these events will be proposed considering reducing dependencies, increasing reliability and availability, improving redundancy, and decreasing support system requirements. The effect on CDF and cost to implement each proposed alternative will be estimated leading to a corresponding value/impact measure for each alternative. Consequence calculations will be made using the accident sequence release category mapping and value/impact methods used in the TAP A-45 study or other compatible methodologies such as NUREG/CR-1150. This subtask will be accomplished by manipulating the dominant cut sets, i.e., changes will not modify the basic models directly. Uncertainty will be addressed in the final results whenever possible.

The two tasks can be condensed into the specific tasks given below:

Task 1

1. Evaluate Safety Importance of SW

   Basis: CDF Measure
   NRC-Sponsored PRA as Basis
   Internal Events

   a. Identify Dominant Accident Sequences Involving SWS
   b. Identify Specific Contributing Components or Related Failures
   c. Identify Candidate Plants for Pilot Plant Analysis

2. Review ASEP SW Models

3. Review Operational Experience of SWS

Task 2

1. Select Pilot Plant

2. Perform Best Estimate Calculation of CDF Due to SWS Failure

3. Correlate Pilot Plant SWS Failure to Failures Found in Task 1, Items 1 and 3

4. Discuss Contribution of External Events

5. Perform Sensitivity Studies on SW Related Events

6. Identify SWS Vulnerabilities

7. Propose Modifications to Address These Vulnerabilities

8. Combine Modifications into Groups Called Alternatives

9. Perform Value/Impact Analysis on Each Alternative

Basis: Extrapolate costs from TAP A-45
Use NUREG-1150 PDS to Risk Mapping
Manipulate Dominant Cut Sets

a. Evaluate ΔCDF
b. Estimate Costs
c. Determine ΔRisk Measure
d. Calculate value/impact measures

The tasks presented in condensed form above essentially provide an orderly procedure. Tasks 1-1a, 1-1b, 1-2, and 1-3 are discussed in Section 2.0. Tasks 1-1c and 2-1 are covered in Section 3.0. Tasks 2-2 through 2-8 are covered in Section 4.0. Finally, Task 2-9 is described in Section 5.0.

1.5 Methodology

A typical PRA systems analysis model is depicted simplistically in Figure 1.1. The purpose of this flow diagram is to suggest that any specific system, e.g., the service water system, can be addressed individually, and with any desired changes reinserted into the systems analysis model. The systems model is then reevaluated and requantified resulting in a new core damage frequency (CDF) and possibly in new accident sequences or different cut sets. In this study, the effects of modifications were examined by changing event frequencies in the service water fault trees. The model was then requantified to determine the effect of the modifications (see Section 4.0). This provided results which were consistent with the requirements of the study and eliminated the effort required to generate and analyze new accident sequences or cut sets which would have provided additional information of limited value.

The service water system or essential service water system can encompass several related systems depending on the plant. As an example, suppose a plant were configured as shown below:

1. Normal Service Water System (NSWS) - supplies cooling water during normal operation.

2. Turbine Building Cooling Water (TBCW) System - Supplies Cooling Water to the power conversion system during normal operation.

3. Reactor Building Cooling Water (RBCW) System - Supplies cooling water to some loads that are required in both normal and emergency conditions.

4. High Pressure Service Water (HPSW) System - Supplies cooling water to RHR heat exchanges in normal and emergency conditions.

5. Emergency Service Water System (ESWS) - Provides room cooling and pump cooling for safety systems during an emergency.

All of these systems can be categorized as part of the total service water system. Systems such as the NSWS and TBCW may not feed engineered safety systems, but do feed systems that are analyzed in PRAs because they do provide some benefit under certain circumstances toward preventing core damage. This is only an example. Some plants may only have one all purpose service water system. In such cases, failure of that system not only causes shutdown, but also severely degrades the safety system responding to the shutdown. There are other plants with combinations of service water systems between these extremes.

In this study, the analysis proceeded as shown in Figure 1.2. This is based upon the specified program tasks, typical NRC type PRA methods, e.g., NUREG-1150, and the value/impact methods used in TAP A-45. Additional methodology details are available in the Appendix L of NUREG/CR-4767.[13]

1.6 Assumptions and Limitations

Every study must limit the areas to be covered and by necessity assumptions are made in order to accomplish the work without addressing issues and details that really do not bear significantly upon the results desired. These limitations and assumptions are tabulated below.

Limitations

1. External events are discussed but not included in the quantitative analysis. Certain external events are clearly very important and have service water contributions, but resources did not permit a detailed analysis.

2. Service water failure initiating events can be important at some plants. The pilot plant selected was not susceptible to this special initiator since the emergency service water system is essentially independent of the normal service water system. Therefore, it did not make sense to artificially introduce a SW initiator into the analysis.

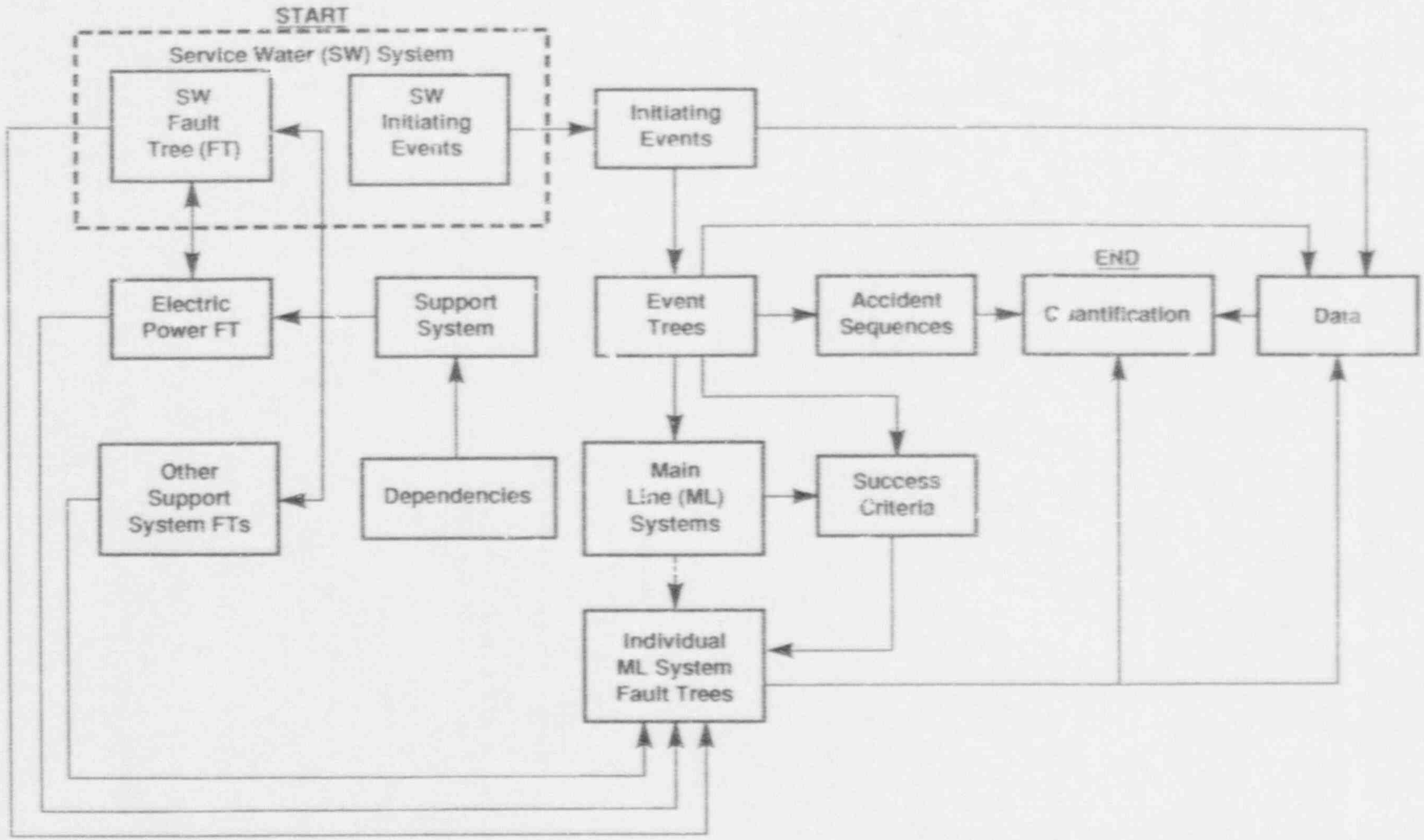

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Figure 1.1 Probabilistic Risk Assessment Model

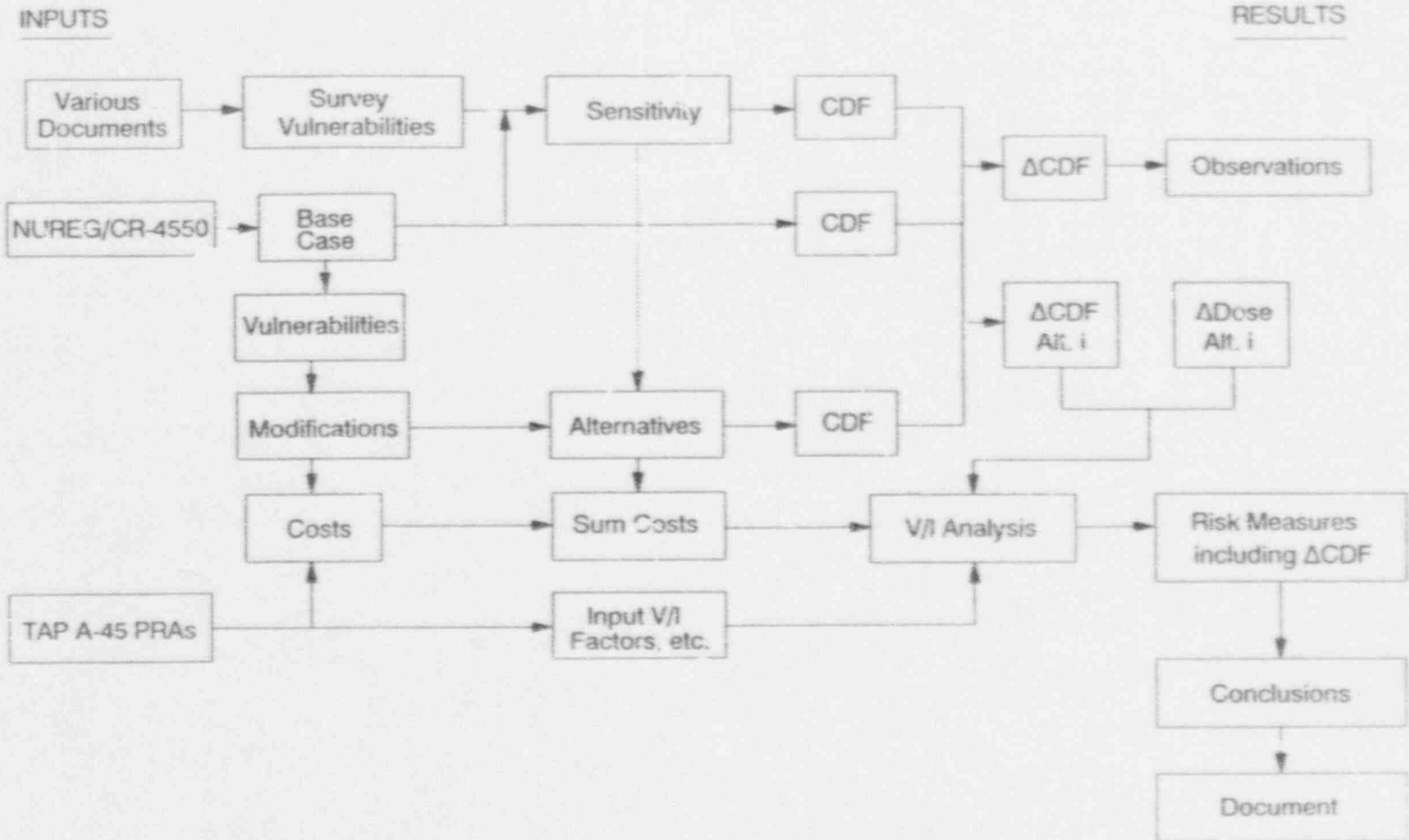


Figure 1.2 Basic Service Water System Pilot Plant Analysis Flow Diagram

Assumptions

1. Sensitivity analyses performed starting with the base case pilot plant model did not account for cut sets that were truncated out of the analysis that might have reappeared when certain event frequencies were increased. This assumes that the ΔCDF obtained is representative of the effect of changes in event frequencies. Effort well beyond the scope of this project would have been required to verify this assumption. However, the assumption is considered reasonable based on previous analyses.

2. The plant damage state to consequence mapping factors were derived from the NUREG/CR-4551 numbers. These factors could have been more accurately computed by rerunning parts of the back-end analysis. Due to the effort required to do this and the limited objectives of the study, the simpler, less accurate, approach was adopted. The results or more detailed requirements might justify a more accurate analysis.

3. The costs of the modifications were obtained by comparing the modification proposed here with similar ones from TAP A-45. There could be differences such as labor costs, structural changes needed to accommodate the modifications, the length and size of pipe or conduit needed, and the capacity of pumps. The cost estimates in TAP A-45 were done very accurately by an experienced architect engineer with complete plant drawings and plant site visits. This level of effort was clearly not feasible in this study. Nevertheless, we feel our estimates are representative enough to provide meaningful results.

4. Modification costs were increased based on the increase in the consumer price index (CPI) for the seven years from 1/1985 to 1/1992. We assumed that construction costs followed the CPI during that period.

2.0 SUMMARY OF OPERATIONAL EXPERIENCE AND PRA RESULTS

As part of the scoping study a review of operational experiences was performed to establish typical service water system vulnerabilities that should be represented in a pilot plant analysis. The dominant accident sequences for eleven NRC sponsored PRAs were then reviewed to determine the service water contribution to core damage frequency (CDF) and also to gain insights into the dominant service water failure modes.

2.1 Operational Experiences

Several studies have addressed the operational experience related to service water system failures. The work is not repeated here, but the results from these studies are briefly summarized. It should be noted that these studies were done by different people for different purposes. Therefore, it should not be expected that the results are completely consistent.

Precursor Reports

The Accident Sequence Precursor Program at Oak Ridge National Laboratory reviews Licensee Event Reports (LERs) of operational events that have occurred at LWRs to identify and categorize precursors to potential severe core-damage accidents. Accident sequences considered in this program are those associated with inadequate core cooling. As a result of this work, a series of status reports have been published that describe those events that have occurred as reported in LERs.[24-31] These published reports were reviewed for service water related events. This review turned up 24 events directly related to this scoping study. Appendix B documents these findings and Table 2.1 lists the events found and provides a description of each. Some of the events were significant. However, most were not. As a group, the events represent a variety of causes.

Operational Experience Feedback Reports NUREG-1275[9]

This report is a comprehensive study of service water related operational events. There were 980 events identified with 276 considered to have potential generic safety significance. The results were categorized and are summarized as follows:

1.	Fouling	58.3%
2.	Single Failures	6.5%
3.	Multiple Failures	3.6%
4.	Personnel Errors	16.7%
5.	Flooding	4.4%
6.	Seismic	10.5%

We did not tabulate specific component and operator errors that could be easily related to PRA models and results. However, the failures and errors which comprise items 2, 3, and 4 above are typically included in a PRA internal events analysis. That is, the data did not indicate any obvious pattern of failures and errors not covered by PRA methods.

There were twelve events reported as complete loss of service water events. These are repeated briefly in Table 2.2 with simplified descriptions that demonstrate the diversity of the failures. In a sense all the events listed are covered implicitly in PRA, however, fault tree events do not normally specify the root cause of the failure (e.g., pump fails to run due to broken shaft).

Only two of the events in Table 2.2 appear in Table 2.1. The exact reasons for this would require detailed study to determine. Such a study was beyond the scope of the work done for this report. However, the following general conclusions can be drawn:

1. The events extracted from the precursor reports were judged to be precursors to potential severe core damage accidents and did not necessarily involve complete loss of service water, either potentially or operationally. Therefore, only limited overlap with the results of NUREG/CR-1275 should be expected.

2. As pointed out previously, the precursor reports and NUREG/CR-1275 were done by different people for different purposes. Therefore, different conclusions about the same events are to be expected.

3. The events extracted from NUREG/CR-1275 were judged by the authors to be complete loss of service water events. However, two of the events were loss of service water events which

Table 2.1

Precursors to Potential Severe Core Damage Accidents Involving Service Water Systems

Plant	LER Number	Description
Hatch 1	LER 321/80-103	Inlet strainers partially clogged.
San Onofre 1	LER 206/80-006	Three salt water cooling trains failed.
St. Lucie 1	LER 335/80-029	RCP seal cooling lost due to inadvertent valve closure.
Calvert Cliffs 1	LER 317/80-027	Two service water pumps fail due to loss of compressed air.
Pilgrim 1	LER 293/80-070	Component cooling water lost due to maintenance and breaker trip.
Salem 1	LER 272/80-060	Lost SW to DG due to valve indicating open when actually closed.
Kewaunee	LER 305/81-033	Operator error - two component cooling water trains unavailable.
San Onofre 3	LER 262/84-035	Operator error - outside limiting condition for operation.
Surry 1	LER 280/84-011	Operator error - safety injection pump CCW supply found isolated.
Salem 2	LER 311/85-018	Operator error - maintenance and closed valve could not be opened.
LaSalle 1	LER 373/85-045	Loss of non-safety service water due to expansion joint failure.
Susquehanna 2	LER 388/85-014, 015	Emergency service water failed during testing.
Surry 1	LER 280/86-029[1]	Service water subsystem pump lost due to air binding.
McGuire 2	LER 370/87-016, 017	Trip with service water train out for cleaning.
Palisades	LER 255/83-021	Incorrectly set relays could have resulted in loss of service water.
Zion 1	LER 295/88-019	Potential component cooling water failure due to design deficiency.
Davis Besse	LER 346/88-007 R1	Possible prolonged loss of instrument air would cause SW to isolate.
San Onofre	LER 361/88-010 R1	Emergency cooling water unavailable due to low freon in chillers.
Farley 1 and 2	LER 348/88-018 R1	Postulated loss of service water due to fire.
Peach Bottom 2	LER 277/89-002	Unacceptable emergency service water performance due to I&C problems.
Calvert Cliffs 1	LER 317/89-023 R1	Potential pipe rupture could fail both service water pumps.
Davis Besse 1	LER 346/89-004	Potential pipe rupture could fail both service water pumps.
Nine Mile Point 2	LER 410/89-002	Potential service water and ECCS pump failure due to flooding.
River Bend	LER 458/89-020	Service water flooded auxiliary building impairing electric power and control.

[1]Listed in NUREG-1275 tables as a service water event involving equipment failures.

Table 2.2

Twelve Events From NUREG-1275 Resulting in Complete Loss of SW Function

Plant	LER Number	Description
Oconee 1	LER 269/86-11	Inadequate siphon flow to service water pumps.
Susquehanna 1	LER 387/86-21	All service water pumps failed due to operation below design flow.
Oyster Creek	LER 219/85-18	Heat exchangers plugged by coal tar enamel
Brunswick 1	LER 325/84-01	Entrapped air in suction header piping.
Palisades	LER 255/84-01	Loss of power to service water pumps due to operator error.
Salem 2	LER 311/83-32	Service water bay flooded due to failed piping gasket.
Salem 1	LER 272/82-15	Loss of vital bus when 1 train of service water out for maintenance.
Brunswick 2	LER 324/82-05	All pumps failed to start due to low suction pressure and sediment in sensing lines.
Hatch 1	LER 321/80-103	Inlet strainers partially clogged.
San Onofre 1	LER 206/80-06	One pump shaft sheared and valve in other train failed.
Calvert Cliffs 2	LER 318/82-34	Failure of common valve in discharge header.
Catawba 1	LER 413/85-68	Train A input valve failed to open and train B discharge valve failed to open.

were caused by LOSP and three others occurred during shutdown. As a result, a comparison with the results of the precursor reports would be expected to produce apparent inconsistencies.

Analysis of ESWS at Multi-Unit Sites NUREG/CR-5526[1]

Results of this study indicate that the dominant failures causing partial or complete loss of the ESWS are traveling screen and common intake structure failures, failure of the ESW pumps, loss of electric power to the ESWS, and operator error relating to the ESW pumps. Degradation of the ESWS results from sediment, corrosion, and mechanical and electrical problems associated with the ESW pumps. As in the case with other reports reviewed there are no special failure modes that would change the basic approach to be used to analyze the pilot plant in this study.

2.2 Review of Plant-Specific Probabilistic Risk Assessment Studies

This study used eleven NRC-sponsored probabilistic risk assessments (PRAs) to evaluate the importance of service water (SW) using core damage frequency (CDF) contribution as a metric. Note that in this study the term "service water" implies any cooling water system, both open and closed loop systems, that provides cooling to safety related equipment and therefore must function following an accident. The eleven plant-specific PRAs reviewed are given in Table 2.3.

SAIC System Source Books[32]

The NRC contracted with Science Applications International Corporation (SAIC) to accumulate a set of plant information on selected U.S. commercial nuclear power plants. One piece of information contained in these notebooks is a service water functional flow diagram. It is well known that service water system configurations vary significantly from plant to plant. An example of that variation is shown in Figure 2.1 for four PWR plants. The Westinghouse (W) plant examined has emergency loads (L) directly on the primary SWS (S) and indirectly through the component cooling water system (C). The Babcock and Wilcox (B&W) plant examined has all its emergency loads fed directly off the SWS. In the Combustion Engineering (CE) plants examined, plant A feeds all emergency cooling loads directly through a secondary cooling water system (C). The CE plant B has three ways to cool its emergency loads. Clearly there are numerous variations just within the flow path configuration. When the number of pump trains, alternate systems, and the association with normal service water are considered it is easy to see why every plant SWS could be unique. There will be some plants with similar SWSs but of the approximately 120 commercial nuclear plants, there could be numerous unique SW configurations.

Table 2.4 lists for each plant the service water systems modeled in each of the PRAs reviewed and found to be significant contributors to CDF. Appendix C describes each of the systems listed in terms of its configuration, success criteria, cross-ties, vulnerabilities, and potential recovery actions as considered in the applicable PRA.

Dependency diagrams in terms of the safety functions that are served by each of the systems listed in Table 2.4 are provided in Appendix D. A review of the information found in Appendices C and D leads to the conclusion that service water system configurations are highly plant-specific. This observation is consistent with the work of the Accident Sequence Evaluation Program (ASEP) which concluded that where service water was concerned each plant is unique.[33] However, though the SW configurations may be unique, the plant safety functions that are served by the SW system(s) tend to be similar as seen in the dependency diagrams provided in Appendix D.

To determine the contribution to CDF made by the service water system(s) in each of the eleven PRAs, the cutsets of the dominant accident sequences were reviewed. This review revealed three important pieces of information significant to this study: (1) the CDF contribution made by service water; (2) the accident types and conditions where the plant is most vulnerable to service water faults; and (3) a ranking of the specific service water faults in terms of their contribution to CDF.

It should be noted that when reviewing the dominant accident sequences for service water contributions to CDF, station blackout sequences were not considered where station blackout leads to loss of service water. This approach was taken because these sequences represent only one problem which results from the loss of all electrical power. Also, systems which depend on service water will be unavailable following a station blackout regardless of the availability of service water. Service water contributions were accounted for in those cutsets in which loss of service water leads to loss of power. For those cutsets where a portion of the service water system is lost due to a partial loss of onsite power and an independent service water system fault occurs, the contribution was counted.

Table 2.3

Plant-Specific Probabilistic Risk Assessments Reviewed

Plant	Type	NSSS Vendor	PRA Program	Total Internal CDF (mean)
Calvert Cliffs 1	PWR	CE	IREP	1.3E-04
Point Beach 1	PWR	W	TAP A-45	1.4E-04
Turkey Point 3	PWR	W	TAP A-45	7.1E-05
St. Lucie 1	PWR	CE	TAP A-45	1.4E-05
ANO-1	PWR	B&W	TAP A-45	8.8E-05
Quad Cities 1	BWR	GE	TAP A-45	9.9E-05
Cooper	BWR	GE	TAP A-45	2.9E-04
Surry 1	PWR	W	NUREG-1150	4.0E-05
Sequoyah 1	PWR	W	NUREG-1150	5.7E-05
Peach Bottom 2	BWR	GE	NUREG-1150	4.5E-06
Grand Gulf	BWR	GE	NUREG-1150	4.1E-06

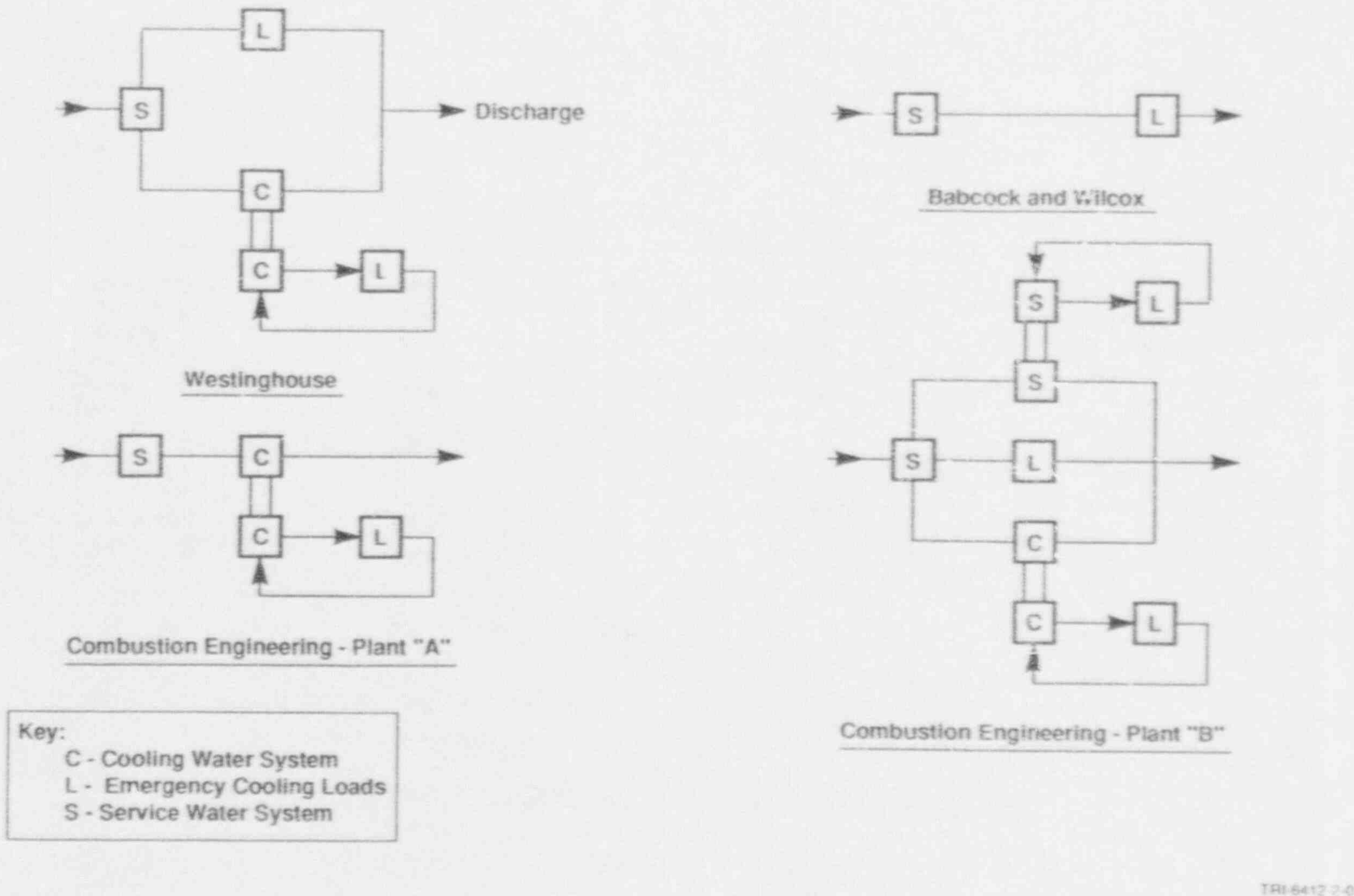


Figure 2.1 Four Service Water System Functional Flow Diagrams

Table 2.4
Plant Service Water Systems Reviewed

Plant	Cooling Water system Reviewed
Cooper Nuclear Station	Service Water System Reactor Building Closed Cooling Water System
Quad Cities	Residual Heat Removal Service Water System Diesel Generator Cooling Water system
Peach Bottom	Emergency Service Water system High Pressure Service Water System
Grand Gulf	Standby Service Water System
St. Lucie	Component Cooling Water System Intake Cooling Water System
Calvert Cliff	Salt Water System Component Cooling Water System Service Water System
ANO-1	Service Water System
Point Beach	Service Water System Component Cooling Water System
Turkey Point	Service Water System Component Cooling Water System
Surry	Service Water System Component Cooling Water System
Sequoyah	Service Water System Component Cooling Water System

The following sections discuss the results of the review of the eleven PRAs.

2.3 Service Water Contribution to Core Damage Frequency

As noted above, the contribution to CDF made by the service water system(s) in each of the eleven PRAs was determined by reviewing the cutsets of each of the PRA dominant accident sequences. All of the dominant accident sequences reported in NUREG/CR-4550 were considered. In the case of the TAP A-45 study, the reports do not include a complete listing of the dominant sequence cutsets and in many cases less than fifty percent of the cutsets contributing to the sequence CDF are given. As a result, a complete review of the TAP A-45 cutsets was not possible.

For the NUREG-1150 PRAs the service water contributions to CDF for Surry 1, Sequoyah 1, and Grand Gulf were determined directly from the TEMAC computer code output. This will overestimate the contribution to CDF for those cutsets which contain more than one service water basic event because the code sets the probability of each basic event to zero and sums the results over all of the cu . If two basic events are present in one cutset, the contribution to CDF of the cutset is thus counted twice. For Peach Bottom, the pilot plant, the cutsets which contained more than one service water basic event were evaluated to determine the contribution of each service water basic event. The contribution for a given basic event in a multiple event cutset was calculated by multiplying the cutset frequency by the sum of the basic event probabilities of the other basic events in the cutset and dividing by the sum of the probabilities of all of the basic events in the cutset. The effect on the pilot plant, for the sequences considered, was to reduce the service water contribution calculated using TEMAC by 10 percent. Due to the time required to complete the calculations, the service water contributions to the other NUREG-1150 plants were not reevaluated.

Appendix E documents the review of the PRA results by listing the service water events found to contribute to the dominant accident sequences in each PRA. The contribution to CDF made by each event found is also given. Also included in Appendix E is a brief discussion of each dominant accident sequence in which service water events are dominant contributors to CDF along with the service water events that contribute to the sequence CDF.

Table 2.5 lists for each PRA the service water contribution to CDF in terms of an absolute value and a percentage. As can be seen from Table 2.5, the contribution made by service water to the total CDF varies from <1% to 65%. The reasons for the large differences for the most part have to do with the degree of dependency a plant has on SW, the reliability of the systems themselves, and, to some extent, the differences in the PRAs in terms of modeling assumptions (e.g., IREP did not consider common mode failures where all the other PRAs did), and scope of each PRA program (e.g., TAP A-45 studies did not consider anticipated transients without scram (ATWS) or large and intermediate LOCAs).

As noted above, Appendix E includes a brief discussi of the dominant accident sequences for each PRA in which service water is a dominant contributor. Included in the discussions is a listing of the service water events contributing to the sequence and the contribution made by the service water event to the sequence. These results are illustrated in Figures 2.2 through 2.15 in terms of reactor type and show for each class of accident (e.g., loss of offsite power (T1), large LOCA (A), etc.) the

% TCDF -	% of the total core damage frequency contributed by the accident type.
% SWS Contribution -	% contribution SW makes to the total CDF for the accident type
% of Total SWS Cont. -	% of the total SW contribution to the total CDF accounted for.

The accident abbreviations used in the figures are:

T1	- Loss of offsite power
T2	- Transients with loss of power conversion system
T3	- Transients with power conversion system initially available
ATWS	- Anticipated transients without scram
TAC	- Loss of AC bus
TDC	- Loss of DC bus
LOCA	- Loss of cooling accident

Looking at the comparison of BWR T1 accident sequences, Figure 2.2, for Grand Gulf, T1 sequences

Table 2.5

Service Water Contribution to Core Damage Frequency

Plant	Type	Total Internal CDF(mean)	SW CDF Contribution	SW % Contribution
Calvert Cliffs 1	PWR	1.3E-04	1.4E-05	11
Point Beach 1	PWR	1.4E-04	2.6E-05	19
Turkey Point 3	PWR	7.1E-05	3.4E-06	5
St. Lucie 1	PWR	1.4E-05	1.8E-06	13
ANO-1	PWR	8.8E-05	1.1E-05	12
Quad Cities 1	BWR	9.9E-05	3.0E-05	30
Cooper	BWR	2.9E-04	1.9E-04	65
Surry 1	PWR	4.0E-05	1.5E-08	<1
Sequoyah 1	PWR	5.7E-05	2.4E-07	<1
Peach Bottom 2	BWR	4.5E-06	1.4E-06	22
Grand Gulf	BWR	4.1E-06	5.6E-07	14

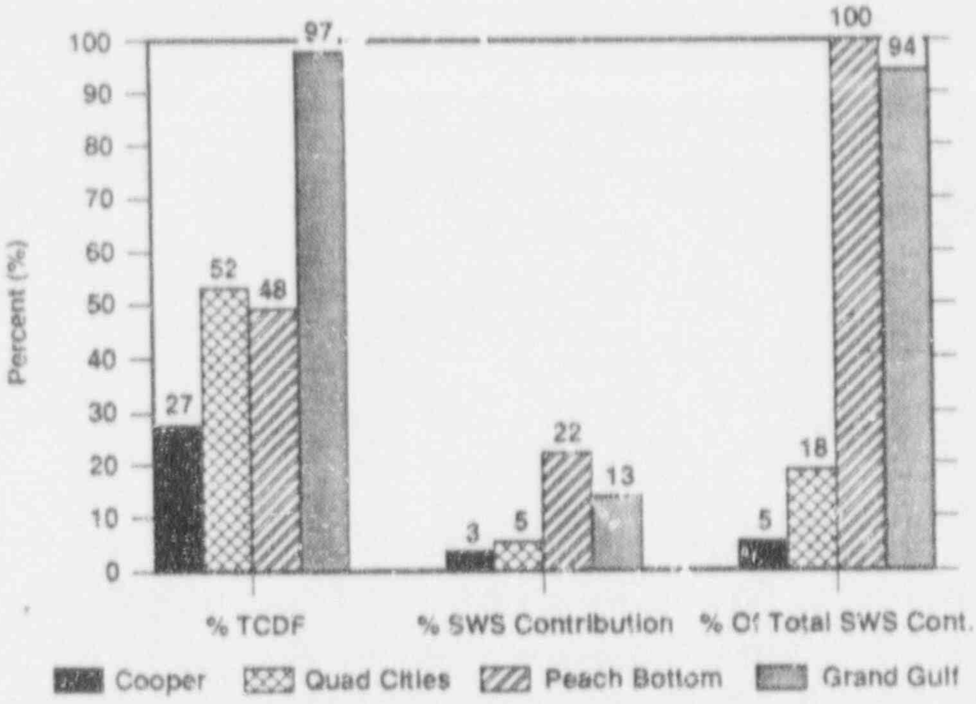


Figure 2.2 Comparison of BWR T1 Accident Sequences Contribution to CDF

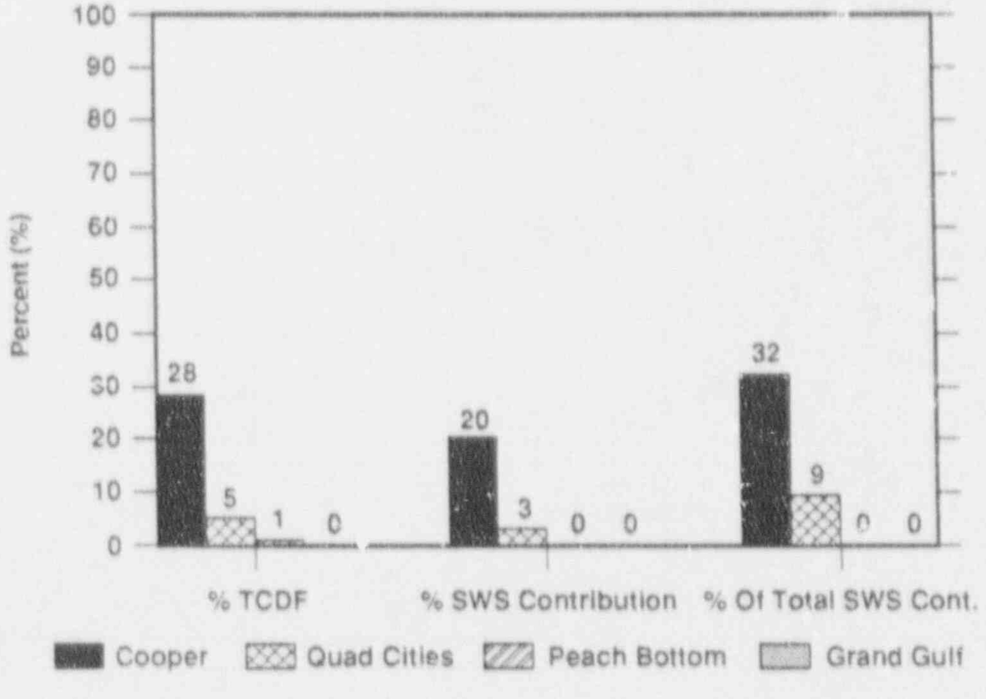


Figure 2.3 Comparison of BWR T2 Accident Sequences Contribution to CDF

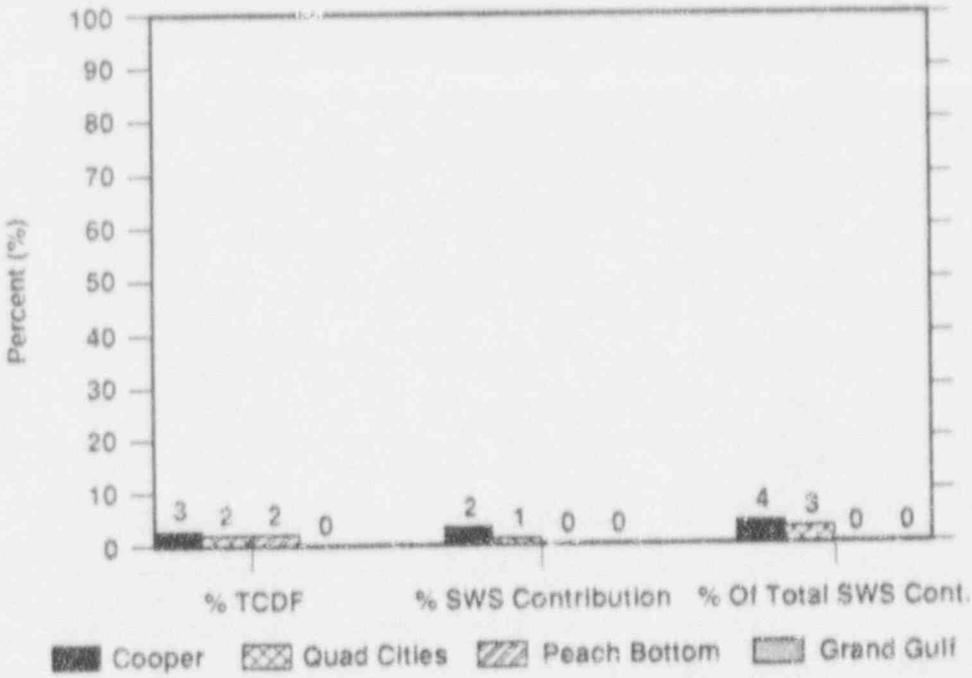


Figure 2.4 Comparison of BWR T3 Accident Sequences Contribution to CDF

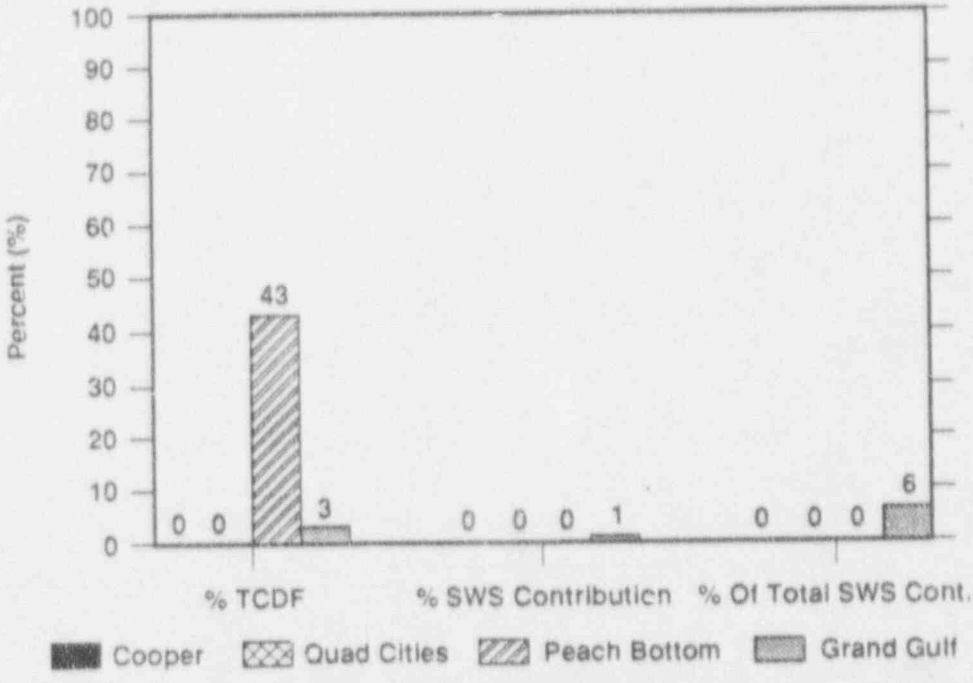


Figure 2.5 Comparison of BWR ATWS Accident Sequences Contribution To CDF

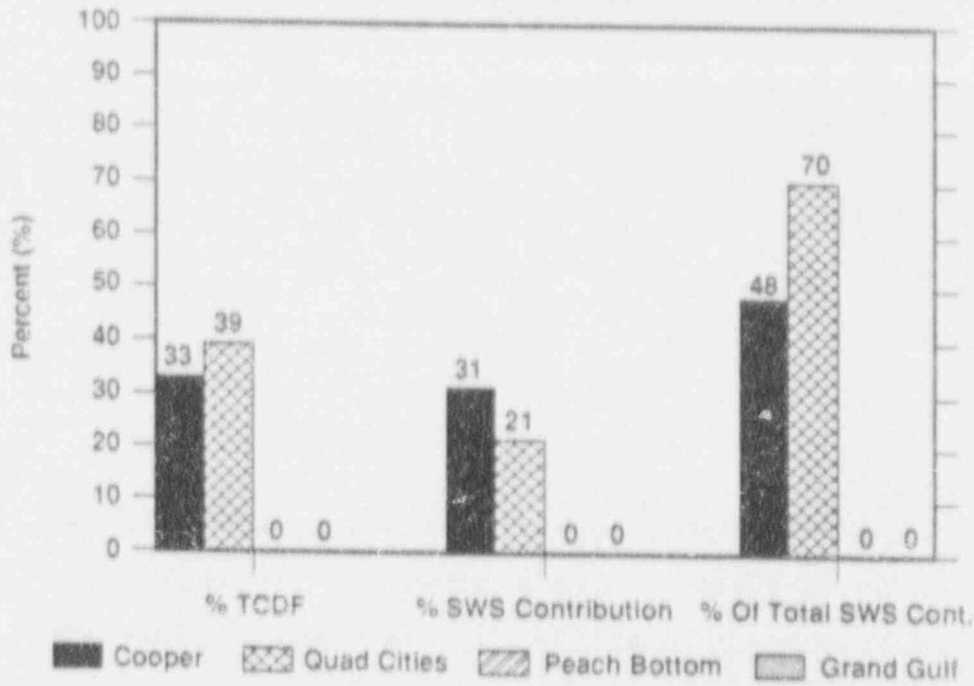


Figure 2.6 Comparison of BWR TAC Accident Sequences Contribution to CDF

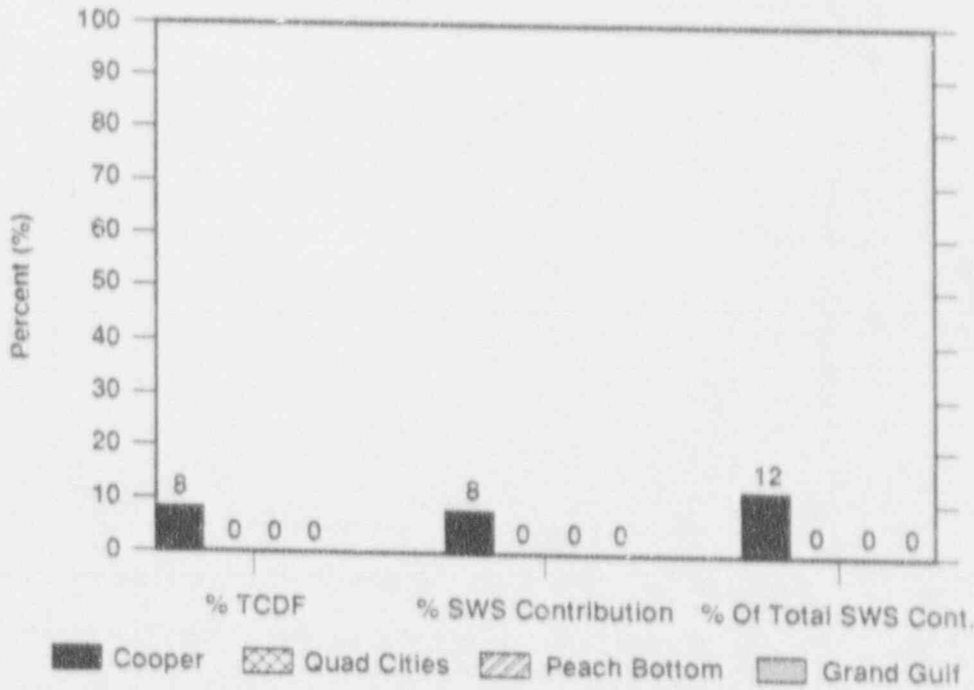


Figure 2.7 Comparison of BWR TDC Accident Sequences Contribution to CDF

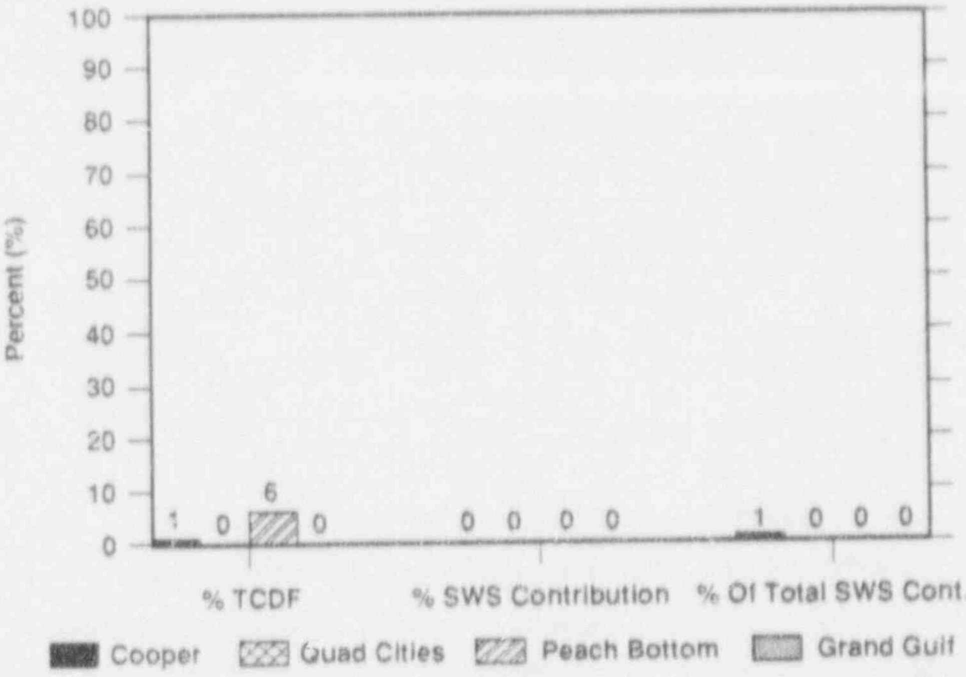


Figure 2.8 Comparison of BWR LOCA Accident Sequences Contribution to CDF

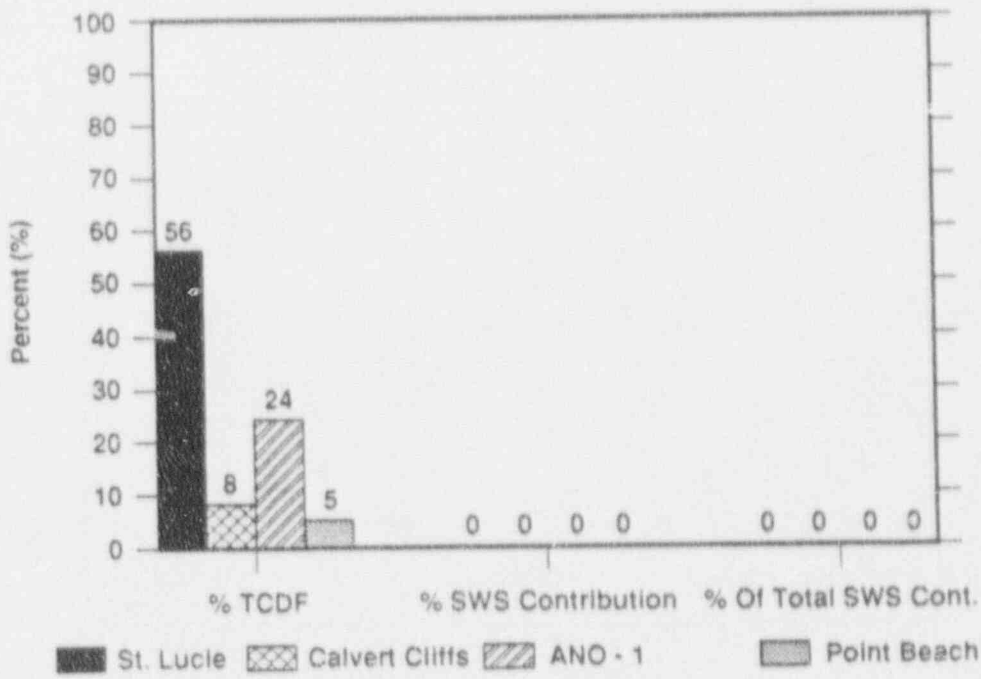


Figure 2.9a Comparison of PWR T1 Accident Sequences Contribution to CDF

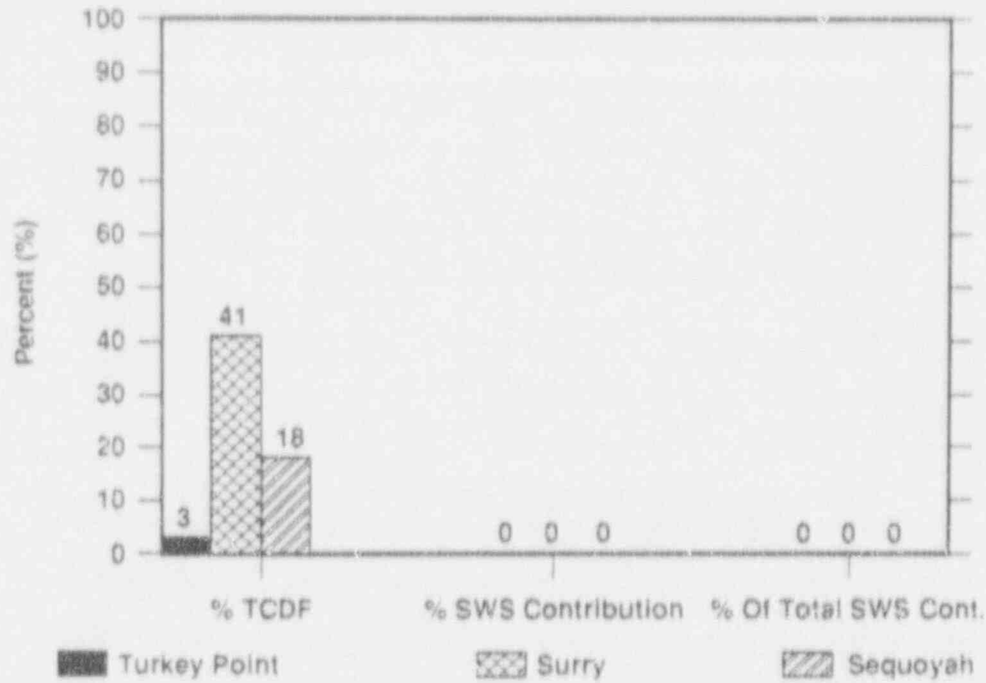


Figure 2.9b Comparison of PWR T1 Accident Sequences Contribution to CDF

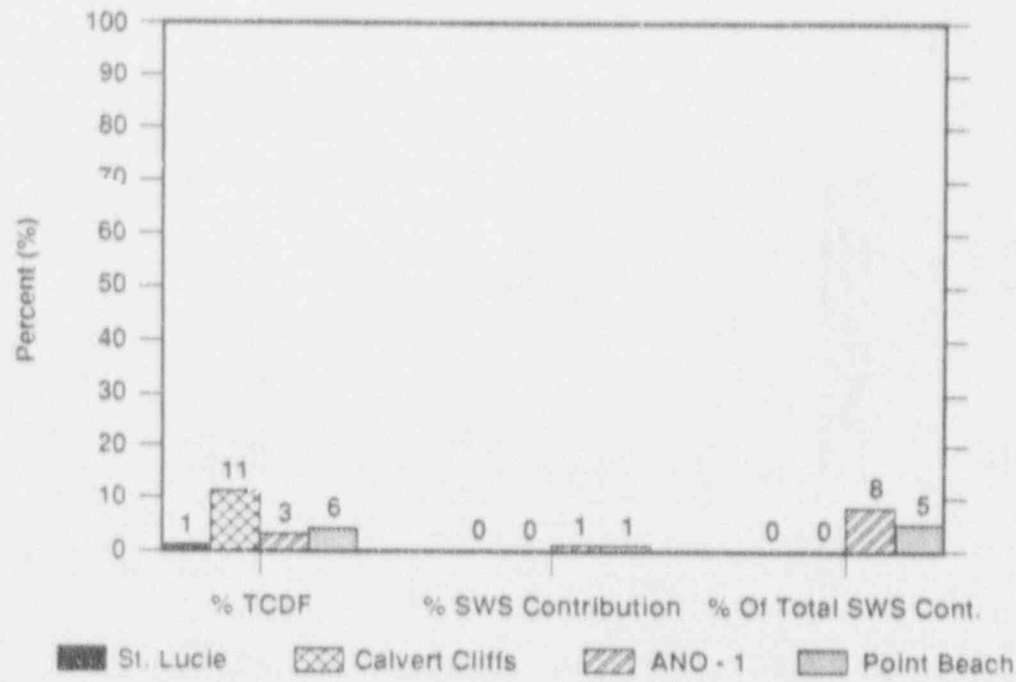


Figure 2.10a Comparison of PWR T2 Accident Sequences Contribution to CDF

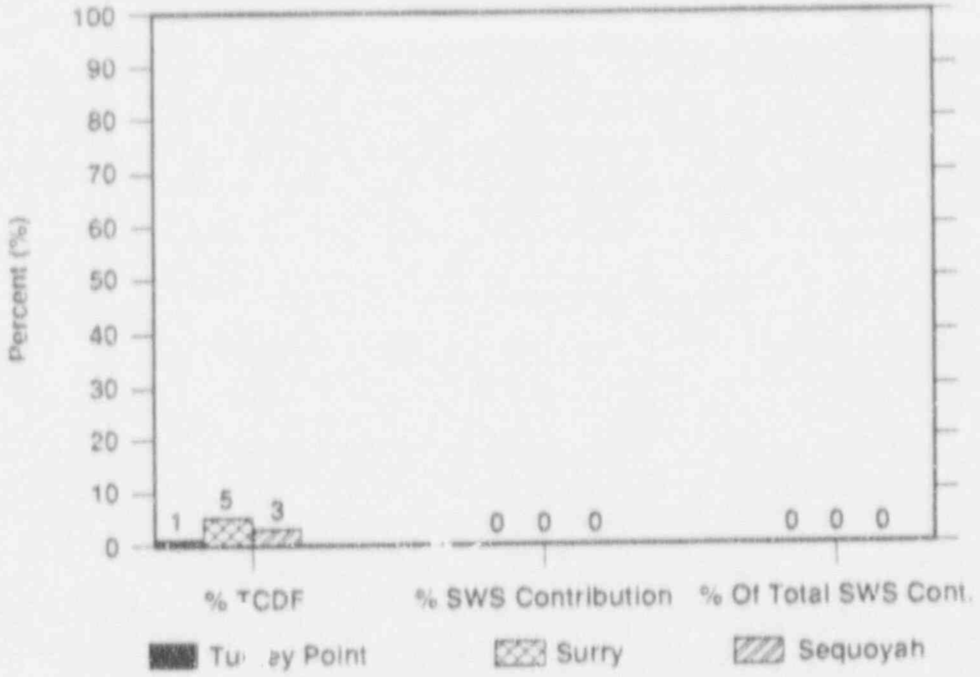


Figure 2.10a Comparison of PWR T2 Accident Sequences Contribution to CDF

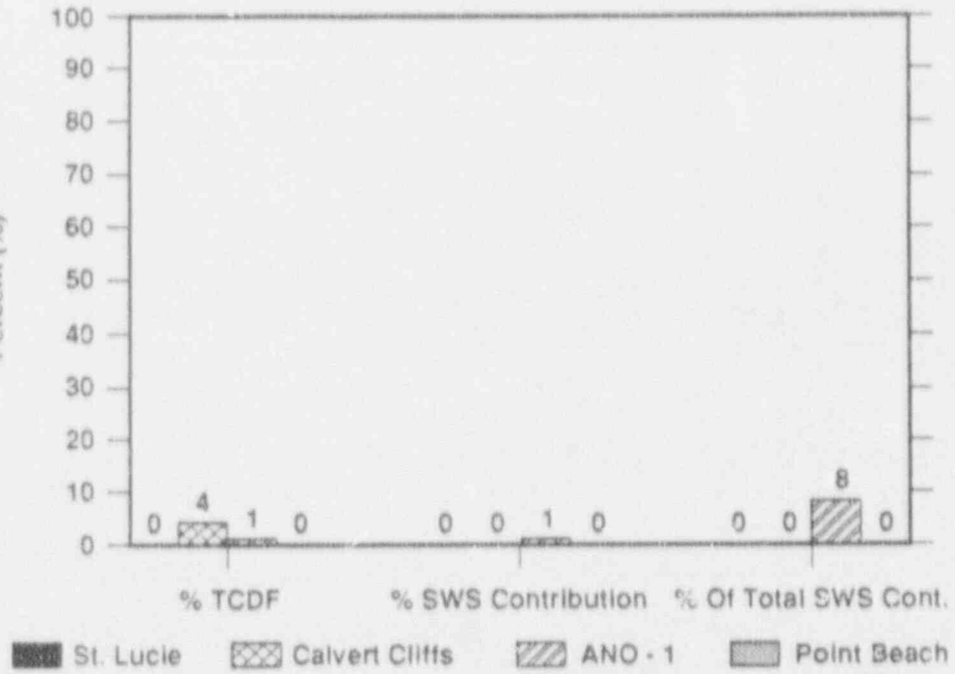


Figure 2.11a Comparison of PWR T3 Accident Sequences Contribution to CDF

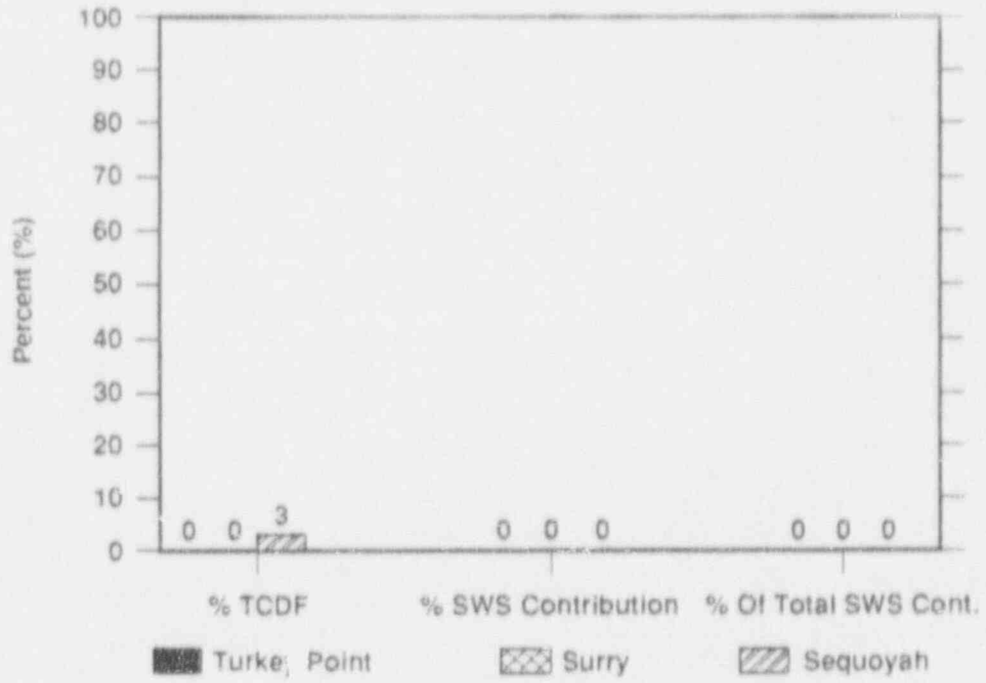


Figure 2.11b Comparison of PWR T3 Accident Sequences Contribution to CDF

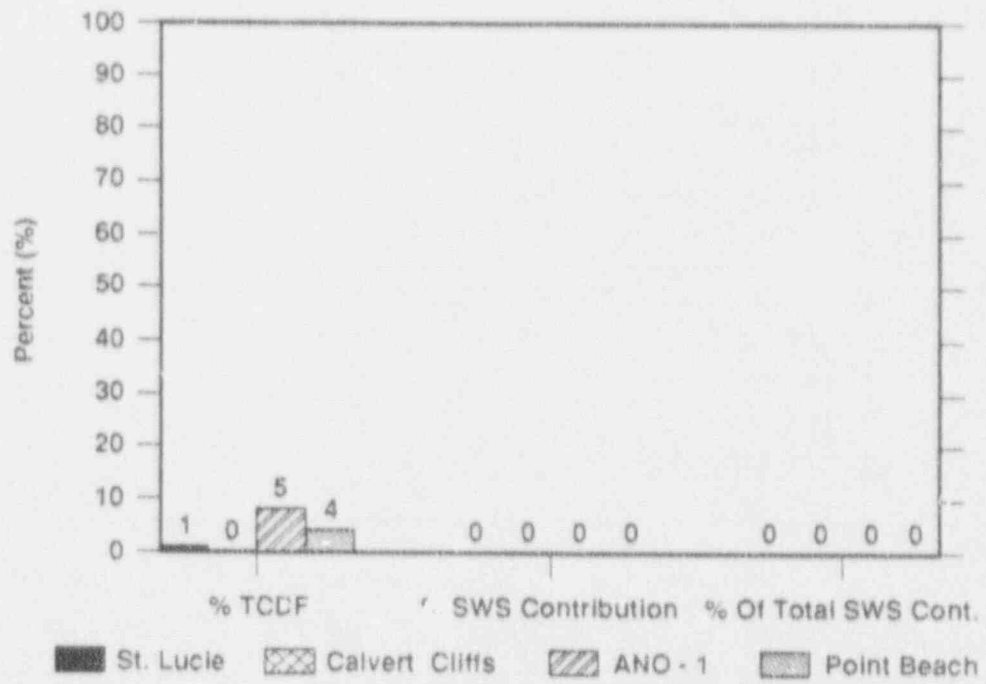


Figure 2.12a Comparison of PWR TAC Accident Sequences Contribution to CDF

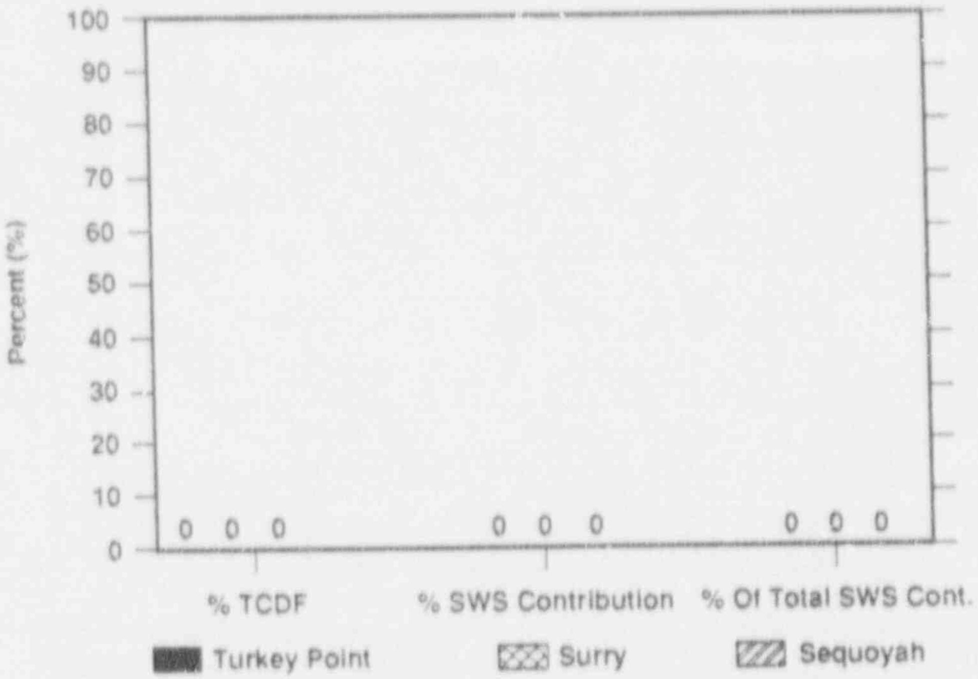


Figure 2.12b Comparison of PWR TAC Accident Sequences Contribution to CDF

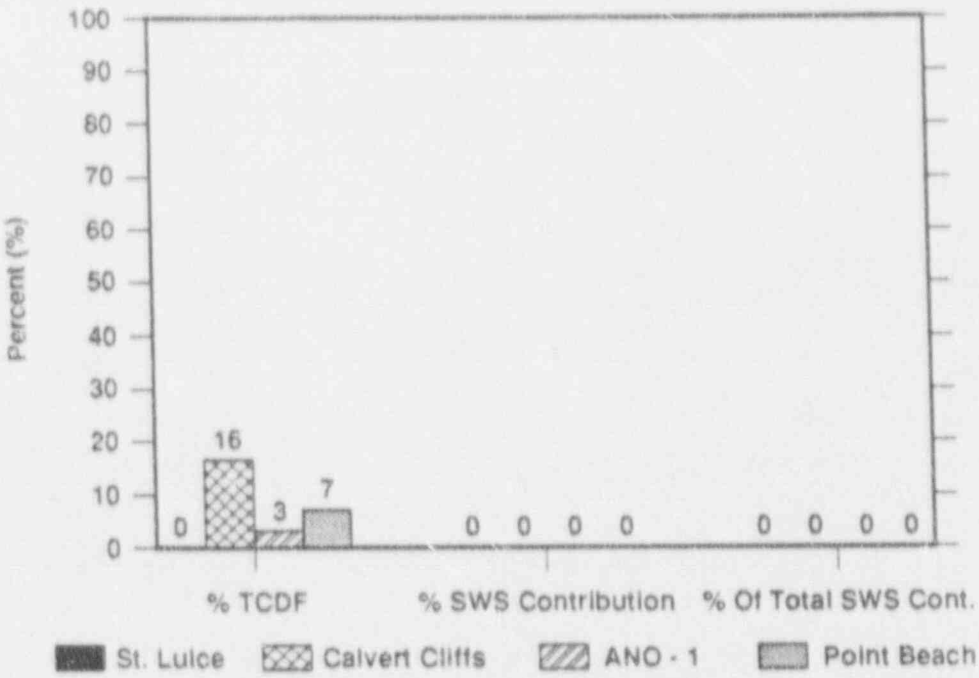


Figure 2.13a Comparison of PWR TDC Accident Sequences Contribution to CDF

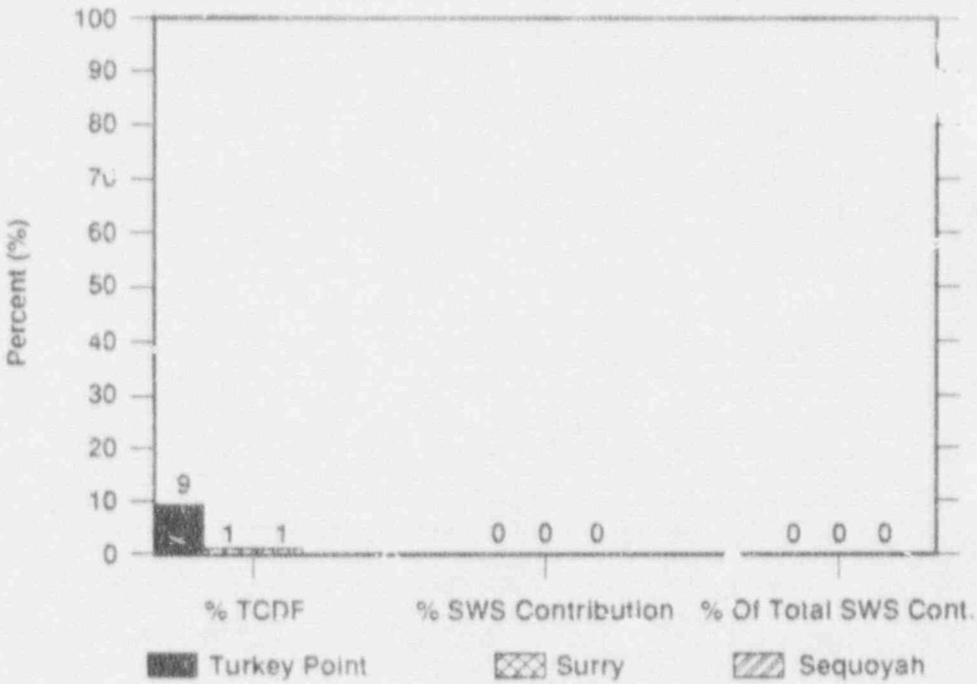


Figure 2.13b Comparison of PWR TDC Accident Sequences Contributio

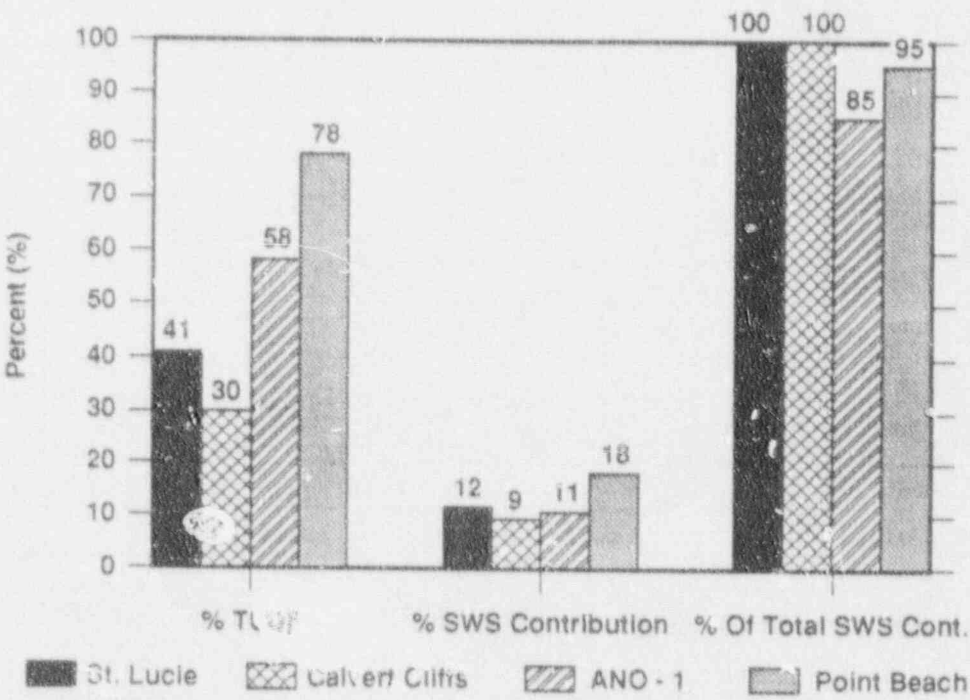


Figure 2.14a Comparison of PWR LOCA Accident Sequences Contribution to CDF

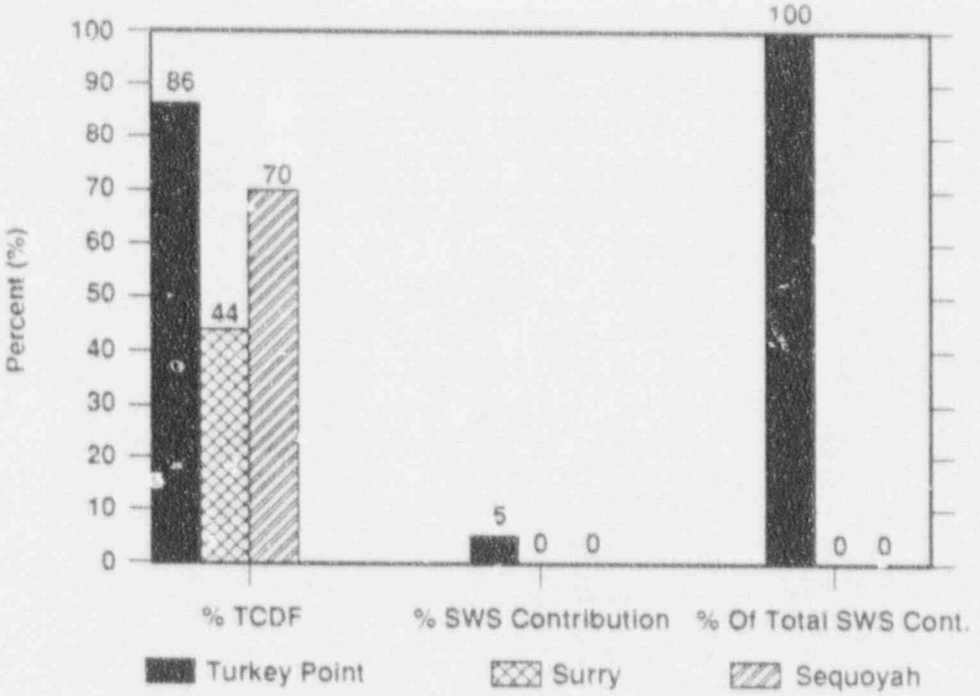


Figure 2.14b Comparison of PWR LOCA Accident Sequences Contribution to CDF

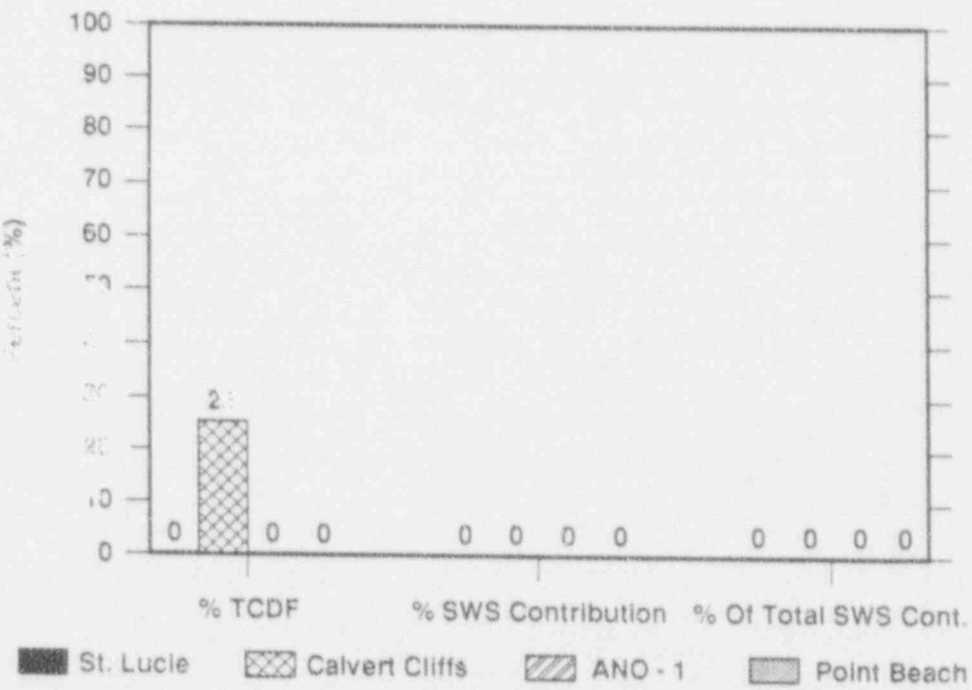


Figure 2.15a Comparison of PWR ATWS Accident Sequences Contribution to CDF

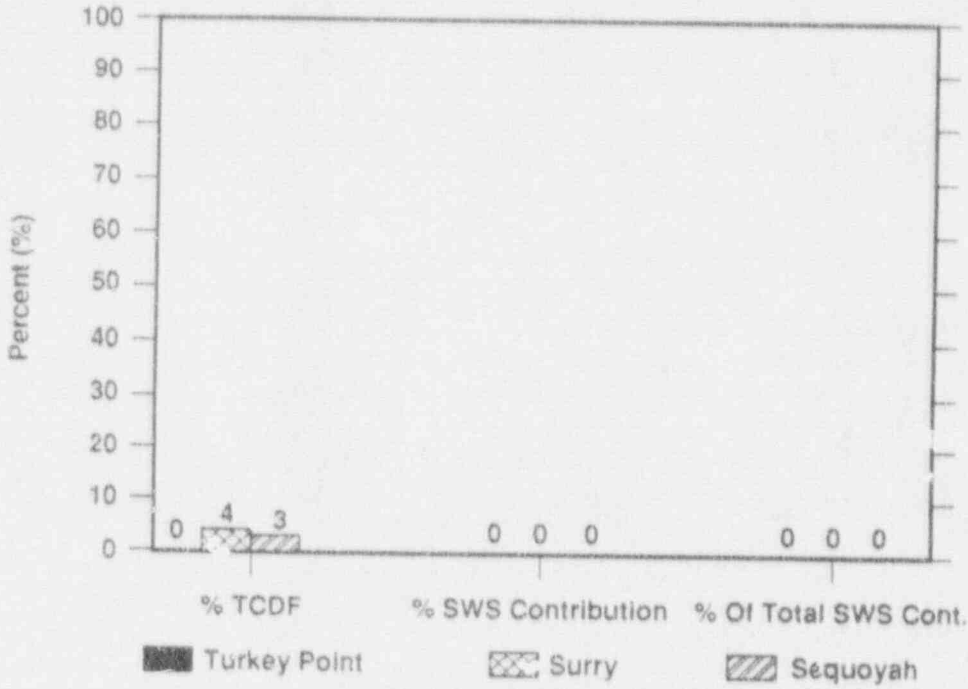


Figure 2.15b Comparison of PWR ATWS Accident Sequences Contribution to CDF

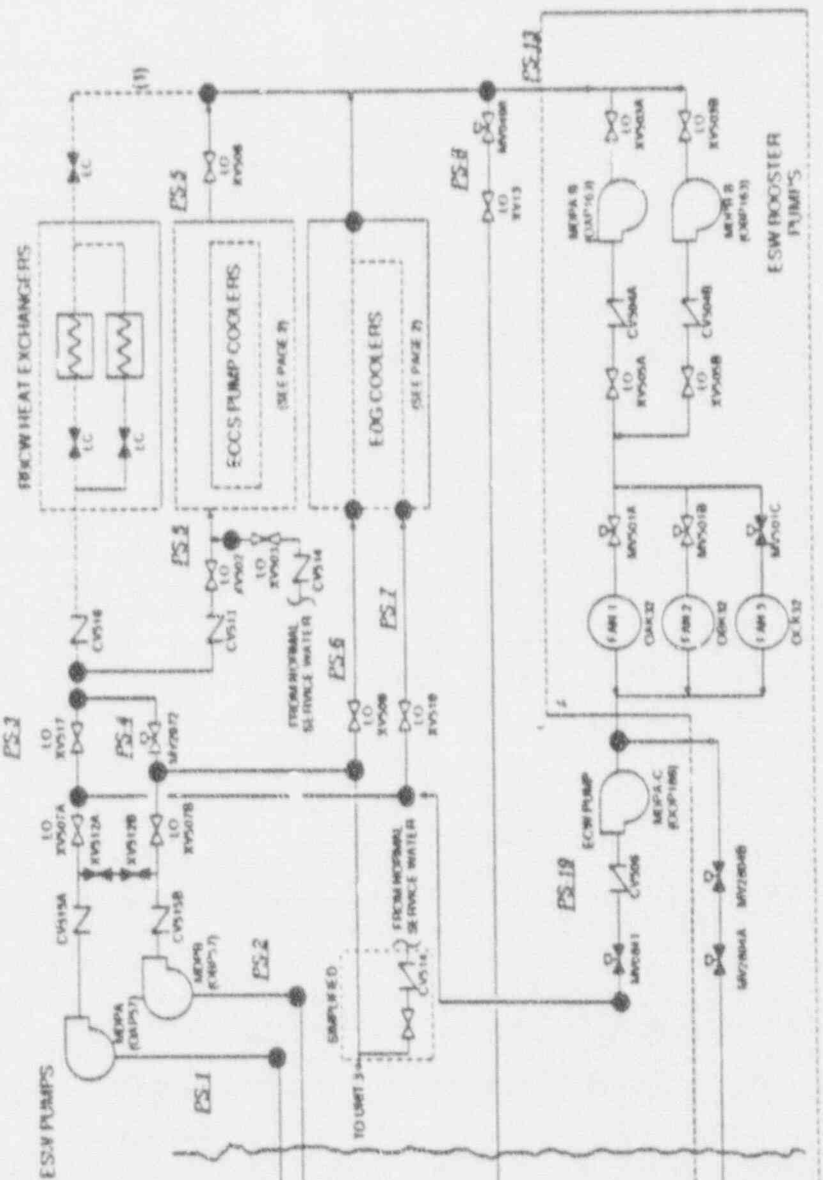


Figure 2.16 Peach Bottom Emergency Service Water System (Page 1 of 2)

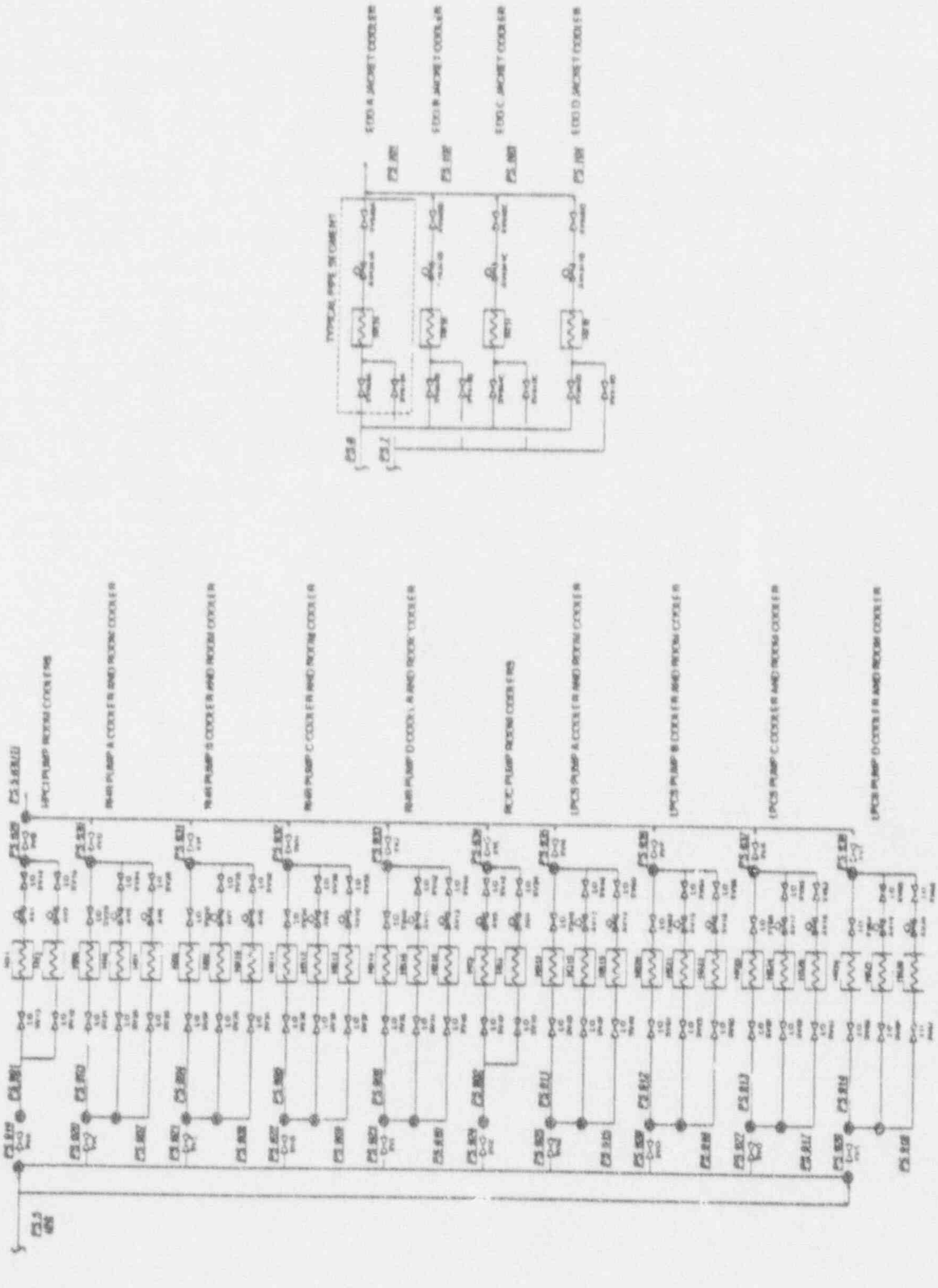


Figure 2.16 Peach Bottom Emergency Service Water System (Page 2 of 2)

contribute 97% of the total CDF as found in the NUREG-4550 results. The service water contribution to the total CDF through T1 sequences is 13%, which accounts for 94% of the total service water contribution to the total CDF at Grand Gulf.

As can be seen from Figures 2.2 through 2.8, for BWRs T1 (i.e., loss of offsite power initiator) sequences tend to dominate the plant CDF. For PWRs LOCA sequences tend to dominate, as shown in Figures 2.9 through 2.15. When considering the SW contribution, SW tends to also dominate in these classes of sequences. However for BWRs it can be seen that for Cooper and Quad Cities, the SW contribution to CDF is predominate in TAC (i.e., loss of an AC Bus initiator) sequences, where SW fails to provide cooling to the Residual Heat Removal system in the suppression pool cooling mode. For Peach Bottom and Grand Gulf, on the other hand, SW is dominate in T1 sequences where SW fails to provide cooling to the emergency diesel generators.

For the PWRs, SW contribution is a predominate contributor to CDF in LOCA sequences, where SW fails to providing cooling to the high and low pressure injection systems either in the injection phase or in the recirculation phase of operation. That is, SW fails to provide cooling to the injection system pumps or pump room coolers, thereby causing loss of injection, for those plants requiring pump cooling; or SW fails to providing cooling to the RHR heat exchangers thereby failing low pressure recirculation.

These results are not unexpected since, as noted above, the service water systems for each plant, though unique, tend to have very similar functions.

2.4 Comparison of Plant-Specific Service Water Faults

As described above and documented in Appendix E, the dominate accident sequences for the eleven NRC sponsored PRAs were reviewed to identify SW faults and to determine the SW contribution to CDF. The purpose of this section is to provide insights into the types of vulnerabilities affecting SW system reliability based on the results of the eleven PRAs reviewed.

2.4.1 BWR Service Water System Faults

The dominant service water component failures and unavailabilities found in the four BWR PRAs reviewed are summarized in the following paragraphs. The percentages in parenthesis are the contribution of the given failure mode to the total CDF for each plant. Credit for recovery prior to core damage is included as contained in the source documents, i.e. the TAP A-45 or NUREG/CR-4550 analyses. Since recovery actions are accident sequence and cut set dependent, recovery actions specific to service water may, or may not, be given credit.

Cooper (see Appendix C, Figures C.1 and C.2)

- one of the two SW loops unavailable due to maintenance (5%)
- one of two Reactor Building Closed Cooling Water (RBCCW) loops unavailable due to maintenance (7%)
- failure of the SW non-critical header isolation valve (motor-operated valve) to isolate nonsafety loads (3%)
- failure of the RBCW non-critical header isolation valve (motor-operated valve) to isolate nonsafety loads (31%)
- failure of RBCCW isolation valve (motor-operated valves) to safety loads to open (18%)

Quad Cities (see Appendix C, Figures C.3 and C.4)

- one of two Residual Heat Removal Service Water (RSW) System loops unavailable due to maintenance (19%)
- local faults of Diesel Generator Service Water (DSW) pumps (4%)
- common mode failure of the RSW pumps (3%)
- common mode failure of the DSW pumps (2%)

Peach Bottom (see Figure 2.16)

- human error, failure to operate the emergency heat sink (14%)
- Emergency Service Water (ESW) pump discharge check valves fail due to back leakage (4%)

- air operated valves in service water lines from the diesel generators fail to open on demand (2%)
- failure to restore ESW components following maintenance (1%)
- ESW pumps fail to start (<1%)

Grand Gulf (see Appendix C, Figure C.7)

- common mode failure of the Standby Service Water (SSW) pumps (4%)
- SSW pumps fail to start (3%)
- normally closed motor-operated valves in the SSW distribution lines to safety loads and return lines from safety loads fail to open on demand (7%)

As can be seen from the above referenced figures, the SW system configurations for each of the BWRs is unique. However there are common dominant failure modes between the plants. These common failure modes are:

- Isolation valve to safety loads fail to open on demand: This failure is common to Cooper (18%), Peach Bottom (4%), and Grand Gulf (7%).

- Standby service water pumps fail to start: This failure mode is common to those plants that have standby emergency service water systems like Quad Cities (9%), Peach Bottom (2%), and Grand Gulf (7%).

Unavailabilities due to maintenance and due to the failure to restore system components also contribute significantly to the SW contribution to CDF for most of the BWR plants.

Two important subtle failures are also dominant in the BWR results. These are failure to isolate nonessential cooling water loads (Cooper) and discharge check valve failures for cross-tied pumps (Peach Bottom). The failure to isolate the nonessential cooling water headers contributes 34% of the total TAP A-45 CDF at Cooper. Unlike the other BWRs, Cooper does not have a standby emergency service water system. Therefore, it is dependent on the noncritical header isolation valves to close. Failure to isolate the noncritical headers results in inadequate cooling of the essential loads. This coupled with the dependency on RBCW to align to safety loads (i.e., normally closed isolation valves have to open on demand) contributes over 50% of the total TAP A-45 CDF.

At Peach Bottom, the failure (stuck open) of an ESW pump discharge check valve, defeats the ESW system. As shown on the first page of Figure 2.16, the Peach Bottom ESW systems consists of two cross-tied pumps (OAP57 and OBP57). Both pumps automatically start when demanded, however the operator will secure one of the pumps once system pressure is achieved. If the pump discharge check valve (CV515A or CV515B) of the idle pump sticks open, the flow from the operating pump is assumed to recirculate back through the idle pump resulting in functional failure of the system.

2.4.2 PWR Service Water System Faults

The dominant service water component failures and unavailabilities found in the four PWR PRAs reviewed are summarized as follows:

St. Lucie (see Appendix C, Figures C.8 and C.9)

- common mode failure of the Component Cooling Water system pumps (10%)
- common mode failure of the Intake Cooling Water system pumps (3%)

Calvert Cliffs (see Appendix C, Figures C.10, C.11, and C.12)

- failure of Salt Water System (SWS) and Component Cooling Water (CCW) normally closed air-operated valves to safety related loads to open (6%)
- failure of SWS normally open air-operated valves to stay open (1%)
- failure of CCW manual valve due to plugging resulting in common mode failure of low pressure and high pressure safety injections pumps seal cooling (1%)

ANO-1 (see Appendix C, Figure C.13)

- common mode failure of Service Water System (SWS) motor-operated valves to safety related loads to open (11%)
- common mode failure of SWS pumps (1%)

Point Beach (see Appendix C, Figures C.14 and C.15)

- unavailability of Component Cooling Water (CCW) manual return valve from RHR pump coolers due to maintenance (9%)
- common mode failure of CCW pumps (5%)
- CCW manual return valve from RHR pumps coolers fails closed due to plugging (2%)
- common mode failure of Service Water (SWS) pumps (2%)

Turkey Point (see Appendix C, Figures C.16 and C.17)

- common mode failure of Component Cooling Water (CCW) pumps (2%)
- failure of the Service Water (SWS) non-critical header isolation valve (air-operated valve) to isolate nonsafety loads (2%)
- common mode failure of SWS pumps (2%)

Surry (see Appendix C, Figures C.18 and C.19)

- common mode failure of Service Water (SWS) isolation motor-operated valves to open (<1%)

Sequoyah (see Appendix C. Figures C.20 and C.21)

- Component Cooling Water motor-operated valves fail to open (<1%)
- Service Water (SWS) manual valves and strainers fail due to plugging (<1%)

Note: Percentages given in parenthesis represent the contribution made by the given failure mode to the total CDF for each plant.

As can be seen from Figures C.8 through C.21 of Appendix C, the SW system configurations for each of the PWRs is unique. However, as with the BWRs two common service water system faults exist between most of the plants. These are the dependency of the service water system on motor-operated or air-operated isolation valves to open on demand to supply cooling to the safety related loads and failure of standby pumps to start.

At Turkey Point, as at Cooper, the dependence of the service water system on isolation of a noncritical header shows up as a dominant failure mode. Failure of the noncritical header to isolate diverts water away from the safety related loads resulting in functional failure of the service water system.

3.0 SELECTION OF THE PILOT PLANT

The pilot plant was selected to be the basis for one example of the type of analysis that can be performed to show the effect of improvements to an ESW system to address its vulnerabilities. The selection was based on the six criteria given below in a general order of priority:

1. One of the twelve NRC sponsored PRAs accessible to SNL with relatively current methods and fault trees in a computer format.

2. A PRA that has current, good quality, and useable models and preferably entered into IRRAS.

3. A PRA where the ESW system is a relatively high contributor to CDF both in frequency and percent of total CDF, i.e., approximately:

   1.0E-06 to 3.0E-05, and
   15% to 35% of the total CDF.

4. A plant representative of a large group of units within a vendor type and/or subtype (see Appendix A).

5. An ESW system representative of a large group of ESW systems.

6. A PRA with external events results which can be used in the current analysis.

There have been 23 NRC sponsored PRAs. Twelve of these were considered suitable candidates for this program. The 11 PRAs excluded are given below with reasons why they were eliminated.

	Plant	Program	Reasons
1.	Surry	WASH-1400	Superseded by NUREG-1150
2.	Peach Bottom	WASH-1400	Superseded by NUREG-1150
3.	Sequoyah	RSSMAP	Superseded by NUREG-1150
4.	Calvert Cliffs	RSSMAP	Superseded by IREP
5.	Crystal River	RSSMAP	Old Method - No Models
6.	Grand Gulf	RSSMAP	Superseded by NUREG-1150
7.	Oconee	RSSMAP	Old Method - No Models
8.	Millstone	IREP	Models Not Available
9.	Browns Ferry	IREP	Models Not Available
10.	ANO-1	IREP	Superseded by TAP A-45
11.	Zion	NUREG-1150	Different Methodology

The twelve candidate plants are given in Table 3.1 with various characteristics of the plant and the associated PRA that relate to the six criteria. The results of evaluating the plants against the criteria are given in Table 3.2. Every plant PRA has one or more marginal or no answers to the criteria except for Peach Bottom. Actually, the criteria were weighted toward the highest priority criteria. For example, they all meet criteria #1, which is absolutely essential or the PRA would not be usable. Criteria #2 was also very essential in that the useability of the model and, in particular its accessibility on IRRAS, were considered important to success of the program. Applying criteria #3 then leads to Peach Bottom as the best choice. The only shortcoming of the Peach Bottom PRA[23] is that the absolute SW contribution to core damage frequency is slightly below the low end of the "acceptable" range. In fact, one can fault every one of these PRAs or perhaps any non-NRC sponsored PRA for some reason relative to its use in this service water analysis. So there being no perfect example, the Peach Bottom NUREG/CR-4550 PRA[23] was a reasonable choice.

Table 3.1 NRC Sponsored PRA Characteristics

Plant	Program	Level	Year PRA Compl.	Initial Opern Yr/ Type	No Units	Total CDF (Internal)	ESW[1] CDR Contr.	ESW % Contr.	Ext.[2] Events Modeled	Model Available /Quality	System Source Book	ASEP Plant	Special Comments
Calvert Cliffs	IREP	1	1984	74/CE	2	1.3E-04	1.4E-05	11	No	Yes-Good	No	Yes	
Point Beach	TAP A-45	1	1986	70/W2	2	1.4E-04	2.6E-05	19	SFLO	Yes-Fair	No	No	Has value impact analysis. Limited IE.
Turkey Point	TAP A-45	1	1986	72/W3	2	7.1E-05	3.4E-06	5	SFLO	Yes-Fair	No	No	Has value impact analysis. Limited IE.
St. Lucie	TAP A-45	1	1986	76/CE	2	1.4E-05	1.8E-06	13	SFLO	Yes-Fair	Yes	Yes	Has value impact analysis. Limited IE.
ANO-1	TAP A-45	1	1986	74-B&W	1	8.8E-05	1.1E-05	12	SFLO	Yes-Fair	No	No	Has value impact analysis. Limited IE.
Quad Cities	TAP A-45	1	1986	72/BWR3	2	9.9E-05	3.0E-05	30	SFLO	Yes-Fair	Yes	Yes	Has value impact analysis. Limited IE.
Cooper	TAP A-45	1	1986	74/BWR4	1	2.9E-04	1.9E-04	65	SFLO	Yes-Fair	Yes	Yes	Has value impact analysis. Limited IE.
LaSalle	RMIEP	3	1990	82/BWR5	2	4.4E-05	3.0E-06	7	SFL	IRRAS-Exc.	No	Yes	Most detailed, but different methods.
Surry	NUREG-4550	3	1988	73/W3	2	4.0E-05	1.5E-08	<1	SF	IRRAS-Exc.	No	Yes	
Sequoyah	NUREG-4550	3	1988	80/W4	2	5.7E-05	2.4E-07	<1	No	IRRAS-Exc.	No	Yes	
Peach Bottom	NUREG-4550	3	1988	73/BWR4	2	4.5E-06	1.4E-06	22	SF	IRRAS-Exc.	Yes	Yes	
Grand Gulf	NUREG-4550	3	1988	85/BWR6	1	4.1E-06	5.6E-07	14	No	IRRAS-Exc.	Yes	Yes	Shutdown Study.

[1]Service Water contribution may be higher than given for the TAP A-45 program plants. Contribution given is based on the cutsets given in the TAP A-45 reports which in many cases represented less than 50% of the total core damage frequency.

[2]S = Seismic, F = Fire, L = Flood, O = Other.

Table 3.2 Evaluation of Criteria

Plant	1	2	3	4	5	6
Calvert Cliff	Y	M	M	Y	M	N
Point Beach	Y	M	Y	M	Y	Y
Turkey Point	Y	M	N	Y	Y	Y
St. Lucie	Y	M	M	Y	M	Y
ANO-1	Y	M	Y	Y	M	Y
Quad Cities	Y	M	Y	M	U	Y
Cooper	Y	M	Y	Y	U	Y
LaSalle	Y	M	N	Y	U	Y
Surry	Y	Y	N	Y	Y	Y
Sequoyah	Y	Y	N	Y	Y	N
Peach Bottom	Y	Y	Y	Y	U	Y
Grand Gulf	Y	Y	N	Y	U	N

Y = Yes
N = No
M = Marginal
U = Unknown needs more study

4.0 Pilot Plant Analysis

4.1 Pilot Plant Essential Services Water Systems

Six systems are available to perform the required cooling functions at the BWR Pilot Plant:

1. Service Water System,
2. Turbine Building Cooling Water System,
3. Reactor Building Cooling Water System,
4. High Pressure Service Water System,
5. Emergency Service Water System, and
6. Emergency Heat Sink.

The acronyms used to refer to these Pilot Plant systems in this chapter are defined as they are used. Note that the acronyms may not use the same words used previously. For example, ESW in this chapter refers to Emergency Service Water. Earlier, ESW referred to Essential Service Water.

The first three systems above are balance of plant (BOP) cooling systems. The Service Water System (SWS) is an open loop system and supplies screened and chlorinated cooling water to the plant during normal plant operation and shutdown periods only. The SWS consists of three one-half capacity pumps, three horizontal fuel pool service water booster pumps, and associated valves and piping. The SWS fails on loss of normal AC power.[47]

The Turbine Building Cooling Water (TBCW) system is a closed loop system and supplies cooling water to auxiliary plant equipment associated with the power conversion system. The system consists of two full-capacity pumps and heat exchangers, one head tank, and associated valves and piping. The SWS provides the heat sink for the TBCW. In the event of loss of offsite power, the TBCW system is not operated.[47]

The Reactor Building Cooling Water (RBCCW) system is a closed loop system whose function is to provide cooling to auxiliary plant equipment associated with the nuclear steam supply system. During normal operation the SWS provides the heat sink for the RBCCW system. Under emergency conditions (e.g., loss of offsite power), the RBCCW heat exchangers are manually connected and served by the Emergency Service Water (ESW) system. The RBCCW system consists of two full-capacity pumps, two full capacity heat exchangers, one head tank, and associated valves and piping.[47]

The High-Pressure Service Water (HPSW) system is a standby system dedicated to the Residual Heat Removal (RHR) system. The HPSW system consists of two cross-tied pump trains. Each train is made up of two pumps and associated valves and piping. The system is designed to supply cooling water from the ultimate heat sink to the RHR heat exchangers under post accident conditions.[47]

The ESW system is a standby system designed to provide adequate cooling to the emergency equipment coolers and compartment air coolers during a loss of offsite power. The system consists of two full capacity pumps installed in parallel. The ESW system is common to both Units 2 and 3.[47] The ESW system is described further below.

The Emergency Heat Sink (EHS) provides onsite heat removal capabilities for Units 2 and 3 in the event the normal heat sink becomes unavailable. The EHS consists of an induced-draft cooling tower, one full capacity Emergency Cooling Water (ECW) pump, and associated valves and piping. The EHS can be operated in either a closed loop mode or an open mode.[47] The EHS is described further below.

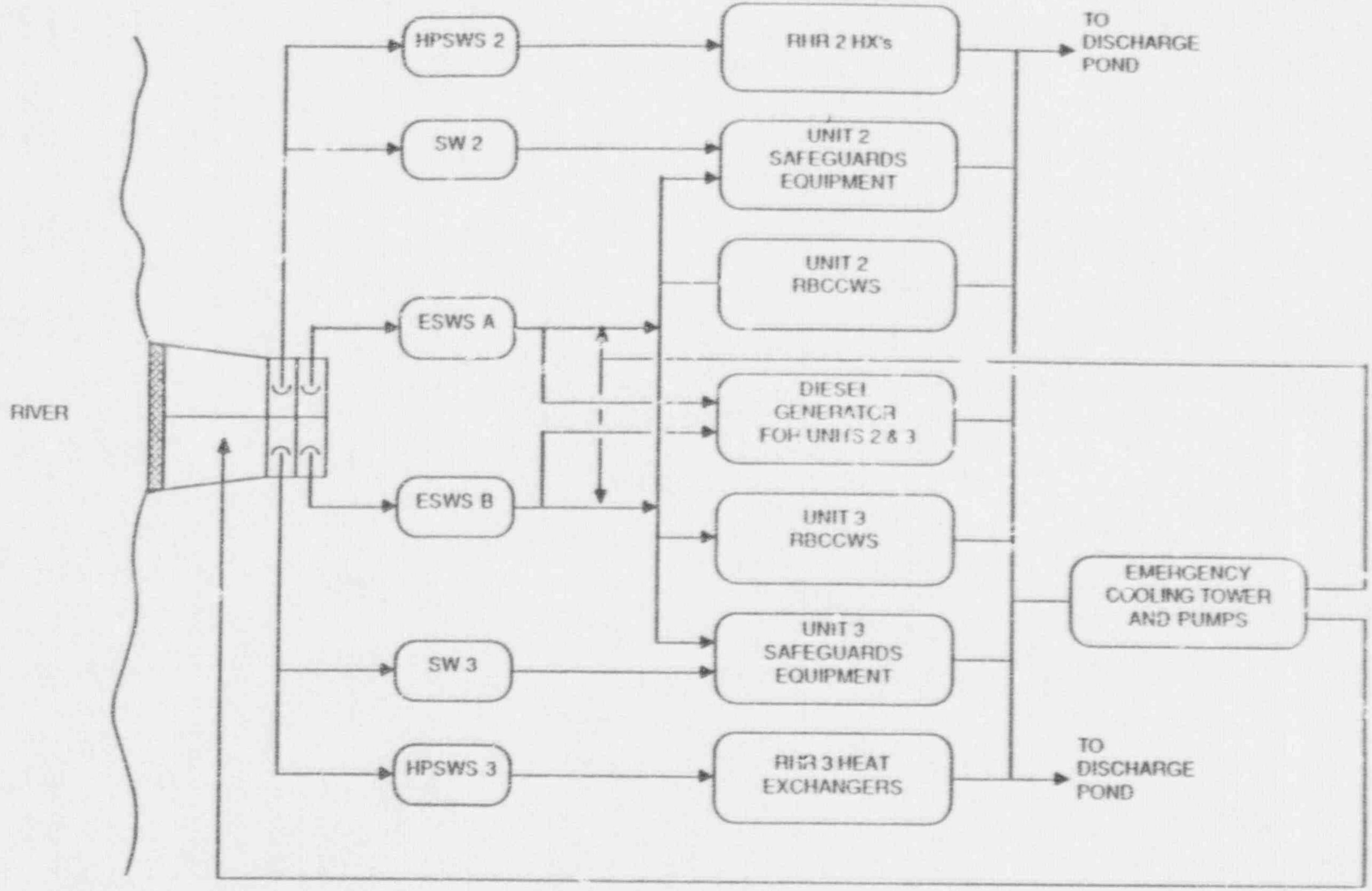
Figure 4.1, taken from Reference 48, shows the functional relationship between the SWS, RBCCW, EHS, and ESW systems.

As described in Section 2.2, the NUREG/CR-4550 dominant accident sequences were reviewed to determine the service water contribution to CDF. This review is documented in Appendix E. As can be seen from the results of this review, for the Pilot Plant the dominant service water faults are associated with the ESW system and EHS. Therefore, in this analysis, only these two systems were reviewed to determine system vulnerabilities and to determine possible modifications to enhance system reliability. The following describes the ESW and EHS vulnerabilities and associated modifications.

4.2 Pilot Plant Emergency Service Water System

As described above, the ESW system is common to both Units 2 and 3. The system consists of two full-capacity pumps installed in parallel. The normal suction source for the pumps is a pond. The pump discharge piping consists of two headers with service loops to supply the diesel-engine coolers and selected equipment coolers. A common discharge header routes the system effluent back to the pond. Figure 4.2 illustrates the ESW system.

Both pumps start automatically whenever standby diesel-generators are started. One of the ESW pumps is manually shut off if both pumps are running.



ESWS = Emergency Service Water System
HPSWS = High Pressure Service Water System
RBCCWS = Reactor Building Closed Cooling Water System

Figure 4.1 Cooling Water Systems Functional Diagram for Pilot Plant Units 2 and 3

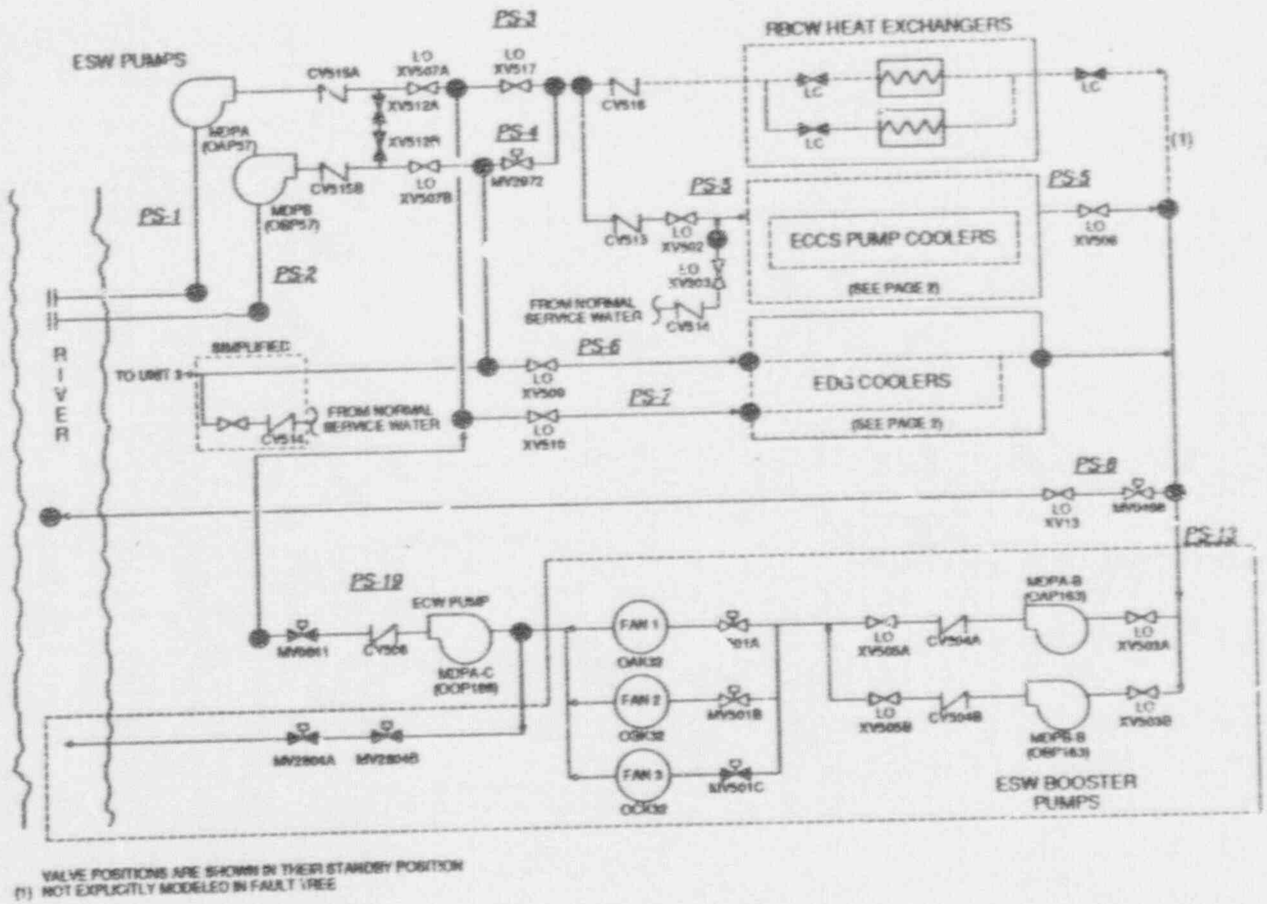


Figure 4.2 Pilot Plant Emergency Service Water System (1 of 2)

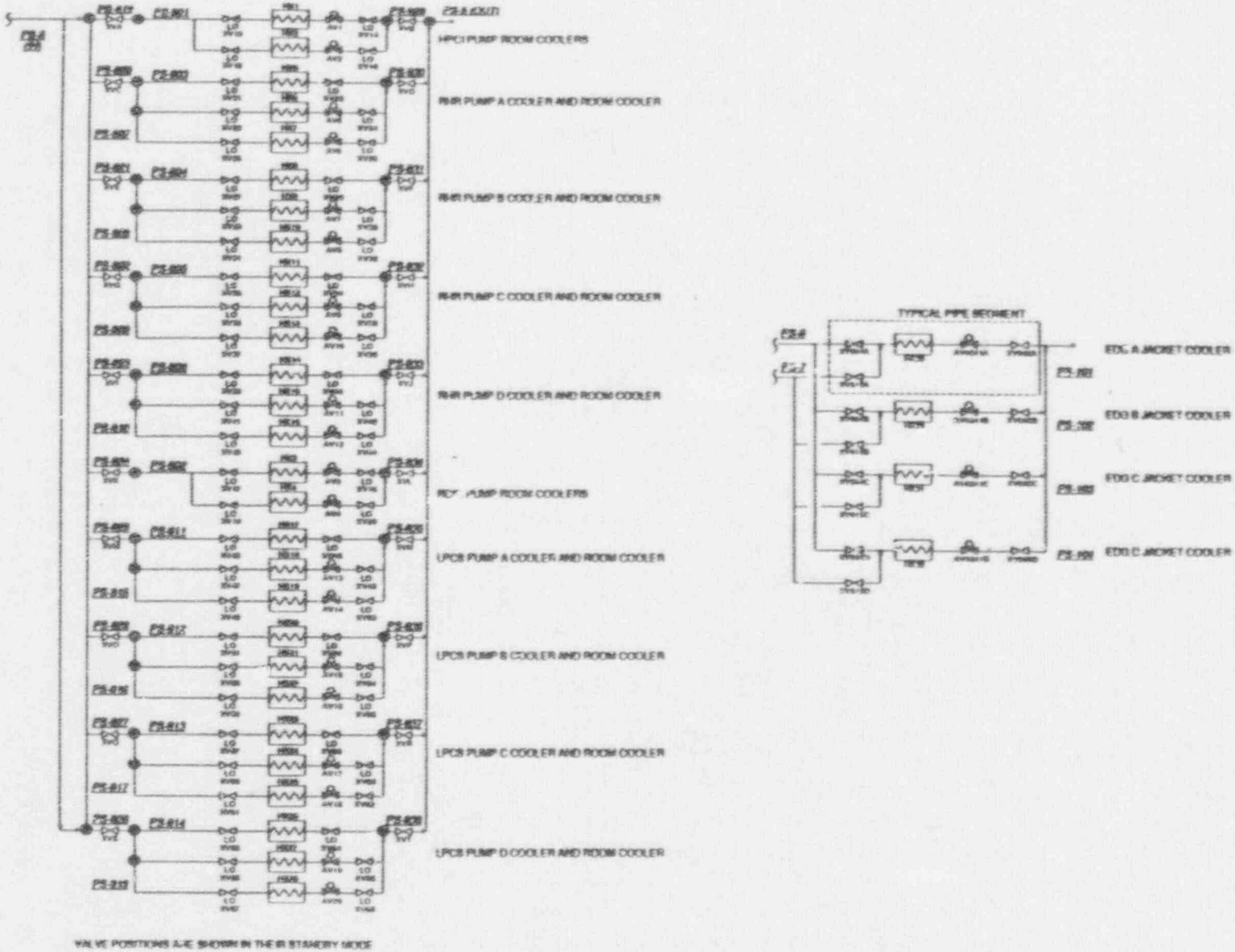


Figure 4.2 Pilot Plant Emergency Service Water System (2 of 2)

Should the ESW pumps fail, the ESW may be operated in conjunction with the emergency heat sink in a closed or open loop fashion. In the closed loop mode, two ESW booster pumps take return water from various coolers, boost pressure, and deliver the water to the emergency cooling tower. The ECW pump then takes suction from the cooling tower and discharges through a motor-operated valve to the ESW loads. The booster pumps are not required in this mode since it has been demonstrated by test that booster pump failure would not fail the cooling function of the ECW pump. In the open loop mode, the ECW pump delivers water from the cooling tower structure, through the ESW loads, and back to the bay. There is sufficient water supply in the cooling tower to last for days; hence the open loop mode is considered a success path. The NUREG/CR-4550 analysis only considered the open loop mode of operation in their model development.

Upon system automatic initiation, the operator checks discharge pressure for the two primary ESW pumps. If discharge pressure appears normal, the operator will secure one ESW pump at his discretion. He also secures the ECW pump which automatically starts on an emergency diesel auto-start signal (after a 22 second time delay). The ECW pump discharge motor-operated valve will open on ESW low system pressure and an emergency diesel auto-start signal (after a 45 second time delay). The ECW pump will trip if ESW pressure is not low and an emergency diesel auto-start signal is present (after a 45 second time delay). At some later time, if the operating ESW pump trips and the standby ESW fails to operate, the operator must manually start the ECW pump. In the closed loop mode, the cooling tower fans must also be manually started.

4.3 External Events

External events were not considered explicitly in the pilot plant analysis described in the other portions of this section and Section 5.0 because of resource limitations. Nevertheless, external events are almost always important in PRA and usually involve essential service water. A brief summary of the external events analysis for the pilot plant and the corresponding contribution to CDF of essential service water are provided in this section. The ESW faults contributing to core damage are discussed in the following section.

An external event analysis starts with a screening process to determine which potential external events should be studied in more detail. An extract from NUREG/CR-4550 Vol. 4, Rev. 1, Part 3 is given below.

"3.4 Summary

The scoping quantification study considered all possible external events at the site except for seismic and fire events, since these two events were included in a detailed external events analysis. The PRA Procedures Guide, suitably augmented with other available information, was used as a guideline for identification of all possible external events at the Peach Bottom site. Next, an initial screening process was carried out to eliminate events not applicable to Peach Bottom from the list. For this purpose, a set of screening criteria was developed and then each external event was examined for possible elimination based on these criteria. After the initial screening process was completed, the following events were found to be potential contributors to the plant risk.

a. Aircraft Impact
b. Extreme Winds and Tornadoes
c. External Flooding
d. Industrial or Military Facility Accident
e. Release of Chemicals from Onsite Storage
f. Turbine Generated Missiles
g. Transportation Accidents
h. Internal Flooding

The degree of sophistication in the bounding analysis for each event depended on whether the event could be eliminated based on only a hazard analysis or a complete analysis including hazard analysis, fragility evaluation and plant response analysis. The detailed plant response analysis was conservatively neglected in evaluating the impact of these external events.

The risk due to an aircraft striking the plant structures and causing unacceptable radiological consequences was screened out on the basis of the probability of strike and the design of different structures.

Evaluation for the potential for flooding as a result of the most conservative combination of Probable Maximum Flood (computed from conservative estimates of probable maximum precipitation), failure of Holtwood Dam and wind-generated waves showed that the essential structures in the plant are located much above the probable maximum surge level and the risk of flooding is negligibly small.

Tornadoes and tornado missile impacts were eliminated on the basis of a detailed computation of tornado strike probability of 9 x 10^{-7}/year and other features of plant structures and components designed to withstand the effects of a Design Basis Tornado.

The information available from Philadelphia Electric Company on the frequency of turbine disk inspection was used as the basis to assume the safety of essential plant structures from damage due to turbine missiles.

Finally, explosions due to transportation accidents and both on-site and off-site chemical releases have a low probability of affecting the site.

Thus, all external hazards except fire and seismic events were found to be negligible contributors to the risk of core damage at the Peach Bottom plant. Detailed evaluations of fire and seismic events contained in the remainder of this report."

Thus only seismic and fire events were considered further. Most of the following information was taken directly from the above reference.

Seismic

The seismic risk was found to be dominated by relatively few accident sequences. The dominant accident sequences primarily involve station blackout situations which resulted from loss of cooling water to the emergency diesel generators. A variety of different component failures were identified which led to this situation, with failures of the emergency service water and emergency heat sink systems being the most important. This is demonstrated in the table given below for both the hazard analyses performed.

Dominant Component Contributions to Mean Core Damage Frequency Ranked by Risk Reduction Potential

Component	Percent Reduction if Not Failed	
	LLNL Hazard	EPRI Hazard
Ceramic Insulators	48%	52%
ESW/ECW Pumps	31%	34%
Diesel Generator	24%	26%
Turbine Building	14%	16%
4kV Busses	12%	13%
Radwaste/Turbine Building	8%	8%
RV Recirculation Pumps Supports	7%	7%
RV Skirt Support	1%	1%

All other components and structures less than 1%

The total seismic CDF was 7.66E-05 for the LLNL hazard curves and 3.09E-06 for the EPRI hazard curves.

Typical service water related events are:

EMER-COOL-TOWER
ESW-MDP-FS-MDPA&B
ESW-CCF-PF-MDPS
ESW-MDP-FS-ECW
ESW-TNK-LL-PS13

The ESW-TNK and COOL-TOWER are direct seismic events outside the system analysis. Failure of the two ESW pumps, the ECW pump, and common cause failure of the ESW pumps are covered in the internal events analysis. Additional credit for improving the ESWS given the seismic environment is unclear since any modifications would have to consider seismic qualification in addition to the basic costs of the changes.

Fire

There were three fire areas with potentially significant core damage frequencies; the control room, the cable spreading room, and the emergency switchgear rooms. Only the emergency switchgear rooms directly involve service water. These can be divided into three groups.

GROUP I — Emergency Switchgear Rooms 2A, 2D, 3A, 3B, and 3C

For all five of these fire areas a similar scenario occurred. This sequence (T1BU1) was a station blackout caused by a fire-induced loss of offsite power and a random loss of the emergency service water system. This random (failure not related to the fire itself) loss of emergency service water caused a station blackout because emergency service water provides cooling for all four diesel generators. Thus, emergency onsite power failed. Emergency service water also provides room cooling for the HPCI system. The HPCI system will fail in approximately 10 to 12 hours due to either loss of room cooling or battery depletion caused by the station blackout. These areas are all similar in that the primary source of fire is electrical switchgear within the fire area. The fire accident sequence involves several terms.

The term that represents random failure of the emergency service water system Q_{ESW} can be represented by the following equation:

$$
\begin{aligned}
Q_{ESW} = {} & \text{ACP-DGN-FR-EDGB} \; * \\
& \text{ACP-DGN-FR-EDGC} \; * \\
& \text{DGHWNR16HR} \; * \\
& \text{ESW-XHE-FO-EHS} \; + \\
& \text{ESW-CCF-LF-AOVS}
\end{aligned}
$$

These random failure events were developed as part of the internal events analysis of the Pilot Plant and are identical except for the postulated mission time of the emergency diesel generators.

GROUP II — Emergency Switchgear Rooms 3D and 2B

The identical scenario to that described above for GROUP I occurs; however, some fire-related failures of the ESW also occur. For emergency switchgear room 3D the fire fails power to the ECW pump, while for room 2B power is failed to ESW pump A. These fire-related failures coupled with additional random failures lead to a loss of ESW system, and consequently, station blackout.

Therefore, the Q_{ESW} term for emergency switchgear room 3D is:

$$
\begin{aligned}
Q_{ESW} = {} & \text{ACP-DGN-FR-EDGB} \; * \\
& \text{ACP-DGN-FR-EDGC} \; * \\
& \text{DGHWNR16HR} \; + \\
& \text{ESW-CCF-LF-AOVS}
\end{aligned}
$$

while for emergency switchgear room 2B:

$$
\begin{aligned}
Q_{ESW} = {} & \text{ESW-CKV-C515A} \; + \\
& \text{ESW-CCF-LF-AOVS} \; + \\
& \text{ACP-DGN-FR-EDGC} \; * \\
& \text{ACP-DGN-FR-EDGD} \; * \\
& \text{DGHWNR16HR}
\end{aligned}
$$

GROUP III — Emergency Switchgear Room 2C

Three scenarios survived screening for emergency switchgear room 2C. The first was the station blackout scenario described above the GROUP II with fire-related failure of offsite power and ESW pump B. The other two sequences were T1BU1W1X2W23U4V23Y and T1BU1W1X2W23U4V2Y. For these last two cases station blackout does not occur and other random failures lead to long-term core damage scenarios. The core damage equation for all three scenarios is identical except Q_{ESW} is replaced with Q_{RANDOM} for the latter two long-term sequences to reflect different random failures necessary for core damage. Thus only Scenario 1 is related to the service water system.

The only difference for Scenario 1 for room 2C is the Q_{ESW} term is changed due to a slightly different fire-induced damage.

Q_{ESW} = ESW-CKV-C515A +
ESW-CCF-LF-AOVS +
ACP-DGN-FR-EDGB *
ACP-DGN-FR-EDGD *
DGHWNF16HR.

Typical service water system related events for these fire areas are:

ESW-XHE-FO-EHS
ESW-CCF-LF-AOVS
ESW-CKV-C515A
ESW-CKV-C515B

These events are addressed in the internal events analysis but credit for modifications that might result from changes in the fire core damage frequency were not included. New core damage frequencie per reactor year for the pilot plant fire areas were:

Fire Area	Mean	Group
Emergency Switchgear Room 2A	7.4E-08	I
Emergency Switchgear Room 2B	3.6E-06	II
Emergency Switchgear Room 2C	4.7E-06	III
Emergency Switchgear Room 2D	7.4E-07	I
Emergency Switchgear Room 3A	7.4E-07	I
Emergency Switchgear Room 3B	7.4E-07	I
Emergency Switchgear Room 3C	7.4E-07	I
Emergency Switchgear Room 3D	8.1E-07	II
Control Room	6.2E-06	
Cable Spreading Room	6.7E-07	
TOTAL CONTRIBUTION	1.95E-05	

The overall fire-induced core damage frequency for Unit 2 of the Pilot Plant was 1.95E-05 per year. The dominant contributing plant areas are the (a) control room, (b) emergency switchgear room 2C, and (c) emergency switchgear room 2B. These three areas comprise 75% of the total fire risk. The total ESW related fire CDF contribution is 1.28E-05. This is 66% of the CDF.

In the case of the control room, a general transient occurs with smoke-induced abandonment of the area. Failure to control the plant from the remote shutdown panel results in core damage.

For the emergency switchgear rooms, a fire-induced loss of offsite power and failure of one train of the ESW occurs. Random failure of the other ESW train and the ECW pump results in station blackout and core damage.

4.4 Dominant ESW Faults Contributing to Core Damage

As described in Section 2.2, the NUREG/CR-4550 results for the Pilot Plant were examined to determine the dominant ESW faults contributing to the total CDF. Emergency Service Water events show up as dominant in four dominant accident sequences (i.e., station blackout sequences). These four accident sequences are listed in Table 4.1.

These four sequences account for 43.9 percent of the total CDF. It is noted that of the 1393 dominant cut sets considered in the NUREG/CR-4550 analysis, these four sequences account for 1330 cut sets. Each of these four sequences are described subsequently.

Accident Sequence T1-BNU11

This accident sequence is initiated by a loss of offsite power (T1), the safety relief valves properly control reactor pressure, but failure of all emergency diesels occurs (B) due to loss of service water which results in a station blackout. High Pressure Coolant Injection (HPCI) in initially successful (NU11) but fails in the long term due to either harsh environment (e.g., loss of room cooling effects) or subsequent battery depletion, resulting in late core damage in a vulnerable containment.

Accident Sequence T1-P1BNU11

This accident sequence is initiated by a loss of offsite power (T1), followed by one stuck open safety relief valve (P1), subsequent failure of all emergency diesels occurs (B) due to loss of service water which results in a station blackout. High Pressure Coolant Injection (HPCI) in initially successful (NU11) but fails in the long term due to either harsh environment (e.g., loss of room cooling effects) or subsequent battery depletion, resulting in core damage in 10 to 13 hours.

Accident Sequence T1-BU11NU21

This sequence is initiated by a loss of offsite power (T1), followed by a loss of emergency diesels (B) due to loss of service water which results in a station blackout. HPCI then fails, followed by either battery depletion or RCIC injection failure due to the harsh environment. Core damage occurs late in a vulnerable containment.

Table 4.1
Pilot Plant Dominant Accident Sequences With Service Water Contributions

Accident Sequence	Sequence Frequency (/R yr)	Sequence % of CDF	SW Contribution	SW % of CDF	Plant Damage State
T1-BNU11	1.64E-06	36.4	8.39E-07	19	5
T1-P1BNU11	1.31E-07	2.9	7.34E-08	2	5
T1-BU11NU21	1.25E-07	2.7	5.88E-08	1	5
T1-P2V234NU11B	8.73E-08	1.9	5.50E-09	<1	2 & 3

Accident Sequence T1-P2V234NU1113

This sequence is initiated by a loss of offsite power (T1). High pressure injection initially operates (NU11), but two relief valves fail to close (P2). This caused the equivalent of an intermediate LOCA. The low pressure system fails on demand (V234), resulting in core damage.

The ESW and ECW are dominant contributors to the first three sequences due to the dependency of the emergency diesel generators on these systems. Failure of both ESW and ECW results in loss of all emergency diesel generators. The ESW is a dominant contributor in the fourth sequence due to the dependency of the low pressure systems dependency on ESW for room cooling. Loss of room cooling fails the low pressure system pumps.

It should be noted that the SWS was not considered to be a special initiator in the NUREG/CR-4550 analysis for the pilot plant. The NUREG/CR-4550 analysis did consider special initiators and screened out all that would not affect the analysis. An excerpt from the NUREG/CR-4550 report[21] follows:

> "A search for other special initiators was also performed and included three major categories: loss of any service water system, loss of instrument air, and loss of heating and ventilation equipment. The NSW system, Reactor Building Cooling Water (RBCCW) system, ESW system, and HPSW system were reviewed as possible sources for special initiators. Possible pipe breaks, the potential for causing a plant trip, and effects on safety systems such as loss of cooling or flooding were considered during the review. While detailed analyses were not possible because of resources available for the study, no special initiators were worthy of examination involving these systems were identified. This is based in part on the generally sharp separation between safety and non-safety cooling water systems; NSW and TBCW are normally running non-safety systems and, thus, the unlikely possibility of both a plant trip and degrading safety systems at the same time. Possibilities of flooding seem small based on the low pressure operation of these systems and their locations with respect to most other safety systems."

Thus the loss of service water initiating event was screened out because of redundancy of system equipment, functional and spatial separation of normally operating versus standby systems, probability of occurrence of failure, and the potential to isolate where required. In those plants where normal service water and emergency service water share the same components this initiating event can be very important.

The dominant ESW events in the Pilot Plant analysis are grouped below for further analysis.

Operator Errors

Basic Event	Contribution to CDF
ESW-XHE-FO-EHS	6.20E-07
ESW-PTF-RE-DGC	7.88E-09
ESW-PTF-RE-DGB	7.88E-09
ESW-PTF-RE-MDPA	4.62E-09
ESW-PF\TF-RE-MDPB	4.62E-09
TOTAL CONTRIBUTION	6.45E-07 (14%)

Pump Train Hardware Results

Basic Event	Contribution to CDF
ESW-CKV-CB-C515A	9.84E-08
ESW-CKV-CB-C515B	9.84E-08

ESW-MDP-FS-MDPA	8.29E-09
ESW-MDP-FS-MDPB	8.29E-09
ESW-MDP-FS-CCF	2.06E-09
ESW-MDP-FS-ECW	5.51E-10
ESW-MDP-FR-MDPA	9.17E-10
ESW-MDP-FR-MDPB	9.17E-10
ESW-CKV-HW-C515A	1.11E-11
ESW-CKV-HW-C515B	1.11E-11
TOTAL CONTRIBUTION	2.18E-07 (5%)

ESW Faults Failing the Diesel Generators

Basic Event	Contribution to CDF
ESW-AOV-CC-CCF	9.75E-08
ESW-AOV-CC-0241B	1.26E-09
ESW-AOV-CC-0241C	1.26E-09
ESW-AOV-MA-0241B	3.56E-11
ESW-AOV-MA-0241C	3.56E-11
TOTAL CONTRIBUTION	1.00E-07 (2%)

Pump Train Maintenance Unavailabilities

Basic Event	Contribution to CDF
ESW-MDP-MA-MDPA	4.39E-09
ESW-MDP-MA-MDPB	4.34E-09
ESW-MDP-MA-ECW	2.50E-10
TOTAL CONTRIBUTION	9.03E-09 (<1%)

Other SWS Faults

Basic Event	Contribution to CDF
ESW-CKV-HW-CV513	4.25E-09
ESW-XVM-PG-XV502	1.58E-09
NSW-SYS-FO-NSW-1	3.00E-10
ESW-XVM-PG-XV505B	1.41E-11
ESW-XVM-PG-XV505C	1.41E-11
ESW-XVM-PG-XV510	1.01E-12
ESW-XVM-PG-XV509	1.01E-12
ESW-XVM-PG-XV507A	1.01E-12
ESW-XVM-PG-XV507B	1.01E-12
TOTAL CONTRIBUTION	6.16E-09 (<1%)

The percent given in parenthesis is the percent contribution to the total CDF. Figure 4.3 gives a graphical representation of the above faults.

4.5 Discussion of ESW Vulnerabilities and Proposed Modifications

The vulnerabilities identified above were reviewed to determine what possible modifications might decrease the calculated ESW contribution to CDF. This section describes proposed modifications and the general vulnerabilities they address. It should be understood that the modifications described are based on limited plant design information (i.e., information available in the plant Updated Final Safety Analysis Report) and are not being proposed for implementation at the Pilot Plant.

The modifications are discussed below in accordance with the vulnerability they address.

Vulnerability 1: Operator Fails to Operate the ECW Pump

This failure is dominant in loss of offsite power accident sequences and accounts for approximately 14% of the Pilot Plant total CDF.

The emergency heat sink acts as a backup to the emergency service water (ESW) system during a loss of offsite power. The emergency heat sink (Emergency Cooling Water System) has a single pump supplied by an emergency diesel generator when offsite power is lost.

Following a loss of offsite power, the ECW pump automatically starts after a 22 second time delay following an emergency diesel generator auto start. If the discharge pressure for the emergency service water pumps appear normal, the operator will shutdown the ECW pump. If, later in the accident, the operating ESW pump trips and the standby ESW pump fails to start (receives an auto start signal on low system pressure) or run, the operator must manually restart the ECW pump. This vulnerability addresses the operator failure to restart the ECW pump following a delayed failure of the ESW pumps.

Modification 1: Addition of a Third ESW Pump

The addition of a third ESW pump that would auto start on diesel auto start and/or low ESW system pressure would increase the reliability of ESW and thereby reduce dependance on operator actions to initiate the emergency heat sink and add flexibility in response to a loss of offsite power accident. The new ESW pump would be sized for 100% ESW flow capacity and would operate in the same manner previously described for the existing ESW pumps. That is, all three pumps would start automatically when the standby diesel generators start. Two of the pumps would be manually shut off if all three are running. Figure 4.4 illustrates this proposed modification. In order for this modification to have a positive effect, the third ESW pump would require emergency power from emergency diesel D instead of emergency diesels B and C which power ESW pumps A and B.

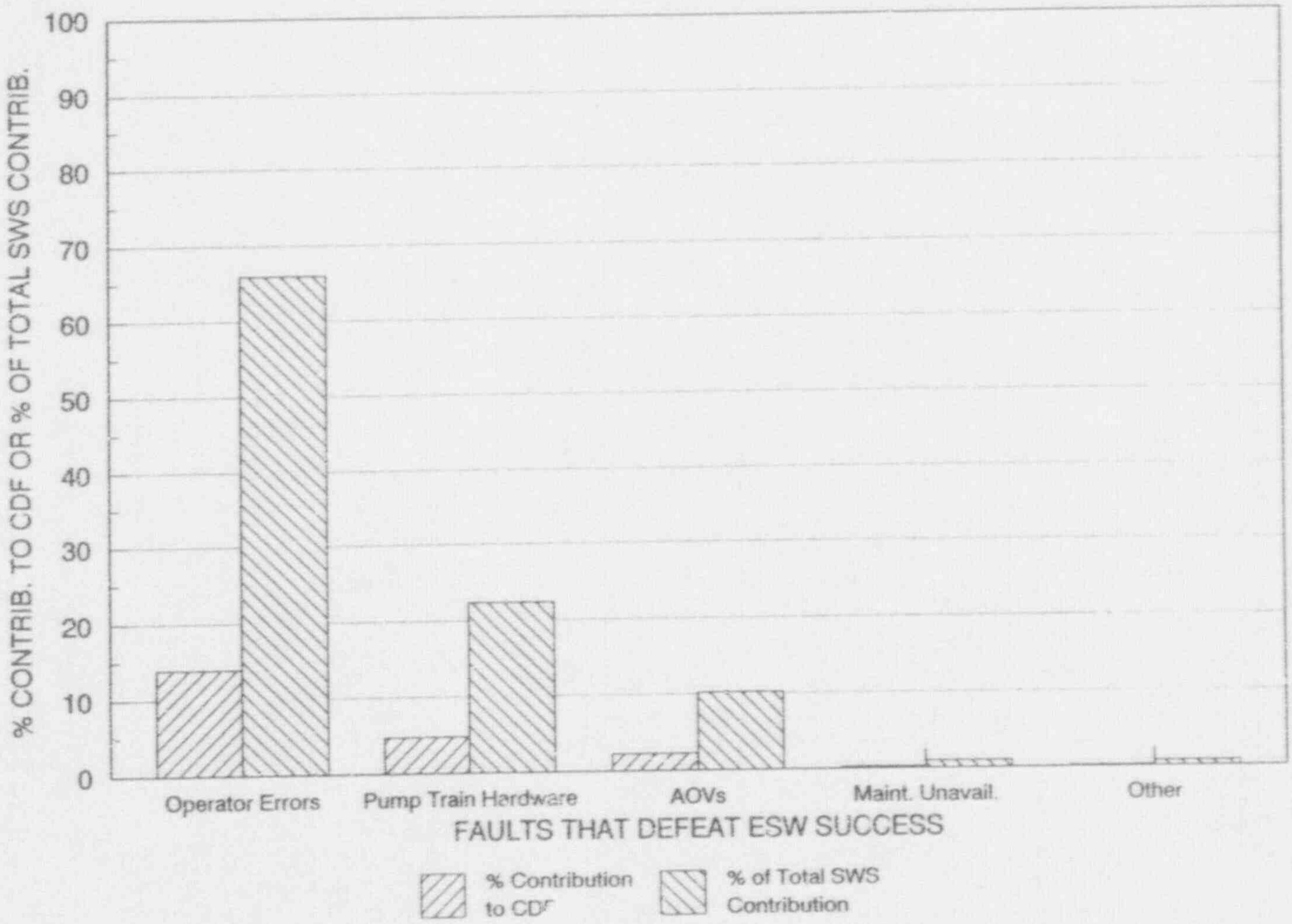


Figure 4.3 Dominant ESW Faults Contributing to CDF

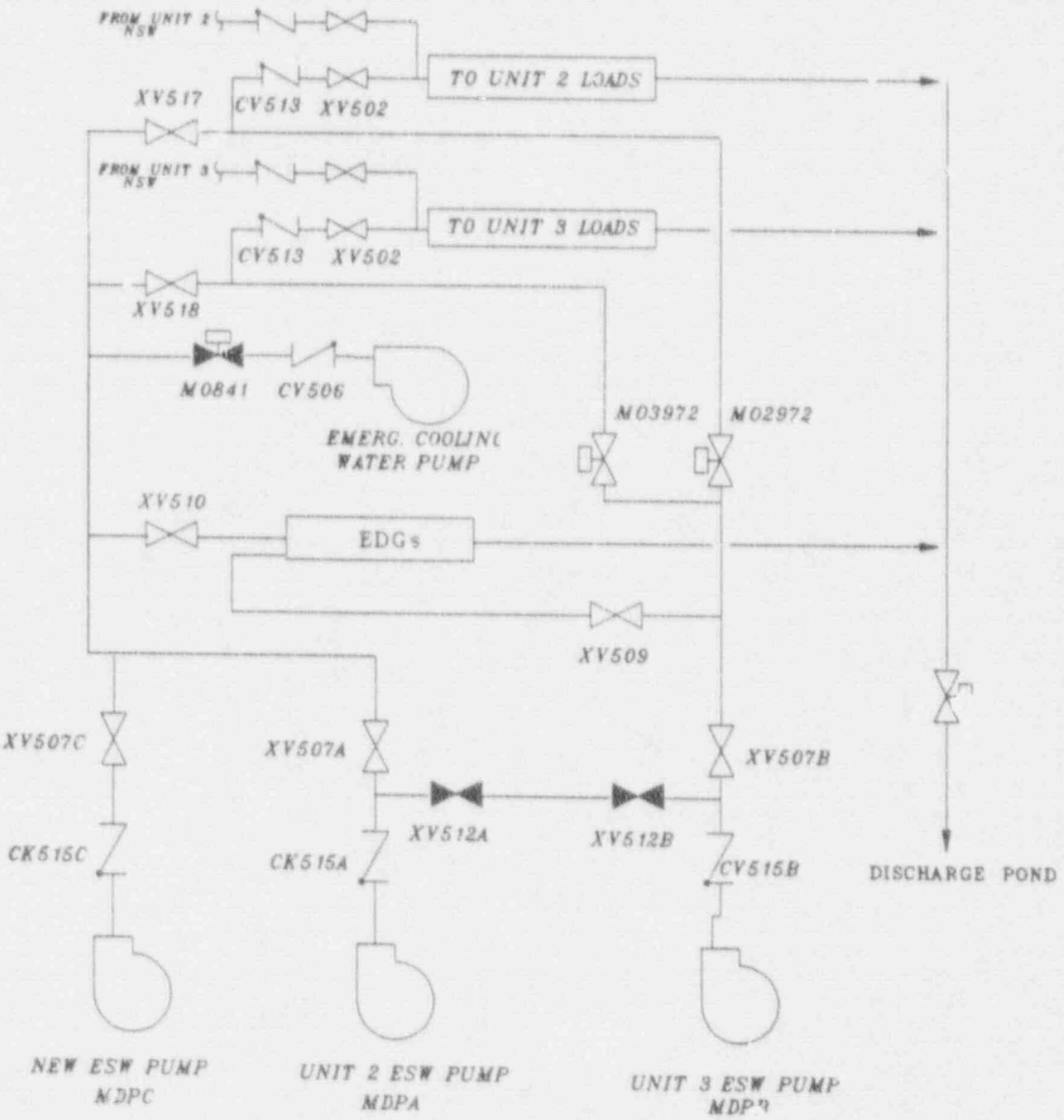


Figure 4.4 A· ıition of a Third ESW Pump

The ECW pump would still act as a backup to the ESW system and auto-actuate on diesel start.

Modification 2: Addition of Standby Auto Actuation Logic for the ECW Pump

Addition of standby auto actuation logic would demand the ECW pump to auto start on low ESW system pressure after the emergency diesel generator auto start signal has been received. This would require the diesel generator auto start signal to be sealed-in to the pump and pump motor-operated discharge valve, until cleared by the operator, and a low ESW system pressure signal be present for the ECW pump to auto start and the pump discharge valve to open. This modification in affect would have the ECW pump respond as if it were a third ESW pump and would eliminate the dependency of the ECW pump on the operator following a loss of offsite power transient.

Figure 4.5 illustrates this proposed modification. Note that all the required signals to the pump control logic currently exist as well as required power supplies, see Figure 4.6. Therefore this modification would be implemented as a change in the pump control circuit logic, i.e., no new sensors or power supplies are needed.

Modification 3: Provide Additional Operator Training, Revise Procedures, Add Additional Alarms in the Control Room

In cases where emergency service water has started and run for > 45 seconds, manual operation of the emergency cooling water pump is required if the ESW pumps should subsequently fail. For T1 or LOSP type events, only minutes are available to supply jacket cooling to the diesels.

This modification would provide additional operator training and revision of procedures to enhance the operators response to conditions requiring the starting of the ECW pump. In addition, additional alarms and indication would be provided to aid the operator.

Vulnerability 2: Failure to Restore ESW Components After Maintenance

These failures are important in loss of offsite power accident sequences and account for approximately 1% of the Pilot Plant total CDF.

Failure to restore an ESW motor driven pump or ESW diesel generator cooling components defeats one-half of ESW. Restoration of these components after maintenance is performed using written procedures with independent verification. Functional testing of these components is performed following maintenance to verify operability. Therefore these failures are a direct result of the operator failing to follow plant procedures.

Modification 3: Provide Additional Operator Training and/or Revise Procedures

This is the same modification as proposed for Vulnerability 1.

Vulnerability 3: Discharge Check Valve Failures Fail Cross-Tied ESW Pumps

This failure is dominant in loss of offsite power accident sequences and accounts for approximately 4% of the Pilot Plant total CDF.

This failure of the running ESW pump is caused by failure (back leakage) of the standby ESW pump discharge check valve. That is, when the standby pump is secured following auto-actuation with the chosen pump running, the flow from the operating pump recirculates back through the standby pump and results in functional failure of the operating pump. The failure probability used in NUREG/CR-4550 for a ESW check valve failure due to back leakage was based on a check valve functional test frequency of three months at the Pilot Plant.

Modification 4: Addition of a Second Pump Discharge Check Valve

During one ESW pump operation, the failure of the idle pump's discharge check valve to reclose following shutdown of the pump will defeat the ESW system in accordance with the NUREG/CR-4550 analysis. This modification would provide a second pump discharge check valve (20 inch valve) in series with the existing pump discharge check valve to reduce the probability of this occurrence. Figure 4.7 illustrates this proposed modification.

Modification 5: Increase System Functional Testing Frequency for ESW Pump Discharge Check Valves

During one ESW pump operation, the failure of the idle pump's discharge check valve to reclose following shutdown of the pump will defeat the ESW system in accordance with the NUREG/CR-4550 analysis. This modification would increase the ESW system test frequency from quarterly (current frequency) to monthly.

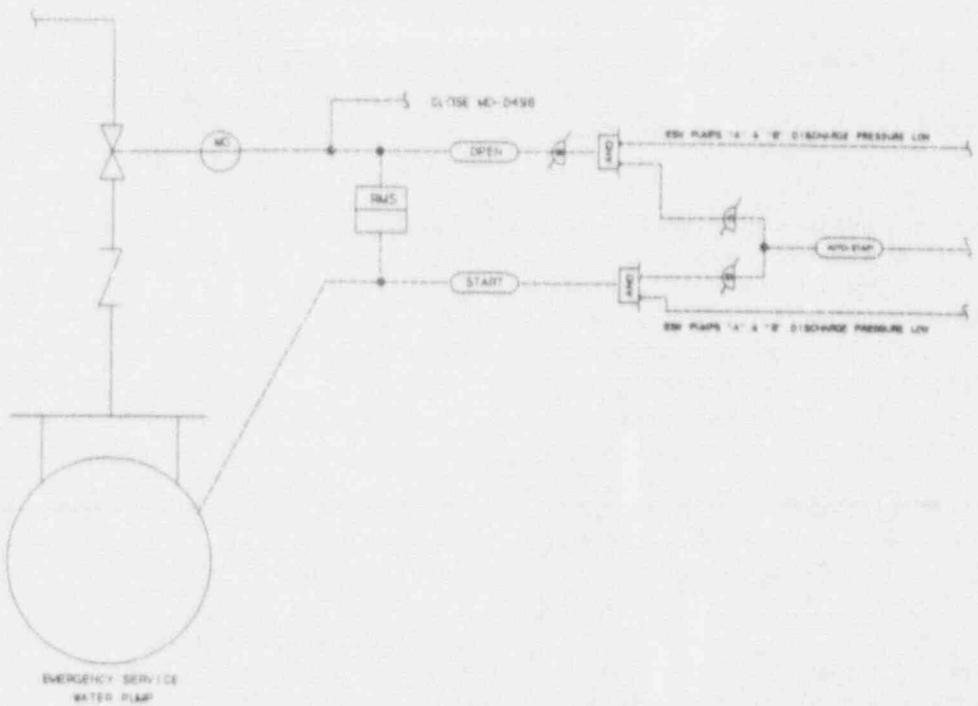


Figure 4.5 Proposed EHS Pump Logic

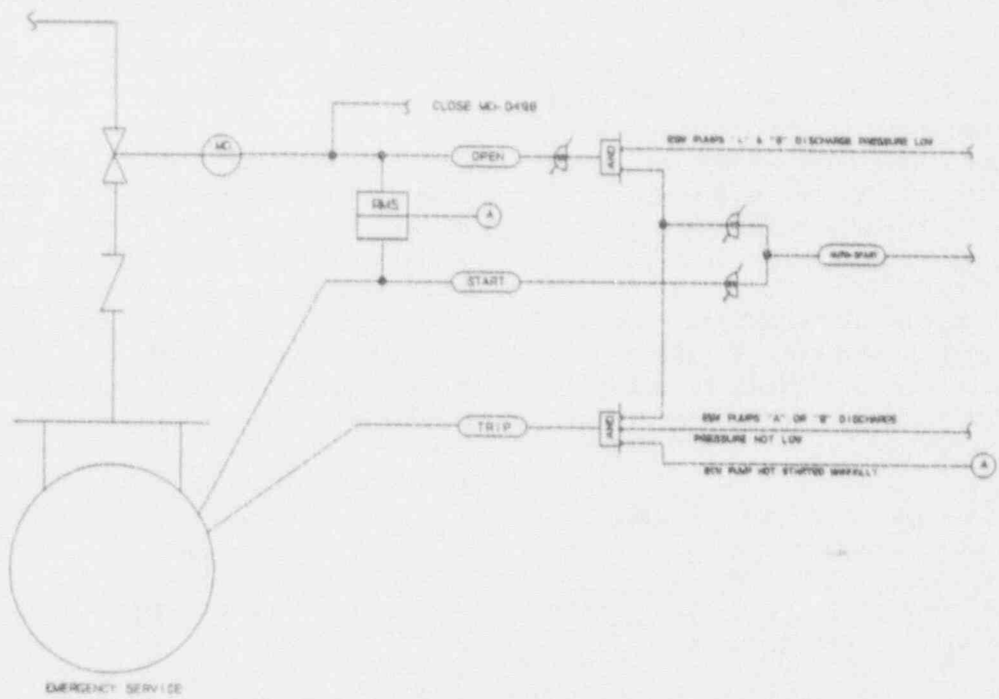


Figure 4.6 Current EHS Pump Logic

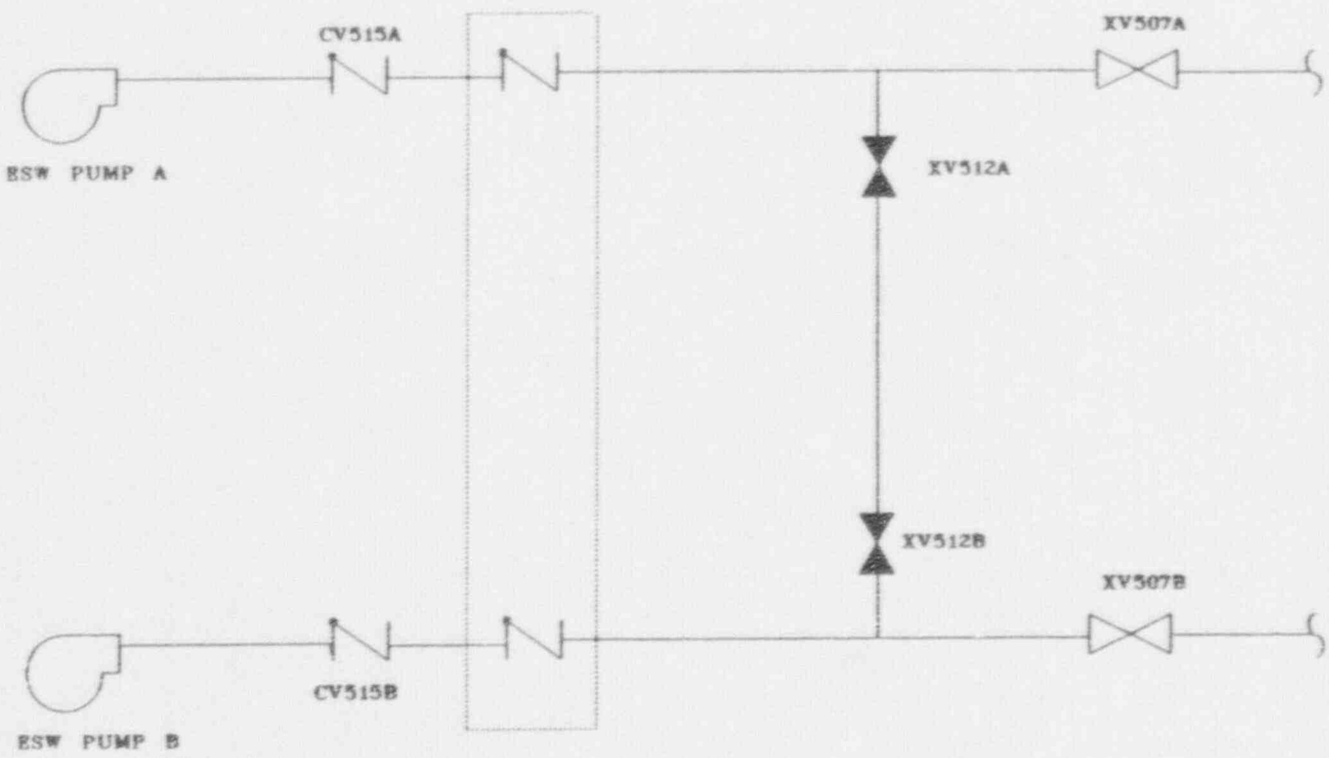


Figure 4.7 Addition of Second Pump Discharge Check Valve

By doing so, the failure probability of a check valve failing to reclose would decrease by a factor of three.

Vulnerability 4: ESW Pump Hardware Faults

ESW pump hardware faults are important in loss of offsite power accident sequences and account for approximately 1% of the Pilot Plant total CDF.

The ESW consists of two redundant, cross-tied pump trains. The success criteria established is one of two ESW pumps operating delivering flow or the ECW pump delivering flow to the ESW system. Therefore multiple failures have to occur before ESW pump failures begin to show up in the cut sets. Dominant cut sets generally consist of EDG B or C failing, which fails one ESW pump, and the resulting available pump failing to start/run, and the operator fails to initiate the ECW pump.

Modification 1: Addition of a Third ESW Pump

This is the same modification as proposed for Vulnerability 1.

Modification 2: Addition of Standby Auto Actuation Logic for the ECW Pump

This is the same modification as proposed for Vulnerability 1.

Vulnerability 5: Failure of ESW to Cool the EDGs Due to AOV Failures

ESW AOV hardware faults are dominant in loss of offsite power accident sequences and account for approximately 2% of the Pilot Plant total CDF.

The ESW provides cooling water to the emergency diesel generators. The ESW outlet header from each emergency diesel generator contains an air operated isolation valve that is signaled open when its respective diesel generator starts. Failure of this valve to open on diesel start defeats ESW cooling to that diesel which results in failure of the respective diesel generator. Failure of the diesel generators following a loss of offsite power results in a station blackout.

Modification 6: Addition of a Check Valve in Series to the Diesel Generator AOVs

This modification would remove the demand on the AOVs to open on diesel start by making them normally open valves and installing a check valve (six-inch valve) in series with the AOV. Figure 4.8 illustrates this proposed modification.

Modification 7: Addition of a Swing, Self-Cooled Diesel Generator

This modification consists of the addition of a swing, self-cooled diesel generator that would auto start in the event of loss of normal sources of power to the onsite power system. The diesel generator would be manually started and cross-connected to the appropriate bus. The engine would have its own self contained cooling system which would consists of a forced circulation cooling water system. The cooling water system would cool the engine directly and an air-cooled radiator system would remove the heat from the cooling water. The cooling water pump would preferentially be directly driven by the engine crankshaft. Thereby no external source of power would be required and no external cooling source would be required.

The engine would also have a self contained lube oil system. The lube oil pump would preferentially be directly driven by the engine crankshaft. The lube oil heat exchanger would be served by the engine cooling water system. Thereby no external power source would be required and no external cooling source would be required.

A new (dedicated) 125 volt battery, battery charger, and distribution panel will be required to provide field flashing and control.

A summary of the important internal events vulnerabilities and the proposed SWS modifications is given in Table 4.2. Note that each vulnerability is addressed by one or more of the proposed modifications.

4.6 Implementation of Proposed ESW Modifications

This section describes the implementation of the proposed modifications of the NUREG/CR-4550 analysis. In order to perform this analysis the Pilot Plant models as available on IRRAS were used. The IRRAS Pilot Plant model is a replication of the NUREG/CR-4550 analysis. A description of this model can be found in Reference 49. Before implementing the proposed modifications, changes to the IRRAS model were made as described below.

A check of the IRRAS Pilot Plant cut sets for the dominant accident sequences was performed to determine where ESW events occurred and to determine the

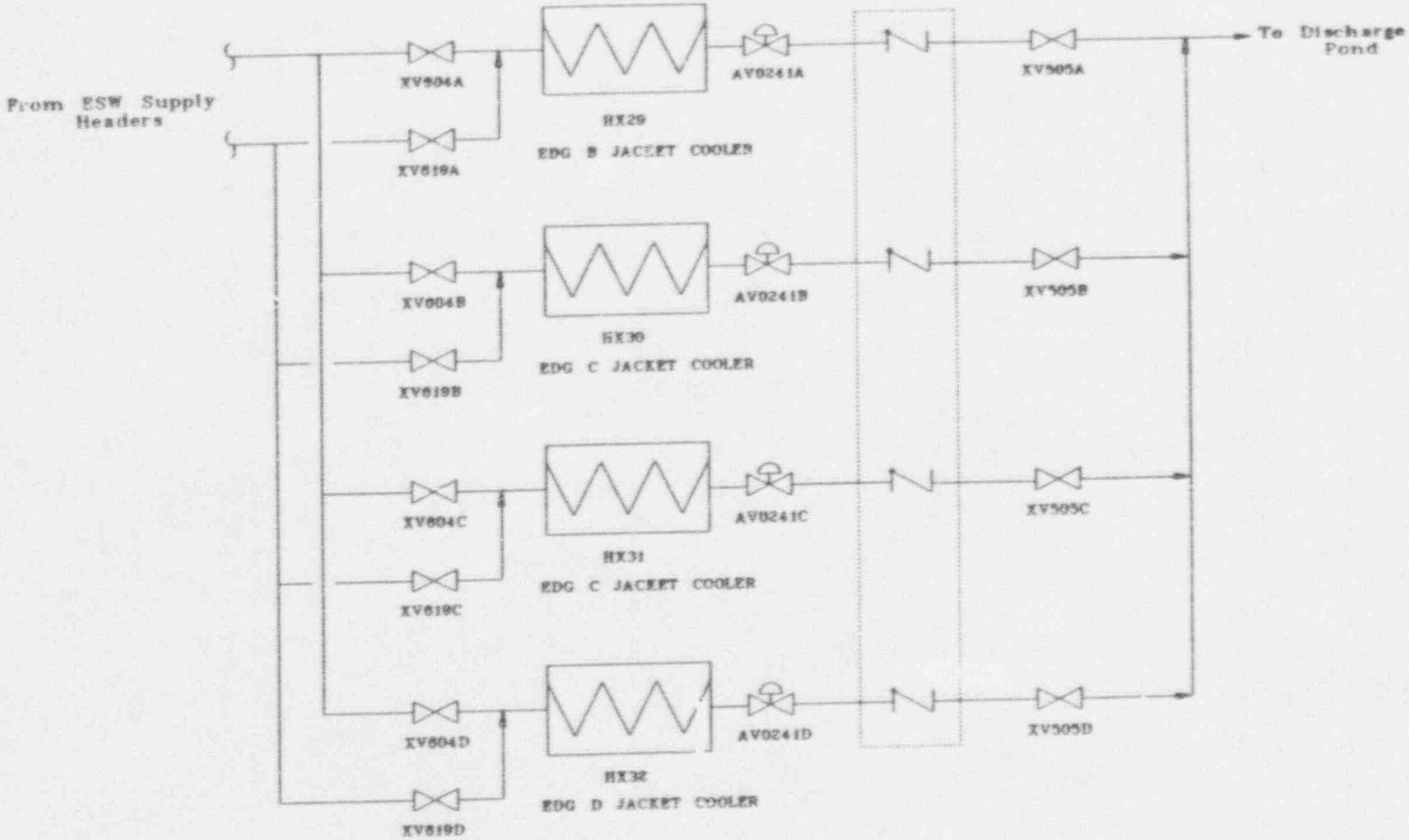


Figure 4.8 Addition of a Check Valve in Series with EDG ESW Outlet AOV

Table 4.2

Internal Event Vulnerabilities

Vulnerability	Modification
1. Operator fails to operate the ECW pump	1. Addition of a third ESW pump
2. Failure to restore ESW components after maintenance	2. Addition of standby auto-actuation logic for the ECW pump
3. Discharge check valve failures fail cross-tied ESW pump	3. Additional operator training, revise procedures, add additional alarms in the control room
4. ECW pump hardware faults	4. Addition of a second pump discharge check valve
5. Failure of ESW to cool the EDGs due to AOV failures	5. Increase system testing frequency
	6. Addition of check valves in series to the AOVs
	7. Addition of a swing, self-cooled, DG

contribution these cut sets make to the total core damage frequency. As a result of this review it was evident that some of the cut set probabilities were in disagreement with the NUREG/CR-4550 results even though the cut sets were in agreement. As a check, the IRRAS basic event data base was reviewed to account for these discrepancies. The following basic event data was found to be different in the IRRAS model when compared to the NUREG/CR-4550 model for which the IRRAS model is to reflect.

Basic Event	IRRAS Unavailability	NUREG/CR-4550 Unavailability
ACP-DGN-LP-CCF	3.3E-03	3.0E-03
ACP-DGN-FR-EDGA	4.5E-03	1.6E-02
ESW-MDP-FS-CCF	7.8E-05	3.0E-03

The NUREG/CR-4550 model basic event probabilities were entered into the IRRAS model and the dominant accident sequences were then requantified. The results reflect the NUREG/CR-4550 results for the Pilot Plant and are given in Table 4.3. Note that the values shown in this table for the sequences listed in the Executive Summary (EXEC-3) are the point estimates which correspond to the means shown on EXEC-3.

The reason for using point estimates is that an uncertainty analysis was not available on IRRAS for all accident sequences, therefore an IRRAS calculated mean CDF is not available. For those sequences for which an uncertainty analysis was performed on IRRAS, the results varied from approximately +10% to -79% when compared with the NUREG/CR-4550 Pilot Plant results. Therefore, to avoid having to complete the IRRAS uncertainty analysis and to ensure comparable results with NUREG/CR-4550, point estimates are used throughout this analysis.

In an attempt to generalize the Pilot Plant results, generic data was to be substituted for plant specific data. A review of the Pilot Plant NUREG/CR-4550 data base showed that generic ASEP data was used almost exclusively. Notable exceptions found were:

Basic Event	Probability
ACP-DGN-LP-EDGA	3.0E-03/d
ACP-DGN-LP-EDGB	3.0E-03/d
ACP-DGN-LP-EDGC	3.0E-03/d
ACP-DGN-LP-EDGD	3.[illegible]E-03/d

Generic ASEP data[51] for diesel generator failures to start is 3.0E-02/d, which is an order of magnitude higher. Updating the accident sequences with this generic ASEP data gives a new point estimate for CDF of 4.67E-06, a

Table 4.3

Corrected IRRAS Model Point Estimate Results

Sequence Name	IRRAS Point Estimate	NUREG/CR-4550 Point Estimate
T1-BNU11	9.29E-07	9.29E-07
T3A-C-SLC	1.41E-06	1.41E-06
T3A-CU11X	2.62E-07	2.62E-07
S1-V2V3V4NU11	1.60E-07	1.60E-07
T1-BU11U21	1.78E-07	1.78E-07
T1-P1BNU11	8.15E-08	8.12E-08
T1-BU11NU21	6.63E-08	6.60E-08
T3C-C-SLC	1.07E-07	1.07E-07
T1-P2V234NU11B	8.97E-08	8.99E-08
T2-P2V234NU11	5.32E-08	5.32E-08
T3B-P2V234NU11	6.41E-08	6.41E-08
A-V2V3	5.34E-08	5.34E-08
T1-C-SLC	4.42E-08	4.42E-08
T3B-C-SLC	3.36E-08	3.36E-08
T2-C-SLC	2.80E-08	2.80E-08
T3A-P2V234NU11	2.66E-08	2.66E-08
T3C-CU11X	1.94E-08	1.94E-08
T1-P1BU11U21	1.71E-08	1.71E-08
Totals	3.62E-06	3.62E-06

Note: All values are per reactor-year of operation.

29% increase. Table 4.4 gives a listing of the new point estimate for each dominant accident sequence. The values shown in this table for the sequences listed in the Executive Summary (EXEC-3) do not agree since they are point estimates, rather than means, for sequences using different, i.e., generic data.

The cut set results following the above data changes provide the basis for all quantitative analyses performed in this report. Appendix F provides a listing of the resulting cut sets for all dominant accident sequences.

4.7 Combinations of Proposed Modifications to be Implemented

Five alternative ESW modification packages were proposed for analysis. These alternatives are defined as follows:

	Modification 1	2	3	4	5	6	7
Alternative 1			X		X	X	
Alternative 2			X	X		X	
Alternative 3		X			X	X	
Alternative 4	X				X	X	
Alternative 5							X

The basic goal of the alternatives is to maximize the benefit of one or more selected modifications. Since the cost of the modifications varies, the alternatives were structured so the cost of Alternative 1 would be the least expensive and easiest to implement and Alternative 5 would be the most expensive. The other alternatives were structured so that they would provide a range of costs and benefits between the extremes. This structure corresponds to alternatives which progress from additional training, revised procedures, and additional testing, to modest hardware additions, and finally to major hardware

Table 4.4

Base Case: IRRAS Model Point Estimate Results

Sequence Name	CDF Point Estimate
T1-BNU11	1.83E-06
T3A-C-SLC	1.41E-06
T3A-CU11X	2.62E-07
S1-V2V3V4NU11	1.60E-07
T1-BU11NU21	1.78E-07
T1-P1BNU11	1.62E-07
T1-BU11NU21	1.36E-07
T3C-C-SLC	1.07E-07
T1-P2V234NU11B	8.99E-08
T2-P2V234NU11	5.32E-08
T3B-P2V234NU11	6.41E-08
A-V2V3	5.34E-08
T1-C-SLC	4.42E-08
T3B-C-SLC	3.36E-08
T2-C-SLC	2.80E-08
T3A-P2V234NU11	2.66E-08
T3C-CU11X	1.94E-08
T1-P1BU11U21	1.71E-08
Total	4.67E-06

Note: all values are per reactor-year of operation.

additions and modifications. The specific modifications selected for each alternative are described below.

Alternative 1

Alternative 1 would implement three of the identified modifications: (1) provide additional operator training, revise procedures, and/or add additional alarms in the control room in order to reduce the probability that the operator fails to operate the ECW pump and to reduce restoration errors; (2) increase the ESW functional testing frequency from quarterly to monthly to reduce the probability of pump discharge check valve failures due to back leakage (i.e., fails to reclose); and (3) add check valves in series to the diesel ESW discharge air-operated valves which are required to open on diesel start.

Alternative 2

Alternative 2 is the same as Alternative 1 except that instead of increasing the ESW functional testing frequency to reduce the probability of check valve failures due to back leakage (i.e., fails to reclose) a second check valve would be installed in the pump discharge line in series with the existing check valve.

Alternative 3

Alternative 3 is the same as Alternative 1 except that instead of providing additional training for the operators, revising procedures, and/or adding additional alarms in the control room, standby auto-actuation logic would be provided for the ECW pump and pump discharge motor-operated valve.

Alternative 4

Alternative 4 is the same as Alternative 3 except that instead of providing auto-actuation logic for the ECW pump, a third ESW pump would be installed that would function the same as the existing two ESW pumps.

Alternative 5

Alternative 5 would add a self-cooled diesel generator that would be manually initiated and loaded to the appropriate AC bus.

4.7.1 Implementation of Alternatives

Alternative 1 consists for the following modifications:

1. provide additional operator training, revise procedures, and/or add additional alarms in the control room,

2. increase the functional testing frequency of the ESW system from quarterly to monthly for the pump discharge check valves,

3. add check valves in series to the diesel ESW discharge air-operated valves.

No credit is taken for increasing operator training to reduce the probability of the operator failing to operate the ECW pump due to the amount of time (just a few minutes) available for the operator to take action.

No credit is taken for revising procedures to reduce the component restoration faults following maintenance. The current practice is proceduralized and requires appropriate operator sign-offs and functional testing of components taken out for maintenance before declaring ESW operable.

No credit is taken for installing additional alarms in the control room to alert the operator of failed ESW system and the need to operate the ECW pump. System parameters such as system pressure and flow already exist in the control room and it is assumed that high diesel engine jacket water temperature and high diesel engine lube oil temperature (indicating failed cooling) is already alarmed in the control room.

Increasing the functional testing frequency of the ESW system from quarterly to monthly would reduce the probability of check valve failure due to back leakage (i.e., fails to reclose) by a factor of 3. The generic failure frequency used in NUREG/CR-4550 for a check valve failing to close was 3.0E-03/d which was derived from the time related component failure probability term, $1/2 \lambda t$, where the failure rate λ = 3.0E-06/hour and time t = 2160 hours (720 hours/month x 3 months between actuations). Increasing the functional testing frequency to monthly gives a new failure probability for check valve failure due to back leakage of 1.0E-03/d. This modification is implemented into the model as a simple data base change, i.e., change the failure probability of check valves in question (ESW-CKV-CB-C515A and ESW-CKV-CB-C515B) from 3.0E-03/d to 1.0E-03/d.

Adding check valves in series with the air-operated valves and changing the AOVs normal operating position from closed to open is implemented as a change in basic event probability for the normally closed AOV failing to open. The new failure probability is composed of the following events:

1. Check valve fails to open (p = 1.0E-04/d)
2. Normally open AOV spurious closure (p = 1.0E-07/hr).

Using an 8 hour mission time to be consistent with the NUREG/CR-4550 analysis, a new unavailability for the existing basic events under question (normally closed AOV fails to open) is calculated as follows: (1.0E-04/d x 1d) + (1.0E-07/hr x 8 hr) = 1.0E-04.

Implementation of Alternative 1, in short, consisted of updating the unavailability number of the applicable basic events and requantifying the dominance accident sequences to get the overall effect on CDF. The basic events affected and their associated unavailability is given in Table 4.5.

Implementation of Alternative 2

Alternative 2 is the same as Alternative 1 except that instead of increasing the functional testing frequency of the pump discharge check valves, a second pump discharge check valve would be installed in series with the existing valve. Adding the second check valve would result in a change of the failure probability of the check valve already modeled from a single event to a common mode event of two check valves in series failing to reclose. Assuming a beta factor of 0.1 for screening purposes, the failure probability for one check valve failing to reclose (p = 3.0E-03/d) is changed to 3.0E-04/d (3.0E-03 x 0.1) to account for the second check valve.

Adding the second check valve also increases the failure probability of the pump train since the check valve must open for successful pump operation. This failure mode is accounted for by updating the already modeled failure of the existing check valve to open by factor of 2. The failure probability for the existing check valve to open (ESW-CKV-HW-C515A and ESW-CKV-HW-C515B) is 1.0E-04/d, doubling this to account for the addition of the second check valve gives a failure probability of 2.0E-04/d.

Implementation of Alternative 2, in short, consisted of updating the unavailability number of the applicable basic events and requantifying the dominant accident sequences to get the overall effect on the CDF. The basic events

Table 4.5

Alternative 1 Affected Basic Events and Associated Unavailabilities

Basic Event	Original Unavailability	Alternative 1 Unavailability
ESW-AOV-CC-0241A	1.0E-03	1.0E-04
ESW-AOV-CC-0241B	1.0E-03	1.0E-04
ESW-AOV-CC-0241C	1.0E-03	1.0E-04
ESW-AOV-CC-0241D	1.0E-03	1.0E-04
ESW-AOV-CC-CCF	1.0E-03	1.0E-04
ESW-CKV-CB-C515A	3.0E-03	1.0E-03
ESW-CKV-CB-C515B	3.0E-03	1.0E-03

affected and their associated unavailability are given in Table 4.6.

Implementation of Alternative 3

Alternative 3 is the same as Alternative 1 except that instead of providing additional operator training, updating procedures, and/or providing additional alarms and indication in the control room, Alternative 3 would provide standby auto-actuation of the ECW pump and pump discharge motor-operated valve.

Addition of standby auto-actuation logic for the ECW pump eliminates the need for operator intervention to restart the pump should the ESW pumps fail during an accident. This modification is implemented by revising the operator error probability from 0.9 to 0.0. No additional changes are necessary since in the NUREG/CR-4550 analysis, control circuit failures are accounted for in the pump and valve failure probabilities a used.

Implementation of Alternative 3, like Alternatives 1 and 2, is accomplished by updating applicable basic event probabilities and requantifying the dominant accident sequences to get the overall effect on the CDF. The basic events affected and their associated unavailability is given in Table 4.7.

Table 4.6

Alternative 2 Affected Basic Events and Associated Unavailabilities

Basic Event	Original Unavailability	Alternative 2 Unavailability
ESW-AOV-CC-0241A	1.0E-03	1.0E-04
ESW-AOV-CC-0241B	1.0E-03	1.0E-04
ESW-AOV-CC-0241C	1.0E-03	1.0E-04
ESW-AOV-CC-0241D	1.0E 03	1.0E-04
ESW-AOV-CC-CCF	1.0E-03	1.0E-04
ESW-CKV-CB-C515A	3.0E-03	3.0E-04
ESW-CKV-CB-C515B	3.0E-03	3.0E-04
ESW-CKV-HW-C515A	1.0E-04	2.0E-04
ESW-CKV-HW-C515B	1.0E-04	2.0E-04
ESW-CKV-CM-C515	-	3.0E-04

Table 4.7

Alternative 3 Affected Basic Events and Associated Unavailabilities

Basic Event	Original Unavailability	Alternative 3 Unavailability
ESW-AOV-CC-0241A	1.0E-03	1.0E-04
ESW-AOV-CC-0241B	1.0E-03	1.0E-04
ESW-AOV-CC-0241C	1.0E-03	1.0E-04
ESW-AOV-CC-0241D	1.0E-03	1.0E-04
ESW-AOV-CC-CCF	1.0E-03	1.0E-04
ESW-CKV-CB-C515A	3.0E-03	1.0E-03
ESW-CKV-CB-C515B	3.0E-03	1.0E-03
ESW-XHE-FO-EHS	9.03-01	0.0E-00

Table 4.8

Alternative 4 Affected Basic Events and Associated Unavailabilities

Basic Event	Original Unavailability	Alternative 4 Unavailability
BETA-2SWSPS	2.6E-02	No Change
BETA-3SWSPS	1.4E-02	No Change
ESW-AOV-CC-0241A	1.0E-03	1.0E-04
ESW-AOV-CC-0241B	1.0E-03	1.0E-04
ESW-AOV-CC-0241C	1.0E-03	1.0E-04
ESW-AOV-CC-0241D	1.0E-03	1.0E-04
ESW-AOV-CC-CCF	1.0E-03	1.0E-04
ESW-CKV-CB-C515A	3.0E-03	1.0E-03
ESW-CKV-CB-C515B	3.0E-03	1.0E-03
ESW-CKV-CB-C515C	3.0E-03	1.03-03
ESW-CKV-HW-C515C	1.0E-04	No Change
ESW-MDP-FR-MDPC	1.2E-03	No Change
ESW-MDP-FS-MDPC	3.0E-03	No Change
ESW-MDP-MA-MDPC	2.0E-03	No Change
ESW-PMPC[1]	N/A	1.0E-02
ESW-PTF-RE-MDPC	2.19E-03	No Change
ESW-XVM-PG-X507C	4.0E-05	No Change

[1]Event module added to cut sets to account for the addition of Pump C. Consists of Pump C hardware faults.

Implementation of Alternative 4

Alternative 4 is the same as Alternative 3 except that instead of providing standby auto-actuation logic for the ECW pump and pump discharge valve, a third, 100% capacity, ESW pump would be installed that would operate in the same manner as the existing ESW pumps.

Implementation of this alternative required updating basic event probabilities where applicable and also manipulating the accident sequence cut sets where applicable. Manipulation of the cut sets was required to account for the change is ESW system fault tree logic and to account for the added failure modes attributed to the addition of the third pump. To aid in this analysis, a fault tree model for the third pump was developed and is shown in Figure 4.9. Unavailability data for the basic events shown in Figure 4.9 as well as for those basic events in which their failure probabilities were updated to account for the other modifications implemented in this Alternative is given in Table 4.8 on the previous page.

The ESW events affected by this alternative show up in three dominant accident sequences (i.e., station blackout sequences). Therefore only the cut sets which contained ESW events in these sequences (i.e., T1-BNU11, T1=P1BNU11, and T1-BU11NU21) were manipulated in order to implement this modification. Dominant cut sets involving ESW faults generally consisted of the following events:

1. Failure of one ESW pump to run and failure of the other ESW pump due to hardware faults and failure of the operator to start the ECW pump, or

2. ESW discharge check valve fails open and independent failure of the pump associated with failed check valve, or

3. Common cause failure of the two ESW pumps to start and failure of the ECW pump. All three of these fail the ESW system which in turn fails the emergency diesel generators (i.e., fails onsite AC power).

For those cut sets consisting of Type 1, a single module event was added to account for the addition of pump train C. This module event (ESW-PMPC) is made up of pump train C hardwere faults as follows:

Basic Event	Description
ESW-CKV-HW-C515C	Pump C discharge check valve fails to open on demand
ESW-MDP-FR-MDPC	Motor-driven pump C fails to run given start
ESW-MDP-FS-MDPC	Motor-driven pump C fails to start
ESW-MDP-MA-MDPC	Motor-driven pump C out for maintenance
ESW-PTF-RE-MDPC	Failure to restore motor-driven pump C after maintenance
ESW-XVM-PG-X507C	Motor-driven pump C discharge manual valve fails due to plugging
DGACTD	Failure or diesel generator D actuation to initiate pump C

The cumulative unavailability of these basic events is 1.0E-02, which is the unavailability of term ESW-PMPC.

For those cut sets of Type 2, additional cut sets were added to the accident sequences to account for pump discharge check valve failure to reclose, resulting in backflow through the idle pump and subsequent failure of the ESW system to provide cooling to the emergency diesel generators. These additions were a simple matter of duplicating the cut sets containing check valve back leakage faults and substituting in the pump C pump fault and pump C check valve CB term. The following example is offered:

Existing cutset - T1 * ESW-CKV-CB-C515A * ESW-MDP-FR-MDPA

This cut set was duplicated and the following revisions made

T1 * ESW-CKV-CB-C515C * ESW-MDP-FR-MDPC

to account for the addition of pump C and its associated valving.

Cut sets of Type 3 consist of common mode failures of two ESW pumps to start. With the addition of a third ESW pump, the beta factor was changed from two pumps to three, i.e., BETA-2SWPS became BETA-3SWPS.

Note that the pump C would be powered from AC and DC division D, the same as the ECW pump. Therefore, division D faults are already accounted for in the cut sets

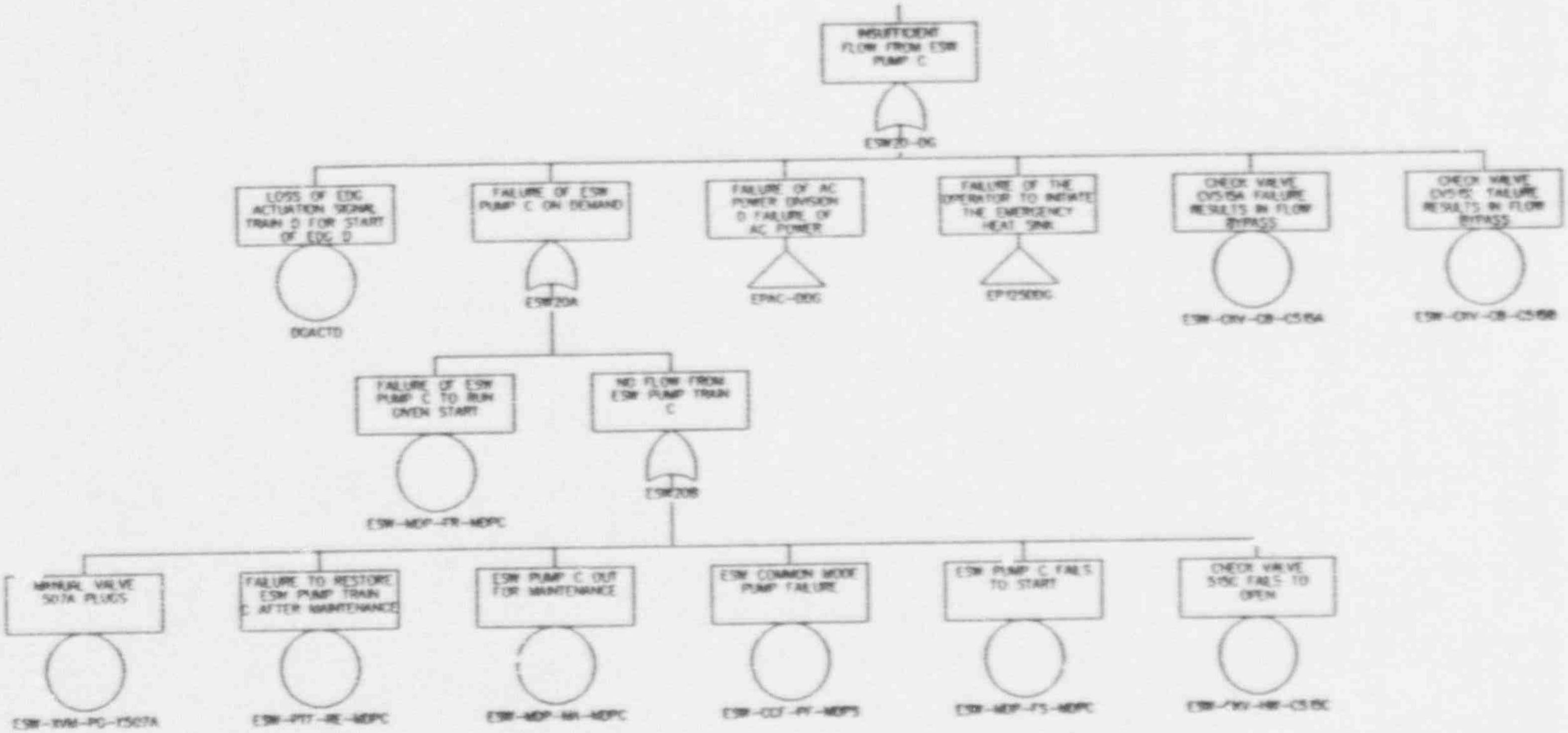


Figure 4.9 Fault Tree for Insufficient Flow From ESW Pump C

due to the ECW pump and no additional additions were necessary.

Once the cut sets were revised to account for the addition of the third ESW pump, the sequences were requantified to get the overall effect this alternative has on the total CDF.

Implementation of Alternative 5

Alternative 5 would add a self-cooled swing diesel generator that would be manually initiated and loaded to the appropriate AC bus from the control room. This alternative would not change the configuration of the ESW system but would reduce the plants onsite electric power dependency on ESW.

Implementation of this alternative required updating post-accident human error probability (HEP) data where applicable to account for the operator actions to start and load the swing diesel generator. Also included in the updated HEP data were swing diesel independent faults. The following swing diesel generator failure modes were accounted for in this analysis:

Basic Event	Description
ACP-DGN-FR-EDGS	Swing diesel fails to run (unavail. = 1.2E-02)
ACP-DGN-LP-EDGS	Swing diesel fails to start (unavail. = 3.0E-02)
ACP-DGN-MA-EDGS	Swing diesel out for maintenance (unavail. = 6.0E-03)
ACP-DGN-TE-EDGS	Swing diesel unavail. due to test (unavail. = 2.3E-03)
ACP-DGN-RE-EDGS	Failure to restore swing diesel after maintenance (unavail. = 7.98E-04)

The cumulative unavailability of these basic events is 5.5E-02, which is the unavailability of the swing diesel.

Table 4.9 lists the basic HRA post-accident terms updated in this analysis along with their NUREG/CR-4550 HEP values and the value of each term used in this analysis to calculate the effect the addition of a swing diesel would have on the CDF. The value of each term in this analysis is a combination of the diesel generator faults listed above and the probability of the operator failing to cross-tie the swing diesel. The HEP values were extracted from the Grand Gulf NUREG/CR-4550 analysis.[36]

After updating the HEP value for each of the terms listed in Table 4.9, the dominant accident sequences were requantified to get the overall effect on the CDF.

4.7.2 Modification Results

The results of the quantification for the alternative design modification described above are presented in Table 4.10. It compares the sequence frequencies after modification. Recovery factors have been accounted for in all the sequences in Table 4.10.

From the results listed in Table 4.10, it is seen that the greatest reduction in CDF is obtained with Alternatives 3 and 4 (i.e., approximately 33% and 31% reduction in CDF, respectively). Both of these alternatives decrease the dependency on the operator to initiate the ECW pump and also eliminate the dependency of the diesel generators on the ESW AOVs which must open for successful diesel operation.

4.8 Sensitivity Analysis

Sensitivity analyses were performed for selected ESW components to determine the sensitivity of the risk model to the increase in component failure probability. The ESW faults selected for sensitivity analysis were chosen using the following criteria:

1. Based on NUREG/CR-4550 risk increase results, the ESW basic event has the potential for being a significant contributor to risk if current levels are not maintained.

2. The ESW component is susceptible to water quality problems such as silt (e.g., plugging of valves), corrosion (e.g., degrades proper functioning of components such as valves), and erosion (e.g., increased wear on pumps).

Based on these criteria, the following ESW component types and failure modes were selected for sensitivity analysis.

Component	Failure Mode
Check valves	Back leakage (CB) Failure to open (HW)
Air-operated valves	Closed fails to open (CC) Maintenance unavailability (MA)
Manual valves	Plugging (PG)

Table 4.9

Alternative 5 Diesel Generator Cross-Tie Recovery Action Data

Basic Event	NUREG/CR-4550 HEP Value	X-Tie HEP Value	DG Unavailability	Alt. 5 Value
DGHWNR3HR	8.0E-01	1.0E-01	5.5E-02	1.6E-01
DGHWNR5HR	7.0E-01	8.5E-02	5.5E-02	1.4E-01
DGHWNR7HR	6.0E-01	6.0E-02	5.5E-02	1.2E-01
DGHWNR9HR	5.8E-01	4.0E-02	5.5E-02	9.5E-02
DGHWNR12HR	5.5E-01	6.6E-03	5.5E-02	6.2E-02

Table 4.10

ESW Alternative Modification Results

Sequence Identifier	Original Probability	Alternative 1	Alternative 2	Alterative 3	Alternative 4	Alternative 5
T1-BNU11	1.83E-06	1.41E-06	1.33E-06	5.01E-07	5.70E-07	9.21E-07
T3A-C-SLC	1.41E-06	1.41E-06	1.41E-06	1.41E-06	1.41E-06	1.41E-06
T3A-CU11X	2.62E-07	2.62E-07	2.62E-07	2.62E-07	2.62E-07	2.62E-07
S1-V2V3V4NU11	1.60E-07	1.60E-07	1.60E-07	1.60E-07	1.60E-07	1.60E-07
T1-BU11U21	1.78E-07	1.78E-07	1.78E-07	1.78E-07	1.78E-07	1.78E-07
T1-P1BNU11	1.62E-07	1.24E-07	1.17E-07	4.60E-08	5.24E-08	8.10E-08
T1-BU11NU21	1.36E-07	1.12E-07	1.07E-07	4.04E-08	4.51E-08	6.79E-08
T3C-C-SLC	1.07E-07	1.07E-07	1.07E-07	1.07E-07	1.07E-07	1.07E-07
T1-P2V234NU11B	8.99E-08	8.99E-08	8.99E-08	8.99E-08	8.99E-08	8.99E-08
T2-P2V234NU11	5.32E-08	3.32E-08	5.32E-08	5.32E-08	5.32E-08	5.32E-08
T3B-P2V234NU11	6.41E-08	6.41E-08	6.41E-08	6.41E-08	6.41E-08	6.41E-08
A-V2V3	5.34E-08	5.34E-08	5.34E-08	5.34E-08	5.34E-08	5.34E-08
T1-C-SLC	4.42E-08	4.42E-08	4.42E-08	4.42E-08	4.42E-08	4.42E-08
T3B-C-SLC	3.36E-08	3.36E-08	3.36E-08	3.36E-08	3.36E-08	3.36E-08
T2-C-SLC	2.80E-08	2.80E-08	2.80E-08	2.80E-08	2.80E-08	2.80E-08
T3A-P2V234NU11	2.66E-08	2.66E-08	2.66E-08	2.66E-08	2.66E-08	2.66E-08
T3C-CU11X	1.94E-08	1.94E-08	1.94E-08	1.94E-08	1.94E-08	1.94E-08
T1-P1BU11U21	1.71E-08	1.71E-08	1.71E-08	1.71E-08	1.71E-08	1.71E-08
Totals	4.67E-06	4.19E-06	4.09E-06	3.13E-06	3.21E-06	3.61E-06

Note: all values are per reactor-year of operation.

Motor-driven pumps — Fails to run (FR); Maintenance unavailability (MA)

A sensitivity analysis was performed for each component with all failure modes listed with an increase in basic event probability of 3 and 10 times the original basic event probability. These multipliers were selected to provide a comparable range of results from which to draw conclusions. A new core damage frequency was found which is an indicator of the sensitivity of the risk model to the increase in component failure probability. After the sensitivity analysis was performed for each component selected, a sensitivity analysis was run with all components listed above. Table 4.11 gives the basic event unavailabilities used in the analysis.

The reader should note that only the dominant accident sequence cut sets are available on IRRAS and were manipulated in this analysis. It is technically incorrect to do this in that all the accident sequences should be requantified with the new data to determine all the cut sets. However, the information (e.g., sequence logic, mutually exclusive event files, flag files, etc.) required to perform this requantification are not on IRRAS and would have to be recreated and checked to ensure IRRAS gives the same results as the NUREG/CR-4550 analysis. This level of effort is beyond the scope of this project.

Table 4.12 gives the results for each component from the sensitivity runs made with all selected components failure probabilities increased by factors of 3 and 10.

Table 4.11

Sensitivity Analysis Basic Event Unavailabilities

ESW COMPONENT	FAIL MODE	BASE UNAVAIL	BASE X 3	BASE X 10
Check Valve	CB	3.0E-03	9.0E-03	3.0E-02
	HW	1.0E-04	3.0E-04	1.0E-03
Air-Operated Valve	CC	1.0E-03	3.0E-03	1.0E-02
	MA	2.0E-04	6.0E-04	2.0E-03
Manual Valve	PG	4.0E-05	1.2E-04	4.0E-04
Motor-Driven Pump	FR	1.2E-03	3.6E-03	1.2E-02
	MA	2.0E-03	6.0E-03	2.0E-02

Table 4.12

Sensitivity Analysis Results in Terms of CDF

COMPONENT	CDF BASE X 3	ΔCDF[1] INCREASE	CDF BASE X 10	ΔCDF[1] INCREASE
Check Valve	5.54E-06	8.70E-07	8.56E-06	3.89E-06
Manual Valve	4.68E-06	1.00E-08	4.70E-06	3.00E-08
Air-Operated Valve	5.14E-06	4.70E-07	6.85E-06	2.18E-06
Motor-Driven Pump	5.00E-06	3.30E-07	6.43E-06	1.76E-06
All	6.52E-06	1.85E-06	1.63E-05	1.16E-05

[1]*ΔCDF calculated based on a base case CDF equal to 4.67E-06.*

5.0 INTEGRATED VALUE-IMPACT ANALYSIS

In this section the quantitative value analysis and the impact analysis are combined to form an integrated value-impact analysis. The methodology for the value-impact analysis is presented in Appendix L of NUREG-CR-4767.[13] In order to implement the value-impact analysis and illustrate the steps performed, the methodology will be reviewed briefly prior to summarizing the pilot plant results.

5.1 Methodology

5.1.1 Value and Impact Analysis Variables

Each of the variables to be used as input in the value-impact analysis is defined in Table 5.1 and characterized in several ways. First, the costs and values may be incurred one time or on an annual basis. All recurring costs or costs which might occur at any time during the remaining plant lifetime are valued in 1992 dollars by using a present worth factor. The present worth factor for the pilot plant based upon 16 years remaining life is 10.8 at a 5 percent discount rate.

$$\textit{present worth factor} = \frac{(1.05)^{16}-1}{0.05(1.05)^{16}} = 10.8$$

Second, there are positive and negative values and impacts. The value measures involve the potential radiation dose incurred during the installation or operation of an alternative (a negative value) or the dose averted from a lower core melt probability (a positive value). Impacts are the costs associated with implementation of an alternative. The direct material and labor costs of an alternative represent positive impacts. The power replacement, cleanup and other costs which are averted by implementation of an alternative are treated as negative impacts. Third, costs or doses result from either the proposed modifications or an accident. Fourth, each variable may affect the utility, and the NRC, or the public. Last, the information for each variable comes from the appendices and/or the value analysis.

In addition to the value and impact variables, the change (reduction) in core damage frequency (ΔCDF) for each alternative from the base case core damage frequency (i.e., without any modifications) is calculated from:

$$\Delta CDF(j) = CDF - CDF(j),$$

where:

CDF = base case core damage frequency, and

CDF(j) = core damage frequency of the jth alternative.

These values, as derived from Table 4.10, are given in Table 5.2.

5.1.2 Value Impact Analysis Measures

Impact Measures - Impacts I_2 and I_4 (refer to Table 5.1) must be multiplied by the present worth factor, which is 10.8 for the pilot plant assuming 5 percent discount rate. The present worth factor accounts for the reduced worth of the payments made or incurred at some future date. Therefore, the total positive impact, TI(j), of the jth alternative is given by:

$$TI(j) = I_1(j) + 10.8\, I_2(j) + I_3(j) + 10.8\, I_4(j).$$

This is the total of all the positive impacts. The negative impacts sum to the total avertable cost, $I_5(j)$, or

$$I'_5(j) = I'_{51}(j) + I'_{52}(j) + I'_{53}(j).$$

where

$$I'_{51}(j) = \Delta CDF(j) \times I_{51}(j)$$

$$I'_{52}(j) = \Delta CDF(j) \times I_{52}(j)$$

$$I'_{53}(j) = \Delta CDF(j) \times I_{53}(j)$$

The net impact, NI(j), of the jth alternative can now be estimated by subtracting the total avertable costs from the total impact or:

$$NI(j) = TI(j) - I'_5(j).$$

Table 5.1. Value and Impact Analysis Input Variables

Symbol	Description	Results from	Affects the	Source of Information	
I_1	Engineering and Installation Cost one time	Positive Impact	Modifications	Utility	[illegible] Engineer
I_2	Operations and Maintenance Costs/year - present worth	Positive Impact	Modifications	Utility	Architect Engineer
I_3	Installation Replacement Power Costs - one time	Positive Impact	Modifications	Public	Architect Engineer
I_4	In-service Replacement Power Costs - per year	Positive or Negative Impact	Modifications	Public	Not available - but assumed negligible
I_5	Avertable Onsite Costs - one time	Negative Impact	Accident	Utility analysis	Based on previous
I_{51}	Replacement Power Costs				
I_{52}	Loss of Investment Costs				
I_{53}	Site Cleanup Costs				
I[illegible]	Other Costs - one time	Positive Impact	Modifications & NRC	Utility analysis	Not covered in this
V_1	Averted Onsite Dose Over Plant Lifetime	Positive Value	Accident	Utility analyses	Based on previous
V'_1	Present Worth of Averted Onsite Dose @ $1000/p-rem	Positive Value	Accident	Utility analyses	Based on previous
V_2	Averted Offsite Dose Over Plant Lifetime	Positive Value	Accident	Public	From value analyses
V'_2	Present Worth of Averted Offsite Dose @ $1000/p-rem	Positive Value	Accident	Public	From value analyses
V_3	Installation Dose - one time	Negative Value	Modifications	Utility	Accident Engineer
V'_3	Present Worth of Installation Dose @$1000/p-rem	Positive Value	Modifications	Utility	Architect Engineer
V_4	In-service Operational Dose over Plant Lifetime	Positive or Negative Value	Modifications	Utility	Not available
V'_4	Present Worth of Occupational Dose @ $1000/p-rem	Positive or Negative Value	Modifications	Utility	Not available

Table 5.2 Inputs to Value/Impact Analysis

Alternative	MODS	ΔCDF	Risk (ΔDose) Person Rem/Reactor Yr.	One Time Cost (I_1)	O&M Costs (I_2)
1	3,5,6	4.80E-7	1.07	1805K	50K
2	3,4,6	5.80E-7	1.29	3000K	30K
3	2,5,6	1.54E-6	3.44	1955K	55K
4	1,5,6	1.46E-6	3.26	14.2M	82K
5	7	1.06E-6	2.36	20.9M	175K

The discounted values for the negative impacts due to avertable onsite costs, conditional upon an accident, based on the method in Appendix L of NUREG/CR-4767 are given by:

$$I_{S1} = PW_{rp} \times PW_{pl} \times IF \times R$$

$$I_{S2} = KW_e \times CF_c \times IF \times F_{pl} \times CF_l$$

$$I_{S3} = C_{pw} \times PW_{pl} \times IF$$

where:

PW_{rp} = present worth factor for ten years of replacement power.

PW_{pl} = present worth factor for the pilot plant remaining life.

IF = inflation factor from 1985 to 1992.

R = cost of replacement power for one year.

KW_e = kilowatt electrical output of pilot plant.

CF_c = construction cost per kilowatt electrical output.

F_{pl} = fraction of plant life remaining.

CF_l = ratio of maximum expected loss to current value of plant.

C_{pw} = present worth of plant and site cleanup.

Using a 5 percent discount rate and a remaining plant life of 16 years:

$PW_{rp} = 7.72$ and $PW_{pl} = 10.8$

Based on the consumer price index for the years 1985 to 1992:

IF = 1.327

Using data for the pilot plant from NUREG/CR-4012, and a 65 percent capacity factor:

R = \$1.24E8

For the pilot plant:

KW_e = 1051E3 KW_e

F_{pl} = years of life remaining/total plant life = 16/40

From Appendix L of NUREG/CR-4767:

CF_c = \$1500/KW_e

C_{pw} = \$1.2E9

Finally, based on the average of the results of applying the methodology of Appendix L of NUREG/CR-4767 to six different plants:

CF_l = 4.27

Using the above values:

I_{S1} = 7.72 x 10.8 x 1.327 x 1.24E8 = \$1.37E10

I_{S2} = 1051E3 x 1500 x 1.327 x 16/40 x 4.27 = \$3.57E9

I_{S3} = 1.2E9 x 10.8 x 1.327 = \$1.72E10

all in 1992 dollars.

Value Measures - The averted onsite dose (V_1) for each alternative is estimated from the onsite dose received during an accident. For purposes of this analysis, this onsite dose (40,000 person-rem) is assumed to be the same for any core damage accident as discussed in Appendix L of NUREG/CR-4767. The averted onsite dose (40,000 person-rem) is multiplied by ΔCDF for the jth alternative and by the number of years of operation remaining. Thus:

$$V_1(j) = (40000) \times \Delta CDF(j) \times 16 \ \text{(p-rem)}$$

The present worth, $V'_1(j)$, of the above avertable onsite dose, valued at \$1000 per person-rem is:

$$V'_1(j) = (40000) \times \$1000 \times \Delta CDF(j) \times 10.8 \ (\$)$$

The averted offsite averted dose (V_2) for each alternative is estimated from the avertable offsite dose per reactor year multiplied by the remaining years of plant operation. Thus:

$$V_2(j) = (\text{Averted offsite dose}) \times 16 \ \text{(p-rem)}$$

In this case the ΔCDF is not required because the core melt probability is inherent in the calculation.

The present worth $V'_2(j)$ of the avertable offsite dose valued at \$1000 per person-rem is:

$$V'_2(j) = (\text{Averted dose}) \times \$1000 \times 10.8\ (\$)$$

The totals of the positive values (onsite + offsite) for averted dose and costs are:

$$V_{12}(j) = V_1(j) + V_2(j)\ (\text{p-rem})$$

$$V'_{12}(j) = V'_1(j) + V'_2(j)\ (\$)$$

The ratio of the averted offsite dose (V_2) to the base case dose, ADR_o, is given by:

$$ADR_o = \frac{V_2(j)}{(\text{Base Case Dose} \times 16)}$$

The base case dose is given in Appendix G.

Similarly, the ratio of the total averted dose (V_{12}) and the total base case dose, ADR_n, is given by:

$$ADR_n = \frac{V_{12}(j)}{\text{Base Case Dose} \times 16 + V_1(j)}$$

The negative values considered for the jth alternative included the dose received during installation (a one time dose), $V_3(j)$, and the in-service occupational dose received over the remaining plant life time, $V_4(j)$. These doses can be present valued at \$1000 per person-rem in a manner analogous to that used for the positive values, thus,

$$V'_3(j) = V_3(j) \times \$1000\ (\$)$$

$$V'_4(j) = (V_4(j)/16) \times \$1000 \times 10.8\ (\$)$$

$V'_3(j)$ does not include the present worth factor (10.8) because it is a one time dose, whereas the dose associated with operations, $V_4(j)$ is recurring. It is divided by 16 to account for the years of plant life remaining.

The net averted dose, $NV(j)$, and the present worth of the net averted costs at \$1000/p-rem, $NV'(j)$, associated with each alternative can be calculated by subtracting the negative values from the positive. Thus:

$$NV(j) = V_1(j) + V_2(j) - V_3(j) - V_4(j)\ (\text{p-rem})$$

$$NV'(j) = V'_1(j) + V'_2(j) - V'_3(j) - V'_4(j)\ (\$)$$

Value-Impact Measures - The value-impact measures can be constructed from the variables defined previously. Each of the value-impact measures is calculated from the cost for the total impact (TI) and the cost for the net impact (NI). The first measure considered is the ratio of averted costs to impacts. The first, VIR_o, considers only the averted offsite costs and the total impact. For the jth alternative:

$$VIR_o = V'_2(j)/TI(j)$$

The second ratio, VIR_n, is the net value-impact ratio which accounts for the net averted offsite and onsite costs and the net impacts. For the jth alternative:

$$VIR_n = NV'(j)/NI(j)$$

Similarly there are two net benefit values. The first, NBV_o, considers only averted offsite costs, while the second, NBV_n, includes averted costs and impacts. That is, for the jth alternative:

$$NBV_o = V'_2(j) - TI(j)\ (\$)$$

$$NBV_n = NV'(j) - NI(j)\ (\$)$$

The final value-impact measures are the estimated cost in dollars per person-rem of dose averted if the alternative is implemented. Again, there are two values. The first, DPR_o, is the ratio of the total impact to the averted offsite dose. For the jth alternative:

$$DPR_o = TI(j)/V_2(j)$$

The second is DPR_n, which is the ratio of the net impact to the net averted dose. For the jth alternative:

$$DPR_n = NI(j)/NV(j)$$

A more complete discussion of the reasons for selecting these measures is provided in Appendix L of NUREG/CR-4767.

5.2 Results

The values, impacts, and value-impact measures defined in the previous section were calculated for the Pilot Plant using the results of the internal analysis and the impact analysis. These results are tabulated in Tables 5.3, 5.4, and 5.5. The symbols for the values, impacts, and measures are given at the heading of each column. It is important to note that the offsite population dose is an integrated dose out to a radius of 50 miles from the site and the conversion from dose to cost is \$1000 per person rem. All present value estimates are based on a 5 percent discount rate.

Table 5.3 summarizes the impacts for the pilot plant by alternative. The four positive impacts are individually tabulated and then totaled to obtain the Total Impact (TI) of modifications associated with each alternative. One time costs of installing the modifications and replacement power during the installation are already in present dollars. The in-service operations and maintenance costs and replacement power costs must, however, be multiplied by 10.8 to account for the present worth of these impacts. The installation of modifications at the pilot plant can be accomplished during normal outages so that there are no replacement power costs. Although replacement power costs due to in-service maintenance were not specifically estimated, these costs probably have a negligible impact.

The negative impacts result from the averted onsite costs attributed to a potential accident. The costs are, of course, probabilistic. Thus, the potential costs for I_{S1}, I_{S2}, and I_{S3} in 1992 dollars must all be multiplied by ΔCDF. The net impact (NI) is the positive impacts minus the negative impacts. The lower the net impact the more favorable the alternative appears.

Table 5.4a presents the positive values for each alternative. These are onsite averted dose (V_1) and offsite averted dose (V_2) due to a potential accident. These are both probabilistic in nature; however, the calculation of offsite averted dose (V_2) does not explicitly include ΔCDF since it is implicitly included in the analysis to obtain V_2. Both averted doses must include a factor to account for the remaining plant life which is 16 years in 1992.

The total averted dose (V_{12}) is also given as are the present worth dollar values. Each of the dollar values is based on \$1000/p-rem and a 10.8 present worth factor as described in Appendix L of NUREG/CR-4767.

Table 5.4b summarizes the negative values for each alternative. The installation dose (V_3) results from radiation exposure to contractor personnel during installation of the modifications for any particular alternative. In-service occupational dose is considered to be negligible at the pilot plant for the alternatives proposed here. In each case the doses are converted to dollars by multiplying by \$1000/p-rem. V_3 is already a present worth but V_4 requires application of the 10.8 present worth factor.

The net value of each alternative is the positive values V_{12} or V'_{12} minus the negative values for $V_3 + V_4$ and $V'_3 + V'_4$ respectively. Upper and lower bounds are given for NV and NV' which result from the bounds from the positive values only.

Table 5.5 is a summary of the Value-Impact analysis which repeats several measures from Tables 5.3, 5.4a, and 5.4b. These repeated measures are TI, NI, V_2, V'_2, ADR_{o}, and NV'. The value-impact measures derived from these measures are the Value-Impact Ratio (VIR), the Net Benefit Value (NBV), and the Dollars per person-rem (DPR) based on offsite costs alone and based on offsite and onsite costs combined. Table 5.6 is a further condensation of the results which show eight measures extracted from Table 5.5. The costs (Impact) estimated for each alternative could easily be higher or lower for a different plant. Similarly, the benefits (value) could be higher by an order of magnitude or more for other plants with greater base case core damage frequencies.

Table 5.3 Summary of Impacts (Based Upon 5% Discount)

		POSITIVE IMPACTS ASSOCIATED WITH MODIFICATIONS (Present Worths)					NEGATIVE IMPACTS DUE TO AVERTABLE ONSITE COSTS (Present Worths)				
		Utility Costs		Replacement Power Costs							
Alternative No.	Change in Core Melt Probability (Central Value)	Installation and Engineering Costs ($ x 10^6)	Operations & Maintenance Costs (PW) ($ x 10^6)	Installation ($ x 10^6)	In Service (PW) ($ x 10^6)	TOTAL IMPACT ($ X 10^6)	Replacement Power Costs ($ x 10^5)	Loss of Investment Costs ($ x 10^5)	Site Cleanup Costs ($ x 10^5)	Total Avertable Costs ($ x 10^5)	NET IMPACT ($ x 10^6)
j	Δp_m	I_1	$10.8\ I_2$	I_3	$10.8\ I_4$	TI	Γ_{31}	Γ_{32}	Γ_{33}	Γ_3	NI
1	4.80E-7	1.805	0.540	0.0	ote 1	2.345	5.28	1.73	8.16	15.17	2.33
2	5.80E-7	3.000	0.324	0.0	"	3.324	6.38	2.09	9.86	18.33	3.31
3	1.54E-6	1.955	0.594	0.0	"	2.549	16.94	5.54	26.18	48.66	2.50
4	1.46E-6	14.205	0.886	0.0	"	15.091	16.06	5.26	24.82	46.14	15.05
5	1.06E-6	20.900	1.890	0.0	"	22.79[illegible]	11.66	3.82	18.02	33.50	22.77

Note 1: Not available, probably negligible.
$TI = I_1 + 10.8\ I_2 + I_3 + 10.8\ I_4$
$\Gamma_3 = \Gamma_{31} + \Gamma_{32} + \Gamma_{33}$
$NI = TI - \Gamma_3$

Table 5.4a Summary of Values (Based on Population Dose to 50 Miles, 5% Discount Rate)

ALTERNATIVES		POSITIVE VALUES							
		Onsite		Offsite			Total		
Alternative No.	Change in Core Melt Probability (Central Value)	Averted Dose (p-rem)	Present Worth of Averted Dose @ 1000/p-rem ($ x 10^3)	Averted Dose p-rem	Averted Dose + Base Case Dose	Present Worth of Averted Dose @ 1000/p-rem ($ x 10^3)	Averted Dose (p-rem)	Averted Dose + Base Case Dose	Present Worth of Averted Dose @ 1000/p-rem ($ x 10^3)
j	Δp_m	V_1	V'_1	V_2	ADR_o	V'_2	V_{12}	ADR_t	V'_{12}
1	4.80E-7	0.307	0.207	17.12	0.12	11.56	17.43	0.13	11.77
2	5.80E-7	0.371	0.251	20.64	0.15	13.93	21.01	0.15	14.18
3	1.54E-6	0.986	0.665	55.04	0.40	37.15	56.03	0.40	37.82
4	1.46E-6	0.934	0.631	52.16	0.38	35.21	53.09	0.38	35.84
5	1.06E-6	0.678	0.458	37.76	0.27	25.49	38.44	0.28	25.95

$V_1 = 40000 \times \Delta p_m \times 16$
$V'_1 = 40000 \times \Delta p_m \times \$1000 \times 10.8$
V_2 = Averted Dose per Reactor Year x 16
V'_2 = Averted Dose per Reactor Year x $1000 x 10.8
$ADR_o = V_2 +$ (Basecase Dose x 16)
$V_{12} = V_1 + V_2$
$ADR_t = V_{12} +$ (Basecase Dose x 16 + V_1)
$V'_{12} = V'_1 + V'_2$

Table 5.4b Summary of Values (Based on Population Dose to 50 Miles, 5% Discount Rate)

ALTERNATIVES		NEGATIVE VALUE						Net Value	
		Installation		Operation		Total			
Alternative No.	Change in Core Melt Probability	Installation Dose (p-rem)	Present Worth of Installation Dose @ 1000/p-rem	In-Service Operational Dose (p-rem)	Present Worth of In-Service Oper. Dose @ 1000/p-rem ($ x 10^6)	Installation and Operational Dose	Present Worth of Install. & Oper. Dose @ 1000/p-rem ($ x 10^6)	Averted Dose p-rem	Present Worth of Averted Dose @ 1000/p-rem ($ x 10^6)
j	Δp_m	V_5	V'_5	V_6	V'_6	$V_5 + V_6$	$V'_5 + V'_6$	NV	NV'
1	4.80E-7	0	0	0	0	0	0	17.43	11.77
2	5.80E-7	0	0	0	0	0	0	21.01	14.18
3	1.54E-6	0	0	0	0	0	0	56.03	37.82
4	1.46E-6	0	0	0	0	0	0	53.09	35.84
5	1.06E-6	0	0	0	0	0	0	38.44	25.95

$V'_5 = V_5 \times \$1000$
$V'_6 = (V_6 + 16) \times \$1000 \times 10.8$
$NV = V_1 + V_2 - V_5 - V_6$
$NV' = V'_1 + V'_2 - V'_5 - V'_6$

Table 5.5 Summary of Value-Impact Analysis (Based on Population Dose to 50 Miles, 5% Discount Rate)

		V-I ANALYSIS BASED ON OFFSITE COSTS							V-I ANALYSIS BASED ON OFFSITE AND ONSITE COSTS				
						Measures of V-I					Measures of V-I		
Altern-ative No.	Change in Core Melt Probability	Averted Offsite Dose (p-rem)	Averted Dose + Base Case Dose	Total Impact ($ x 10^6)	Present Worth of Averted Dose @ 1000/ p-rem ($ x 10^3)	V-I Ratio	Net Benefit ($ x 10^6)	Dollars per p-rem ($ x 10^3)	Net Impact ($ x 10^6)	Present Worth of Averted Dose @ 1000/ p-rem ($ x 10^3)	V-I Ratio	Net Benefit ($ x 10^6)	Dollars per p-rem ($ x 10^3)
j	Δp_m	V_2	ADR_o	TI	V'_2	VIR_o	NBV_o	DPR_o	NI	NV'	VIR_a	NBV_a	DPR_a
1	4.80E-7	17.12	0.12	2.345	11.56	4.9E-3	-2.33	137	2.33	11.77	5.1E-3	-2.32	134
2	5.80E-7	20.64	0.15	3.324	13.93	4.2E-3	-3.31	161	3.31	14.18	4.3E-3	-3.30	158
3	1.54E-6	55.04	0.40	2.549	37.15	1.5E-2	-2.51	46	2.50	37.82	1.5E-2	-2.46	45
4	1.46E-6	52.16	0.38	15.091	35.21	2.3E-3	-15.06	289	15.05	35.84	2.4E-3	-15.01	283
5	1.06E-6	37.76	0.27	22.790	25.49	1.1E-3	-22.76	604	22.77	25.95	1.1E-3	-22.74	592

$VIR_o = V'_2 + TI$ $VIR_a = NV' + NI$
$NBV_o = V'_2 - TI$ $NBV_a = NV' - NI$
$DPR_o = TI + V_2$ $DPR_a = NI + NV$

Table 5.6 Summary of Value-Impact Measures

Alternative	Reduction in Core Melt Probability	Offsite Averted Dose p-rem	Averted Dose Ratio	V-I Analysis of Offsite Costs: V-I Ratio	V-I Analysis of Offsite Costs: Net Benefit ($ x 10^6)	V-I Analysis of Offsite Costs: Dollars per p-rem ($ x 10^3)	V-I Analysis Based on Offsite & Onsite Costs: V-I Ratio	V-I Analysis Based on Offsite & Onsite Costs: Net Benefit ($ x 10^6)	V-I Analysis Based on Offsite & Onsite Costs: Dollars per p-rem ($ x 10^3)
j	Δp_m	V_t	ADR_o	VIR_o	NBV_o	DPR_o	VIR_x	NBV_x	DPR_x
1	4.80E-7	17.12	0.13	0.005	-2.33	137	0.005	-2.32	134
2	5.80E-7	20.64	0.15	0.004	-3.31	161	0.004	-3.30	158
3	1.54E-6	55.04	0.40	0.015	-2.51	46	0.015	-2.46	45
4	1.46E-6	52.16	0.38	0.002	-15.06	339	0.002	-15.01	283
5	1.06E-6	37.76	0.28	0.001	-22.76	604	0.001	-22.74	592

6.0 SUMMARY AND CONCLUSIONS

This report documents a scoping study performed by Sandia National Laboratories for the U.S. Nuclear Regulatory Commission (NRC). The main objective of this scoping study was to evaluate the importance of service water systems to core damage frequency (CDF), and to perform limited value/impact and sensitivity studies on a selected prototypical (pilot) plant.

To evaluate the importance of service water systems to CDF, eleven NRC-sponsored PRAs were reviewed to determine the service water contribution to CDF and to identify the dominant service water system component faults and related failures, e.g., human errors or test and maintenance unavailability, contributing to core damage (see Section 2.0).

The contribution made to core damage frequency of each of the NRC-sponsored PRAs reviewed is summarized in Table 6.1. Also included in this table is service water core damage contribution made by six plants analyzed in the Electric Power Research Institute (EPRI) report NSAC-148.[19] These six plants are identified by the letters A through F. As can be seen from Table 6.1, for plants characterized as "old" (i.e., plants with operating licensees prior to January 1976) the service water contribution to CDF is about twice that for "new" plants (i.e., plants receiving operating licensees after January 1, 1976). Also from Table 6.1 the contribution made by service water to the CDF for BWRs is two to three times that made for PWRs.

As shown in Table 6.1, the service water contribution to CDF varies by plant. The reasons for the variation are the degree of dependency a plant has on service water, the reliability of the service water systems themselves, and, to some extent, the differences in the NRC-sponsored PRAs in terms of modeling assumptions and scope of each PRA program. These are the same basic conclusions as found in EPRI report NSAC-148[19] except that the EPRI report also concluded that water quality was a major influence. Water quality problems would not be expected to be a major finding in the NRC sponsored PRAs since these studies typically used generic data to quantify the system models instead of plant specific data. Therefore, water quality problems, e.g., above average maintenance outage times for the service water system and higher component failures rates, would not typically be accounted for.

Sensitivity analysis were performed for selected pilot plant ESW components in part to address the effect water quality problems would have on the NUREG/CR-4550 results. This analysis is discussed in Section 4.7. This analysis showed that water quality could have a significant effect on the SW contribution to CDF as concluded in the EPRI report.

The service water system dominant failure modes found from the review of the NRC-sponsored PRAs tend to have some commonality between the plants even though the service water system configurations for each plant are unique. Two common service water faults found were the dependency of the service water system on motor-operated or air-operated isolation valves to open on demand to supply cooling water to safety related loads and failure of the standby service water pumps to start. Two subtle failure modes identified in the NUREG/CR-4550[51] program were found to be dominant failure modes for three of the plants reviewed. These subtle failures are (1) the failure to isolate nonessential cooling water loads; and (2) pump discharge check valve back flow failing cross-tied pumps. The failure to isolate nonessential cooling loads can result in inadequate cooling of the essential loads due to the diversion of water away from the essential loads and the potential for pump runout and failure.

The pump discharge check valve failure deals with the failure (fail to reclose) of the discharge check valve in one pump train of a multiple pump system where the pumps are all cross-tied. The failure of the check valve to reclose occurs when one of the operating pumps is shut down. This allows flow from the other pump(s) to recirculate back through the idle pump resulting in functional failure of the system.

A review of operational history was performed in an attempt to establish typical service water system vulnerabilities that should be addressed in this analysis (see Section 2.0). The events found were highly plant specific and represented a large variety of root causes, indicating no obvious pattern in terms of hardware or operator errors that are not generally covered by PRA methods.

To provide an example of the type of analysis that can be performed using PRA methods to address service water vulnerabilities, a pilot plant was selected (see Section

Table 6.1

Service Water Contribution to Internal CDF By Reactor Type

PWRs				BWRS			
"Old"		"New"		"Old"		"New"	
A	18%	B	9%	C[1]	57%	F	25%
D	18%	E	5%	Peach Bottom	22%	Grand Gulf	14%
Oconee	16%	St.Lucie	13%	Quad Cities	30%	LaSalle	7%
Calvert Cliffs	11%	Sequoyah[2]	<1%	Cooper	65%		
ANO-1	12%			Millstone 1	7%		
Point Beach	19%						
Turkey Point	5%						
Surry[2]	<1%						
"Average"	12%		7%		36%		15%

[1]Incomplete recovery.

[2]May not be accurate although both plants have unique service water systems.

3.0). This selection was based on the availability and quality of NRC-sponsored PRAs, the contribution of service water failure to core damage, the dominance of common failure modes, and the plant being representative of a large group of vendor types.

Based on the identified failure modes in the pilot plant PRA and the common failure modes found between plants, a number of modifications were suggested for the most significant service water system vulnerabilities (see Section 4.0). These modifications were combined in various ways to define five possible alternatives. The total core damage frequency was then reevaluated for the pilot plant assuming the alternatives were in place (see Section 4.0) with the following results:

Alternative	Probability of Core Damage per Reactor Year	Change in Core Damage
1	4.19E-06	4.80E-07
2	4.09E-06	5.80E-07
3	3.13E-06	1.55E-06
4	[illegible]21E-06	1.46E-06
5	3.61E-06	1.06E-06

The change in core damage frequency is the change from a base case core damage frequency of 4.67E-06/R yr (ref Table 4.9).

These results were used in an integrated value-impact analysis. Detailed results are tabulated and presented in Section 5.0. Table 6.2 provides a summary of the inputs to the value-impact analysis and Table 6.3 compares the pilot plant value/impact analysis results with the TAP A-45 plants. None of the alternatives are attractive from the dollars per person REM results. External events were not included in this analysis. A discussion of external events contribution to CDF is presented in Section 4.3. If external events had been considered, the value/impact analysis might have been more favorable. However, the costs to implement modifications to address external event SW related vulnerabilities might affect some of the improvement in dollars per person-REM resulting from an expected larger ΔCDF.

Table 6.2
Inputs to and Results from the Value/Impact Analysis

Alternative	Modifications	ΔCDF	Risk (ΔDose) Person REM/ R yr.	One Time Cost I_1	O & M Cost I_2	Results for Offsite and Onsite costs $/Person REM
1	3,5,6	4.80E-07	1.07	1805K	50K	134K
2	3,4,6	5.80E-07	1.29	3000K	30K	158K
3	2,5,6	1.54E-06	3.44	1955K	55K	45K
4	1,5,6	1.46E-06	3.26	14.2M	82K	283K
5	7	1.06E-06	2.36	20.9M	175K	529K

Table 6.3

Comparison of Dollars/Person REM For TAP A-45 Plants and the Pilot Plant Selected Alternatives (Offsite and Onsite Costs)

Alternative	Point Beach	Turkey Point	ANO-1	St. Lucie	Quad Cities	Cooper	Pilot Plant
1	3233	1166	37000	0	4486	6894	134000
2	9183	39363	140000	190759	48718	0	158000
3	17676	——	——	——	——	0	45000
4	82325	——	——	——	——	0	283000
5	——	——	——	——	——	24993	592000

Table 6.3 Notes:

1. Zero values imply negative NI, i.e., modification in alternative very cost beneficial.
2. Alternative numbers are for reference only and do not relate between plants.
3. Some plant analyses proposed more alternatives than others depending on the possible meaningful combinations.

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APPENDIX A

NUCLEAR POWER PLANT SUMMARY TABLES

Table A.1
NPPs Sorted By Operating License Date

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
YANKEE-ROWE	W	PWR	4-loop	167	07/19/60	C		Y		
BIG ROCK POINT	GE	BWR	1	69	05/01/64	O		Y		
SAN ONOFRE 1	W	PWR	3-loop	436	03/27/67	O				
HADDAM NECK	W	PWR	4-loop	569	06/30/67	O		Y		
LA CROSSE	AC	BWR		50	07/03/67	C				
OYSTER CREEK	GE	BWR	2	620	08/01/69	O		Y		
NINE MILE POINT 1	GE	BWR	2	610	08/22/69	O	Y			
GINNA	W	PWR	2-loop	470	09/19/69	O				
DRESDEN 2	GE	BWR	3	772	12/22/69	O	Y	Y		
MONTICELLO	GE	BWR	3	536	09/08/70	O	Y	Y		
ROBINSON 2	W	PWR	3-loop	665	09/23/70	O	Y	Y		
POINT BEACH 1	W	PWR	2-loop	485	10/05/70	O			Y	
MILLSTONE 1	GE	BWR	3	654	10/07/70	O	Y	Y	Y	
DRESDEN 3	GE	BWR	3	773	03/02/71	O	Y	Y		
SURRY 1	W	PWR	3-loop	781	05/25/72	O	Y		Y	
POINT BEACH 2	W	PWR	2-loop	485	05/25/72	O				
TURKEY POINT 3	W	PWR	3-loop	666	07/19/72	O				
PILGRIM	GE	BWR	3	670	09/15/72	O				
PALISADES	CE	PWR	2-loop	730	10/[illegible]/72	O				
QUAD CITIES 1	GE	BWR	3	769	12/14/[illegible]	O	Y	Y	Y	
QUAD CITIES 2	GE	BWR	3	769	12/14/72	O	Y	Y		
SURRY 2	W	PWR	3-loop	781	01/29/73	O	Y			
OCONEE 1	B&W	PWR	L-loop	846	02/06/73	O	Y			
VERMONT YANKEE	GE	BWR	4	504	02/28/73	O				
TURKEY POINT 4	W	PWR	3-loop	666	04/10/73	O				
MAINE YANKEE	CE	PWR	3-loop	810	06/29/73	O	Y	Y		
PEACH BOTTOM 2	GE	BWR	4	1051	08/08/73	O	Y	Y	Y	
PRAIRIE ISLAND 1	W	PWR	2-loop	503	08/09/73	O	Y			
FORT CALHOUN	CE	PWR	2-loop	478	08/09/73	O	Y	Y		
INDIAN POINT 2	W	PWR	4-loop	849	09/28/73	O				
OCONEE 2	B&W	PWR	L-loop	846	10/06/73	O	Y			
ZION 1	W	PWR	4-loop	1040	10/19/73	O	Y	Y		
ZION 2	W	PWR	4-loop	1040	11/14/73	O	Y	Y		
BROWNS FERRY 1	GE	BWR	4	1065	12/20/73	O	Y	Y		

*O = Operating
C = Closed
S = Shutdown

Table A.1 (Continued)
NPPs Sorted By Operating License Date

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
KEWAUNEE	W	PWR	2-loop	503	12/21/73	O				
COOPER	GE	BWR	4	764	01/18/74	O	Y	Y	Y	
DUANE ARNOLD	GE	BWR	4	515	02/22/74	O				
THREE MILE ISLAND 1	B&W	PWR	L-loop	776	04/19/74	O	Y	Y		
ANO 1	B&W	PWR	L-loop	836	05/21/74	O			Y	
PEACH BOTTOM 3	GE	BWR	4	1035	07/02/74	O	Y	Y		
OCONEE 3	B&W	PWR	L-loop	846	07/19/74	O	Y		Y	
CALVERT CLIFFS 1	CE	PWR	2-loop	825	07/31/74	O	Y		Y	
BROWNS FERRY 2	GE	BWR	4	1065	08/02/74	O	Y	Y		
RANCHO SECO	B&W	SWR	L-loop	873	08/16/74	C		Y		
HATCH 1	GE	BWR	4	756	10/13/74	O	Y	Y		
FITZPATRICK	GE	BWR	4	778	10/17/74	O	Y	Y		
D.C. COOK 1	W	PWR	4-loop	1020	10/25/74	O	Y			
PRAIRIE ISLAND 2	W	PWR	2-loop	503	10/29/74	O	Y			
BRUNSWICK 2	GE	BWR	4	790	12/27/74	O	Y	Y		
MILLSTONE 2	CE	PWR	2-loop	863	09/30/75	O	Y			
TROJAN	W	PWR	4-loop	1095	11/21/75	O		Y		
ST. LUCIE 1	CE	PWR	2-loop	839	03/01/76	O	Y	Y	Y	
INDIAN POINT 3	W	PWR	4-loop	965	04/05/76	O	Y			
BEAVER VALLEY 1	W	PWR	3-loop	810	07/02/76	O	Y	Y		
BROWNS FERRY 3	GE	BWR	4	1065	08/18/76	O	Y	Y		
BRUNSWICK 1	GE	BWR	4	790	11/12/76	O	Y	Y		
CALVERT CLIFFS 2	CE	PWR	2-loop	825	11/30/76	O	Y			
SALEM 1	W	PWR	4-loop	1106	12/01/76	O				
CRYSTAL RIVER 3	B&W	PWR	L-loop	821	01/28/77	O	Y	Y		
DAVIS-BESSE	B&W	PWR	R-loop	860	04/22/77	O	Y	Y		
FARLEY 1	W	PWR	3-loop	813	06/25/77	O				
D.C. COOK 2	W	PWR	4-loop	[illegible]	12/23/77	O	Y			Y
NORTH ANNA 1	W	PWR	3-loop	[illegible]	04/01/78	O	Y			
HATCH 2	GE	BWR	4	768	06/13/78	O	Y	Y		
ANO 2	CE	PWR	2-loop	858	12/14/78	O				
NORTH ANNA 2	W	PWR	3-loop	915	08/21/80	O	Y			
SEQUOYAH 1	W	PWR	4-loop	1148	09/17/80	O	Y		Y	

*O = Operating
C = Closed
S = Shutdown

Table A.1 (Continued)
NPPs Sorted By Operating License Date

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
FARLEY 2	W	PWR	3-loop	823	03/31/81	O				
SALEM 2	W	PWR	4-loop	1106	05/20/81	O				
MCGUIRE 1	W	PWR	4-loop	1129	07/08/81	O		Y		Y
SEQUOYAH 2	W	PWR	4-loop	1148	09/15/81	O	Y			
LASALLE COUNTY 1	GE	BWR	5	1036	08/13/82	O	Y		Y	
SAN ONOFRE 2	CE	PWR	2-loop	1070	09/07/82	O				
SUSQUEHANNA 1	GE	BWR	4	1032	11/12/82	O		Y		
SUMMER	W	PWR	3-loop	885	11/12/82	O				
MCGUIRE 2	W	PWR	4-loop	1129	05/27/83	O		Y		
ST. LUCIE 2	CE	PWR	2-loop	839	06/10/83	O	Y	Y		
SAN ONOFRE 3	CE	PWR	2-loop	1080	09/16/83	O				
LASALLE COUNTY 2	GE	BWR	5	1036	03/23/84	O	Y			
WNP-2	GE	BWR	5	1095	04/13/84	O	Y	Y		
SUSQUEHANNA 2	GE	BWR	4	1032	06/27/84	O	Y			
CALLAWAY	W	PWR	4-loop	1145	10/18/84	O	Y			
GRAND GULF	GE	BWR	6	1142	11/01/84	O	Y	Y	Y	
DIABLO CANYON 1	W	PWR	4-loop	1073	11/02/84	O	Y			Y
CATAWBA 1	W	PWR	4-loop	1129	01/17/85	O	Y	Y		Y
BYRON 1	W	PWR	4-loop	1105	02/14/85	O	Y	Y		
WATERFORD 3	CE	PWR	2-loop	1075	03/16/85	O	Y			Y
PALO VERDE 1	CE	PWR	2-loop	1221	06/01/85	O	Y			
WOLF CREEK	W	PWR	4-loop	1128	06/04/85	O	Y			
SHOREHAM	GE	BWR	4	820	07/03/85	C	Y			
FERMI 2	GE	BWR	4	1093	07/15/85	O	Y			
LIMERICK 1	GE	BWR	4	1055	08/08/85	O	Y	Y		
DIABLO CANYON 2	W	PWR	4-loop	1087	08/26/85	O	Y			Y
RIVER BEND	GE	BWR	6	936	11/20/85	O	Y	Y		
MILLSTONE 3	W	PWR	4-loop	1142	01/31/86	O	Y	Y		
PALO VERDE 2	CE	PWR	2-loop	1221	04/24/86	O	Y			
CATAWBA 2	W	PWR	4-loop	1129	05/15/86	O	Y	Y		Y
HOPE CREEK	GE	BWR	4	1067	07/25/86	O	Y	Y		
SEABROOK	W	PWR	4-loop	1150	10/17/86	O	Y	Y		
PERRY 1	GE	BWR	6	1205	11/13/86	O	Y	Y		
SHEARON HARRIS	W	PWR	3-loop	860	01/12/87	O	Y	Y		

*O = Operating
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Table A.1 (Continued)
NPPs Sorted By Operating License Date

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
BYRON 2	W	PWR	4-loop	1105	01/30/87	O		Y		Y
VOGTLE 1	W	PWR	4-loop	1079	03/16/87	O		Y		
CLINTON	GE	BWR	6	930	04/17/87	O	Y	Y		
BRAIDWOOD 1	W	PWR	4-loop	1120	07/02/87	O		Y		Y
NINE MILE POINT 2	GE	BWR	5	1080	07/02/87	O	Y	Y		
BEAVER VALLEY 2	W	PWR	3-loop	833	08/14/87	O	Y	Y		
PALO VERDE 3	CE	PWR	2-loop	1221	11/25/87	O		Y		
SOUTH TEXAS PROJECT 1	W	PWR	4-loop	1250	03/22/88	O		Y		
BRAIDWOOD 2	W	PWR	4-loop	1120	05/20/88	O		Y		Y
SOUTH TEXAS PROJECT 2	W	PWR	4-loop	1250	12/16/88	O		Y		
PERRY 2	GE	BWR	6	1205	/ /	S	Y	Y		
VOGTLE 2	W	PWR	4-loop	1079	/ /	O		Y		
LIMERICK 2	GE	BWR	4	1065	/ /	O	Y	Y		
WATTS BAR 1	W	PWR	4-loop	1165	/ /	S	Y			
WATTS BAR 2	W	PWR	4-loop	1165	/ /	S	Y			
BELLEFONTE 1	B&W	PWR	R-loop	1213	/ /	S		Y		
BELLEFONTE 2	B&W	PWR	R-loop	1213	/ /	S		Y		
COMANCHE PEAK 1	W	PWR	4-loop	1150	/ /	O	Y	Y		Y
COMANCHE PEAK 2	W	PWR	4-loop	1150	/ /	S	Y	Y		Y
WNP-1	B&W	PWR		1266	/ /	S	Y			
WNP-3	CE	PWR		1242	/ /	S	Y			

*O = Operating
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Table A.2
NPPs Sorted Alphabetically

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
ANO 1	B&W	PWR	L-loop	836	05/21/74	O			Y	
ANO 2	CE	PWR	2-loop	858	12/14/78	O				
BEAVER VALLEY 1	W	PWR	3-loop	810	07/02/76	O	Y	Y		
BEAVER VALLEY 2	W	PWR	3-loop	833	08/14/87	O	Y	Y		
BELLEFONTE 1	B&W	PWR	R-loop	1213	/ /	S		Y		
BELLEFONTE 2	B&W	PWR	R-loop	1213	/ /	S		Y		
BIG ROCK POINT	GE	BWR	1	69	05/01/64	C		Y		
BRAIDWOOD 1	W	PWR	4-loop	1120	07/02/87	O		Y		Y
BRAIDWOOD 2	W	PWR	4-loop	1120	05/20/88	O		Y		Y
BROWNS FERRY 1	GE	BWR	4	1065	12/20/73	O	Y	Y		
BROWNS FERRY 2	GE	BWR	4	1065	08/02/74	O	Y	Y		
BROWNS FERRY 3	GE	BWR	4	1065	08/18/76	O	Y	Y		
BRUNSWICK 1	GE	BWR	4	790	11/12/76	O	Y	Y		
BRUNSWICK 2	GE	BWR	4	790	12/27/74	O	Y	Y		
BYRON 1	W	PWR	4-loop	1105	02/14/85	O		Y		Y
BYRON 2	W	PWR	4-loop	1105	01/30/87	O		Y		Y
CALLAWAY	W	PWR	4-loop	1145	10/18/84	O		Y		
CALVERT CLIFFS 1	CE	PWR	2-loop	825	07/31/74	O	Y		Y	
CALVERT CLIFFS 2	CE	PWR	2-loop	825	11/30/76	O	Y			
CATAWBA 1	W	PWR	4-loop	1129	01/17/85	O	Y	Y		Y
CATAWBA 2	W	PWR	4-loop	1129	05/15/86	O	Y	Y		Y
CLINTON	GE	BWR	6	930	04/17/87	O	Y	Y		
COMANCHE PEAK 1	W	PWR	4-loop	1150	/ /	O	Y	Y		Y
COMANCHE PEAK 2	W	PWR	4-loop	1150	/ /	S	Y	Y		Y
COOPER	GE	BWR	4	764	01/18/74	O	Y	Y	Y	
CRYSTAL RIVER 3	B&W	PWR	L-loop	821	01/28/77	O	Y	Y		
D.C. COOK 1	W	PWR	4-loop	1020	10/25/74	O	Y			
D.C. COOK 2	W	PWR	4-loop	1060	12/23/77	O	Y			Y
DAVIS-BESSE	B&W	PWR	R-loop	860	04/22/77	O	Y	Y		
DIABLO CANYON 1	W	PWR	4-loop	1073	11/02/84	O	Y			Y
DIABLO CANYON 2	W	PWR	4-loop	1087	08/26/85	O	Y			Y
DRESDEN 2	GE	BWR	3	772	12/22/69	O	Y	Y		
DRESDEN 3	GE	BWR	3	773	03/02/71	O	Y	Y		
DUANE ARNOLD	GE	BWR	4	515	02/22/74	O				

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Table A.2 (Continued)
NPPs Sorted Alphabetically

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
FARLEY 1	W	PWR	3-loop	813	06/25/77	O				
FARLEY 2	W	PWR	3-loop	823	03/31/81	O				
FERMI 2	GE	BWR	4	1093	07/15/85	O	Y			
FITZPATRICK	GE	BWR	4	778	10/17/74	O	Y	Y		
FORT CALHOUN	CE	PWR	2-loop	478	08/09/73	O	Y	Y		
GINNA	W	PWR	2-loop	470	09/19/69	O				
GRAND GULF	GE	BWR	6	1142	11/01/84	O	Y	Y	Y	
HADDAM NECK	W	PWR	4-loop	569	06/30/67	O		Y		
HATCH 1	GE	BWR	4	756	10/13/74	O	Y	Y		
HATCH 2	GE	BWR	4	768	06/13/78	O	Y	Y		
HOPE CREEK	GE	BWR	4	1067	07/25/86	O	Y	Y		
INDIAN POINT 2	W	PWR	4-loop	849	09/28/73	O				
INDIAN POINT 3	W	PWR	4-loop	965	04/05/76	O		Y		
KEWAUNEE	W	PWR	2-loop	503	12/21/73	O				
LA CROSSE	AC	BWR		50	07/03/67	C				
LASALLE COUNTY 1	GE	BWR	5	1036	08/13/82	O	Y		Y	
LASALLE COUNTY 2	GE	BWR	5	1036	03/23/84	O	Y			
LIMERICK 1	GE	BWR	4	1055	08/08/85	O	Y	Y		
LIMERICK 2	GE	BWR	4	1065	/ /	O	Y	Y		
MAINE YANKEE	CE	PWR	3-loop	810	06/29/73	O	Y	Y		
MCGUIRE 1	W	PWR	4-loop	1129	07/08/81	O		Y		Y
MCGUIRE 2	W	PWR	4-loop	1129	05/27/83	O		Y		
MILLSTONE 1	GE	BWR	3	654	10/07/70	O	Y	Y	Y	
MILLSTONE 2	CE	PWR	2-loop	863	09/30/75	O		Y		
MILLSTONE 3	W	PWR	4-loop	1142	01/31/86	O	Y	Y		
MONTICELLO	GE	BWR	3	536	09/08/70	O	Y	Y		
NINE MILE POINT 1	GE	BWR	2	610	08/22/69	O		Y		
NINE MILE POINT 2	GE	BWR	5	1080	07/02/87	O	Y	Y		
NORTH ANNA 1	W	PWR	3-loop	915	04/01/78	O	Y			
NORTH ANNA 2	W	PWR	3-loop	915	08/21/80	O	Y			
OYSTER CREEK	GE	BWR	2	620	08/01/69	O		Y		

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Table A.2 (Continued)
NPPs Sorted Alphabetically

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
PALISADES	CE	PWR	2-loop	730	10/16/72	O				
PALO VERDE 1	CE	PWR	2-loop	1221	06/01/85	O		Y		
PALO VERDE 2	CE	PWR	2-loop	1221	04/24/86	O		Y		
PALO VERDE 3	CE	PWR	2-loop	1221	11/25/87	O		Y		
PEACH BOTTOM 2	GE	BWR	4	1051	08/08/73	O	Y	Y	Y	
PEACH BOTTOM 3	GE	BWR	4	1035	07/02/74	O	Y	Y		
PERRY 1	GE	BWR	6	1205	11/13/86	O	Y	Y		
PERRY 2	GE	BWR	6	1205	/ /	S	Y	Y		
PILGRIM	GE	BWR	3	670	09/15/72	O				
POINT BEACH 1	W	PWR	2-loop	485	10/05/70	O			Y	
POINT BEACH 2	W	PWR	2-loop	485	05/25/72	O				
PRAIRIE ISLAND 1	W	PWR	2-loop	503	08/09/73	O	Y			
PRAIRIE ISLAND 2	W	PWR	2-loop	503	10/29/74	O	Y			
QUAD CITIES 1	GE	BWR	3	769	12/14/72	O	Y	Y	Y	
QUAD CITIES 2	GE	BWR	3	769	12/14/72	O	Y	Y		
RANCHO SECO	B&W	SWR	L-loop	873	08/16/74	C		Y		
RIVER BEND	GE	BWR	6	936	11/20/85	O	Y	Y		
ROBINSON 2	W	PWR	3-loop	665	09/23/70	O	Y	Y		
SALEM 1	W	PWR	4-loop	1106	12/01/76	O				
SALEM 2	W	PWR	4-loop	1106	05/20/81	O				
SAN ONOFRE 1	W	PWR	3-loop	436	03/27/67	O				
SAN ONOFRE 2	CE	PWR	2-loop	1070	09/07/82	O				
SAN ONOFRE 3	CE	PWR	2-loop	1080	09/16/83	O				
SEABROOK	W	PWR	4-loop	1150	10/17/86	O	Y	Y		
SEQUOYAH 1	W	PWR	4-loop	1148	09/17/80	O	Y		Y	
SEQUOYAH 2	W	PWR	4-loop	1148	09/15/81	O	Y			
SHEARON HARRIS	W	PWR	3-loop	860	01/12/87	O	Y	Y		
SHOREHAM	GE	BWR	4	820	07/03/85	C	Y			
SOUTH TEXAS PROJECT 1	W	PWR	4-loop	1250	03/22/88	O		Y		
SOUTH TEXAS PROJECT 2	W	PWR	4-loop	1250	12/16/88	O		Y		
ST. LUCIE 1	CE	PWR	2-loop	839	03/01/76	O	Y	Y	Y	
ST. LUCIE 2	CE	PWR	2-loop	839	06/10/83	O	Y	Y		
SUMMER	W	PWR	3-loop	885	11/12/82	O				
SURRY 1	W	PWR	3-loop	781	05/25/72	O	Y		Y	

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Table A.2 (Continued)
NPPs Sorted Alphabecically

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
SURRY 2	W	PWR	3-loop	781	01/29/73	O	Y			
SUSQUEHANNA 1	GE	BWR	4	1032	11/12/82	O		Y		
SUSQUEHANNA 2	GE	BWR	4	1032	06/27/84	O		Y		
THREE MILE ISLAND 1	B&W	PWR	L-loop	776	04/19/74	O	Y	Y		
TROJAN	W	PWR	4-loop	1095	11/21/75	O		Y		
TURKEY POINT 3	W	PWR	3-loop	666	07/19/72	O				
TURKEY POINT 4	W	PWR	3-loop	666	04/10/73	O				
VERMONT YANKEE	GE	BWR	4	504	02/28/73	O				
VOGTLE 1	W	PWR	4-loop	1079	03/16/87	O		Y		
VOGTLE 2	W	PWR	4-loop	1079	/ /	O		Y		
WATERFORD 3	CE	PWR	2-loop	1075	03/16/85	O	Y	Y		
WATTS BAR 1	W	PWR	4-loop	1165	/ /	S	Y			
WATTS BAR 2	W	PWR	4-loop	1165	/ /	S	Y			
WNP-1	B&W	PWR		1266	/ /	S	Y			
WNP-2	GE	BWR	5	1095	04/13/84	O	Y	Y		
WNP-3	CE	PWR		1242	/ /	S	Y			
WOLF CREEK	W	PWR	4-loop	1128	06/04/85	O		Y		
YANKEE-ROWE	W	PWR	4-loop	167	07/19/60	C		Y		
ZION 1	W	PWR	4-loop	1040	10/19/73	O	Y	Y		
ZION 2	W	PWR	4-loop	1040	11/14/73	O	Y	Y		

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Table A.3 (Continued)
NPPs Sorted by Vendor

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
LA CROSSE	AC	BWR		50	07/03/67	C				
ANO 1	B&W	PWR	L-loop	836	05/21/74	O			Y	
BELLEFONTE 1	B&W	PWR	R-loop	1213	/ /	S		Y		
BELLEFONTE 2	B&W	PWR	R-loop	1213	/ /	S		Y		
CRYSTAL RIVER 3	B&W	PWR	L-loop	821	01/28/77	O	Y	Y		
DAVIS-BESSE	B&W	PWR	R-loop	860	04/22/77	O	Y	Y		
OCONEE 1	B&W	PWR	L-loop	846	02/06/73	O	Y			
OCONEE 2	B&W	PWR	L-loop	846	10/06/73	O	Y			
OCONEE 3	B&W	PWR	L-loop	846	07/19/74	O	Y		Y	
RANCHO SECO	B&W	SWR	L-loop	873	08/16/74	C		Y		
THREE MILE ISLAND 1	B&W	PWR	L-loop	776	04/19/74	O	Y	Y		
WNP-1	B&W	PWR		1266	/ /	S	Y			
ANO 2	CE	PWR	2-loop	858	12/14/78	O				
CALVERT CLIFFS 1	CE	PWR	2-loop	825	07/31/74	O	Y		Y	
CALVERT CLIFFS 2	CE	PWR	2-loop	825	11/30/76	O	Y			
FORT CALHOUN	CE	PWR	2-loop	478	08/09/73	O	Y	Y		
MAINE YANKEE	CE	PWR	3-loop	810	06/29/73	O	Y	Y		
MILLSTONE 2	CE	PWR	2-loop	863	09/30/75	O		Y		
PALISADES	CE	PWR	2-loop	730	10/16/72	O				
PALO VERDE 1	CE	PWR	2-loop	1221	06/01/85	O		Y		
PALO VERDE 2	CE	PWR	2-loop	1221	04/24/86	O		Y		
PALO VERDE 3	CE	PWR	2-loop	1221	11/25/87	O		Y		
SAN ONOFRE 2	CE	PWR	2-loop	1070	09/07/82	O				
SAN ONOFRE 3	CE	PWR	2-loop	1080	09/16/83	O				
ST. LUCIE 1	CE	PWR	2-loop	83[illegible]	03/01/76	O	Y	Y	Y	
ST. LUCIE 2	CE	PWR	2-loop	839	06/10/83	O	Y	Y		
WATERFORD 3	CE	PWR	2-loop	1075	03/16/85	O	Y	Y		
WNP-3	CE	PWR		1242	/ /	S	Y			
BIG ROCK POINT	GE	BWR	1	69	05/01/64	O		Y		
BROWNS FERRY 1	GE	BWR	4	1065	12/20/73	O	Y	Y		
BROWNS FERRY 2	GE	BWR	4	1065	08/02/74	O	Y	Y		
BROWNS FERRY 3	GE	BWR	4	1065	08/18/76	O	Y	Y		
BRUNSWICK 1	GE	BWR	4	790	11/12/76	O	Y	Y		

*O = Operating
C = Closed
S = Shutdown

Table A.3 (Continued)
NPPs Sorted By Vendor

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
BRUNSWICK 2	GE	BWR	4	790	12/27/74	O	Y	Y		
CLINTON	GE	BWR	6	930	04/17/87	O	Y	Y		
COOPER	GE	BWR	4	764	01/18/74	O	Y	Y	Y	
DRESDEN 2	GE	BWR	3	772	12/22/69	O	Y	Y		
DRESDEN 3	GE	BWR	3	773	03/02/71	O	Y	Y		
DUANE ARNOLD	GE	BWR	4	515	02/22/74	O				
FERMI 2	GE	BWR	4	1093	07/15/85	O	Y			
FITZPATRICK	GE	BWR	4	778	10/17/74	O	Y	Y		
GRAND GULF	GE	BWR	6	1142	11/01/84	O	Y	Y	Y	
HATCH 1	GE	BWR	4	756	10/13/74	O	Y	Y		
HATCH 2	GE	BWR	4	768	06/13/78	O	Y	Y		
HOPE CREEK	GE	BWR	4	1067	07/25/86	O	Y	Y		
LASALLE COUNTY 1	GE	BWR	5	1036	08/13/82	O	Y		Y	
LASALLE COUNTY 2	GE	BWR	5	1036	03/23/84	O	Y			
LIMERICK 1	GE	BWR	4	1055	08/08/85	O	Y	Y		
LIMERICK 2	GE	BWR	4	1065	/ /	O	Y	Y		
MILLSTONE 1	GE	BWR	3	654	10/07/70	O	Y	Y	Y	
MONTICELLO	GE	BWR	3	536	09/08/70	O	Y	Y		
NINE MILE POINT 1	GE	BWR	2	610	08/22/69	O		Y		
NINE MILE POINT 2	GE	BWR	5	1080	07/02/87	O	Y	Y		
OYSTER CREEK	GE	BWR	2	620	08/01/69	O		Y		
PEACH BOTTOM 2	GE	BWR	4	1051	08/08/73	O	Y	Y	Y	
PEACH BOTTOM 3	GE	BWR	4	1035	07/02/74	O	Y	Y		
PERRY 1	GE	BWR	6	1205	11/13/86	O	Y	Y		
PERRY 2	GE	BWR	6	1205	/ /	S	Y	Y		
PILGRIM	GE	BWR	3	670	09/15/72	O				
QUAD CITIES 1	GE	BWR	3	769	12/14/72	O	Y	Y	Y	
QUAD CITIES 2	GE	BWR	3	769	12/14/72	O	Y	Y		
RIVER BEND	GE	BWR	6	936	11/20/85	O	Y	Y		
SHOREHAM	GE	BWR	4	820	07/03/85	C	Y			
SUSQUEHANNA 1	GE	BWR	4	1032	11/12/82	O		Y		
SUSQUEHANNA 2	GE	BWR	4	1032	06/27/84	O		Y		
VERMONT YANKEE	GE	BWR	4	504	02/28/73	O				

*O = Operating
C = Closed
S = Shutdown

Table A.3 (Continued)
NPPs Sorted By Vendor

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
WNP-2	GE	BWR	5	1095	04/13/84	O	Y	Y		
BEAVER VALLEY 1	W	PWR	3-loop	810	07/02/76	O	Y	Y		
BEAVER VALLEY 2	W	PWR	3-loop	833	08/14/87	O	Y	Y		
BRAIDWOOD 1	W	PWR	4-loop	1120	07/02/87	O		Y		Y
BRAIDWOOD 2	W	PWR	4-loop	1120	05/20/88	O		Y		Y
BYRON 1	W	PWR	4-loop	1105	02/14/85	O		Y		Y
BYRON 2	W	PWR	4-loop	1105	01/30/87	O		Y		Y
CALLAWAY	W	PWR	4-loop	1145	10/18/84	O		Y		
CATAWBA 1	W	PWR	4-loop	1129	01/17/85	O	Y	Y		Y
CATAWBA 2	W	PWR	4-loop	1129	05/15/86	O	Y	Y		Y
COMANCHE PEAK 1	W	PWR	4-loop	1150	/ /	O	Y	Y		Y
COMANCHE PEAK 2	W	PWR	4-loop	1150	/ /	S	Y	Y		Y
D.C. COOK 1	W	PWR	4-loop	1920	10/25/74	O	Y			
D.C. COOK 2	W	PWR	4-loop	1060	12/23/77	O	Y			Y
DIABLO CANYON 1	W	PWR	4-loop	1073	11/02/84	O	Y			Y
DIABLO CANYON 2	W	PWR	4-loop	1087	08/26/85	O	Y			Y
FARLEY 1	W	PWR	3-loop	813	06/25/77	O				
FARLEY 2	W	PWR	3-loop	823	03/31/81	O				
GINNA	W	PWR	2-loop	470	09/19/69	O				
HADDAM NECK	W	PWR	4-loop	569	06/30/67	O		Y		
INDIAN POINT 2	W	PWR	4-loop	849	09/28/73	O				
INDIAN POINT 3	W	PWR	4-loop	965	04/05/76	O		Y		
KEWAUNEE	W	PWR	2-loop	503	12/21/73	O				
MCGUIRE 1	W	PWR	4-loop	1129	07/08/81	O		Y		Y
MCGUIRE 2	W	PWR	4-loop	1129	05/27/83	O		Y		
MILLSTONE 3	W	PWR	4-loop	1142	01/31/86	O	Y	Y		
NORTH ANNA 1	W	PWR	3-loop	915	04/01/78	O	Y			
NORTH ANNA 2	W	PWR	3-loop	915	08/21/80	O	Y			
POINT BEACH 1	W	PWR	2-loop	485	10/05/70	O			Y	
POINT BEACH 2	W	PWR	2-loop	485	05/25/72	O				
PRAIRIE ISLAND 1	W	PWR	2-loop	503	08/09/73	O	Y			
PRAIRIE ISLAND 2	W	PWR	2-loop	503	10/29/74	O	Y			
ROBINSON 2	W	PWR	3-loop	665	09/23/70	O	Y	Y		

*O = Operating
C = Closed
S = Shutdown

Table A.3 (Continued)
NPPs Sorted By Vendor

PLANT	NSSS	REACTOR	TYPE	MWE	OPERATING LICENSE DATE	STATUS*	ASEP PLANT	SYSTEM SOURCE BOOK	NRC PRA	GI-130 PLANT
SALEM 1	W	PWR	4-loop	1106	12/01/76	O				
SALEM 2	W	PWR	4-loop	1106	05/20/81	O				
SAN ONOFRE 1	W	PWR	3-loop	436	03/27/67	O				
SEABROOK	W	PWR	4-loop	1150	10/17/86	O	Y	Y		
SEQUOYAH 1	W	PWR	4-loop	1148	09/17/80	O	Y		Y	
SEQUOYAH 2	W	PWR	4-loop	1148	09/15/81	O	Y			
SHEARON HARRIS	W	PWR	3-loop	860	01/12/87	O	Y	Y		
SOUTH TEXAS PROJECT 1	W	PWR	4-loop	1250	03/22/88	O		Y		
SOUTH TEXAS PROJECT 2	W	PWR	4-loop	1250	12/16/88	O		Y		
SUMMER	W	PWR	3-loop	885	11/12/82	O				
SURRY 1	W	PWR	3-loop	781	05/25/72	O	Y		Y	
SURRY 2	W	PWR	3-loop	781	01/29/73	O	Y			
TROJAN	W	PWR	4-loop	1095	11/21/75	O		Y		
TURKEY POINT 3	W	PWR	3-loop	666	07/19/72	O				
TURKEY POINT 4	W	PWR	3-loop	666	04/10/73	O				
VOGTLE 1	W	PWR	4-loop	1079	03/16/87	O		Y		
VOGTLE 2	W	PWR	4-loop	1079	/ /	O		Y		
WATTS BAR 1	W	PWR	4-loop	1165	/ /	S	Y			
WATTS BAR 2	W	PWR	4-loop	1165	/ /	S	Y			
WOLF CREEK	W	PWR	4-loop	1128	06/04/85	O		Y		
YANKEE-ROWE	W	PWR	4-loop	167	07/19/60	C		Y		
ZION 1	W	PWR	4-loop	1040	10/19/73	O	Y	Y		
ZION 2	W	PWR	4-loop	1040	11/14/73	O	Y	Y		

*O = Operating
C = Closed
S = Shutdown

APPENDIX B

REVIEW OF THE ACCIDENT SEQUENCE PRECURSOR PROGRAM PUBLISHED REPORTS FOR SERVICE WATER RELATED EVENTS

Appendix B
Review of the Accident Sequence Precursor Program Published Reports for Service Water Related Events

The Accident Sequence Precursor Program at Oak Ridge National Laboratory reviews Licensee Event Reports (LERs) of operational events that have occurred at LWRs to identify and categorize precursors to potential severe core-damage accidents. Accident sequences considered in this program are those associated with inadequate core cooling. As a result of this work, a series of status reports have been published that describe the those events that have occurred. This appendix documents the review of these published reports for service water related events.

J. W. Minarick, C. A. Kukielka, Precursors to Potential Severe Core Damage Accidents: 1969-1979, A Status Report, NUREG/CR-2497, ORNL/NSIC-182, Volume 1, June 1982.

This report describes 1969 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1969 through 1979 that are considered to be precursors to potential severe core damage. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 169 precursors identified in this report, one involves the service water system (LER 321/80-103). At Hatch 1, both divisions I and II service water strainers plugged, thus reducing the plant service water to the turbine and Reactor building. The strainer drive motors had failed. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 9.1E-04.

W. B. Cottrell, J. W. Minarick, P. N. Austin, E. W. Hagen, J. D. Harris, Precursors to Potential Severe Core Damage Accidents: 1980-1981, A Status Report, NUREG/CR-3591, ORNL/NSIC-217, Volumes 1 and 2, July 1984.

This report describes 58 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1980 and 1981 that are considered to be precursors to potential severe core damage. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 58 precursors identified in this report, six involve the service water or component cooling water systems. They are as follows:

1. *Total loss of saltwater cooling (SWC) system at San Onofre 1 (LER 206/80-006).* All three SWC trains failed. The screen wash pumps were manually started and manually aligned to discharge to the bottom component cooling water heat exchanger, which established CCW cooling. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.6E-05.

2. *CCW loss to reactor coolant pump (RCP) seals, loss of RCPs and top head bubble incident at St. Lucie 1 (LER 335/80-029).* A short induced closure of the containment isolation valves in the CCW system caused loss of CCW cooling to all RCPs. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.1E-03.

3. *Failure of service water system plus subsequent auxiliary feedwater system unavailability at Calvert Cliffs 1 (LER 317/80-027).* Complete failure of an instrument air compressor aftercooler tubes allowed compressed air to enter the SWS. Both SW pumps lost suction. The plant was manually tripped. Due to a valve realignment error during shutdown, the auxiliary feedwater system was also unavailable. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 7.0E-05.

4. *Component cooling water inoperable at Pilgrim 1 (LER 293/80-070).* Loop B of the reactor building closed cooling water system (RBCCWS) was unavailable due to maintenance when a 480 V breaker tripped disabling Loop A. Loop A was immediately restored. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 4.2E-09.

5. *Loss of service water cooling to the diesel generators at Salem 1 (LER 272/80-060).* With the reactor in cold shutdown, service water header train 11SW was out of service for repairs. The diesels were found to be overheating. Train 12SW flow valve was found to be indicating open when it was actually closed, resulting in loss of all SW to the DGs. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.4E-07.

6. *Unavailability of diesel generator and component cooling water at Kewaunee (LER 305/81-033).* With the reactor at full power, the 1B diesel generator was removed from service for maintenance. The 1A component cooling water heat exchanger was isolated and the supply MOV breaker opened. This resulted in unavailability of both component cooling water trains in the event of a LOOP. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.1E-08.

J. W. Minatick, J. D. Harris, P. N. Austin, J. W. Cletcher, E. W. Hagen, <u>Precursors to Potential Severe Core Damage Accidents: 1984, A Status Report</u>, NUREG/CR-4674, ORNL/NOAC-232, Volumes 3 and 4, May 1987.

This report describes 48 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1984 that are considered to be precursors to potential severe core damage. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 48 precursors identified in this report, two involve the component cooling water (CCW) system. They are as follows:

1. *All HPSI pumps unavailable at San Onofre 3 (LER 362/84-035).* Train B CCW heat exchanger was removed from service for cleaning. Train B ESF components cooled by CCW, including the Train B HPSI pump, were therefore inoperable. Later the Train A HPSI bypass valves were opened in accordance with the approved surveillance procedure for conducting Train A subgroup relay testing. Opening the Train A HPSI bypass valves rendered Train A HPSI inoperable. The loss of both trains of HPSI while operating at 100% power constitutes operation outside Limiting Condition for Operation. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.5E-07.

2. *Component cooling water isolated from charging pumps at Surry 1 (LER 280/84-011).* Charging/SI pump CCW was found isolated from the intermediate seal cooler 1-SW-E-1B and SW was isolated from the intermediate seal cooler 1-SW-E-1A. This alignment isolated the charging system's intended heat sink. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.1E-05.

J. W. Minarick, J. D. Harris, P. N. Austin, J. W. Cletcher, E. W. Hagen, <u>Precursors to Potential Severe Core Damage Accidents: 1985, A Status Report</u>, NUREG/CR-4674, ORNL/NOAC-232, Volumes 1 and 2, December 1986.

This report describes 63 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1985 that are considered to be precursors to potential core damage. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 63 precursors identified in this report, three involved service water or component cooling water. They are the following:

1. *Component cooling water (CCW) system unavailable at Salem 2 (LER 311/85-018).* While one CCW heat exchanger was unavailable due to maintenance, the outlet valve for the redundant CCW heat exchanger transferred closed. Attempts to manually open the valve failed. Plant was shutdown to hot standby. The CCW heat exchanger that was undergoing maintenance was restored to an operable status and the shutdown was terminated. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 7.1E-06.

2. *Loss of circulating water and nonsafety service water due to expansion joint failure at LaSalle 1 (LER 373/85-045).* Flooding caused by failure of the 1B circulating water pump discharge valve expansion joint rendered the circulation water

pumps and plant service water pumps unavailable. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 7.18E-05.

3. *Potential simultaneous emergency service water (ESW) and RCIC unavailabilities at Susquehanna 2 (LERs 388/85-014, 015).* One ESW system train failed in testing. Three days prior, the RCIC system inboard steam isolation valve had failed. RCIC and the ESW system train could have failed at the same time. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 7.29E-08.

J. W. Minarick, J. D. Harris, P. N. Austin, J. W. Cletcher, E. W. Hagen, Precursors to Potential Severe Core Damage Accidents: 1986, A Status Report, NUREG/CR-4674, Volumes 5 and 6, May 1988.

This report describes 34 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1986 that are considered to be precursors to potential severe core damage. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 34 precursors identified in this report, two involve the service water and component cooling water system. They are as follows:

1. *Charging pump service water pumps are unavailable at Surry 1 (LER 280/86-029).* All service water flow to the charging pump service water subsystem was lost because the pump became air bound. This abnormal condition affected the heat sink for the charging pump lubrication air coolers and the intermediate heat sink for the charging pump mechanical seals.

   Maintenance activities on Service Water Pump A resulted in actuation of a smoke detector, which automatically closed a service water fire isolation valve. Due to a leak on a strainer blowdown line in the service water supply line, the valve closure allowed air in-leakage, which caused Service Water Pump B to become air bound. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 1.0E-08.

2. *Saltwater and CCW systems are unavailable at San Onofre 3 (LER 362/86-011).* Saltwater cooling flow through the train A CCW heat exchanger decreased as a result of fouling with marine growth. The flow rate was below the design basis flow rate required for removal of CCW heat loads, and therefore the heat exchanger was declared inoperable. At the same time, train B was operating with reverse salt water cooling flow to remove similar fouling. Both trains of the saltwater cooling system were considered inoperable until realignment was complete. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 2.6E-07.

J. W. Minarick, J. D. Harris, J. W. Cletcher, P. N. Austin, A. A. Blake, Precursors to Potential Severe Core Damage Accidents: 1987, A Status Report, NUREG/CR-4674, Volumes 7 and 8, July 1989.

This report describes 48 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1987 that are considered to be precursors to potential severe core damage. Each of these events has a conditional probability of subsequent severe core damage of 1.0E-06 or higher. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 48 precursors identified in this report, one involves the service water system.

1. *Trip with service water train and PORVs unavailable at McGuire 2 (LER 370/87-016, -017).* Service water train 2A was taken out of service for cleaning after a test where it failed to provide adequate circulation to the train 2A CCW 2A heat exchanger, containment spray heat exchanger, and RHR pump air handling unit.

   During this period, the reactor tripped, and the precursor power-operated relief valves (PORVs) failed to open on high pressure due to loss of power to the PORVs. All SG PORVs opened and closed late. After recovery from the trip, the unit was placed in hot standby.

   The trip required that the solid state protection system train 2B be tested prior to returning to power. Operations supervision permitted the test even though it would render both SW trains inoperable. The conditional probability of subsequent severe core damage given the failures observed in this event was estimated to be 70E-06.

J. W. Minarick, J. W. Cletcher, A. A. Blake, Precursors to Potential Severe Core Damage Accidents: 1988, A Status Report, NUREG/CR-4674, Volumes 9 and 10, February 1990.

This report describes 32 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1988 that are considered to be precursors to potential severe core damage. Each of these events has a conditional probability of subsequent severe core damage of 1.0E-06 or higher. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 32 precursors identified in this report, three involve service water or cooling water. They are as follows:

1. *Potential loss of service water pumps at Palisades (LER 255/88-021).* Spurious service water pump trips led to the discovery of incorrectly set relays that could have resulted in a loss of service water during high heat load situations. The conditional probability of severe core damage estimated for this event is 2.7E-05.

2. *Potential for AFW and CCW pump failure to autostart during LOOP due to anti-pump breaker design deficiency at Zion 1 (LER/88-019).* The auxiliary feedwater (AFW) pumps (motor driven only) and component cooling water (CCW) pumps might not start during a loss of offsite power, and the service water pumps would lock out in the case of a "degraded grid voltage" condition. A design deficiency of the anti-pump feature of the AFW and CCW breaker control circuits would lock out the breakers in the "tripped" condition if an actual LOOP occurred. The conditional probability of severe core damage estimated for this event is 1.0E-04.

3. *Component cooling valves drift closed on loss of air at Davis Besse (LER 346/88-007 R1).* During maintenance, it was discovered that a prolonged loss of instrument air would cause three service water valves to close. This closure resulted in isolation of service water to the component cooling water heat exchangers, which faults the heat removal capability of this system. The conditional probability of severe core damage estimated for this event is 1.6E-06.

This report also listed 28 potentially significant events that were impractical to analyze. These events are believed capable of significantly impacting core damage sequences. However, they involve component degradations where the extent of the degradation could not be determined or where the impact of the degradation on plant response could not be ascertained. There were two service water events in this list. They are as follows:

1. *Both emergency chilled water system (ECWS) trains inoperable at San Onofre (LER 361/88-010 R1).* The ECWS was unavailable for approximately four days as a result of low freon level in the system chillers, combined with low CCW temperature which caused the chillers to trip when starting. Loss of the ECWS could result in the unavailability of emergency room cooling for the high and low pressure injection and containment spray pumps.

2. *Postulated fire can result in loss of service water at Farley 1 and 2 (LER 348-88-018 R1).* After an evaluation, it was determined that a fire in a single fire area could cause the loss of both trains of the service water system in the plant. The fire could result in damage to circuitry for two valves that allow recirculation of service water back to the service water pond.

J. W. Minarick, J. W. Cletcher, D. A. Copinger, B. W. Dolan, Precursors to Potential Severe Core Damage Accidents: 1989, A Status Report, NUREG/CR-4674, ORNL/NOAC-232, Volumes 11 and 12, August 1990.

This report describes 30 operational events, reported in Licensee Event Reports (LERs), which occurred at commercial light water reactors during 1989 that are considered to be precursors to potential severe core damage. Each of these events has a conditional probability of subsequent severe core damage of 1.0E-06 or higher. These are described along with associated significance estimates, categorization, and subsequent analyses.

Of the 30 precursors identified in this report, one involves service water. At Arkansas Nuclear One, Unit 1 (LER 313/89-028), an unknown contact was discovered in the control circuits for two of the three service water pumps.

In situations involving a safety actuation signal[1] without previous main generator lockout (spurious safety actuation signal or large break LOCA), this contact would prevent service water pump restart. The conditional core damage probability was estimated at 2.8E-04.

This report also listed twenty seven potential significant events that were impractical to analyze. These events are believed capable of significantly impacting core damage sequences. However, they involve component degradations where the extent of the degradation could not be determined or where the impact of the degradation on plant response could not be ascertained. There were five service water events in this list. They are as follows:

1. *Emergency service water and high pressure service water systems may not function correctly at Peach Bottom 2 (LER 277/89-002).* Instrumentation and control problems resulted in unacceptable test performance under low flow conditions.

2. *Potential for pipe rupture in nonsafety service water system to fail both safety-related service water trains at Calvert Cliffs 1 (LER 317/89-023 R1).* Rupture of service water piping in the turbine building could rapidly drain both safety-related service water subsystems supplying the auxiliary building.

3. *Break in nonsafety circulation water line would render service water pumps inoperable at Davis-Besse 1 (LER 346/89-004).* A flood path was identified between the condenser pit and the service water tunnel. Flooding in the condenser pit area could propagate to the service water pump area and cause the loss of all service water pumps.

4. *Potential for service water and emergency core cooling system (ECCS) pump room flooding at Nine Mile Point 2 (LER 410/89-002).* Floods from turbine building could propagate to service water and ECCS pump rooms.

5. *Service water leak flooded auxiliary building at River Bend (LER 458/89-020)* A freeze plug failed in a standby service water line in the auxiliary building. About 15,000 gallons of water were released, which impaired various electrical control and power systems.

APPENDIX C

SERVICE WATER SYSTEM

DATA SHEETS

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1.0 INTRODUCTION

The cooling water systems (e.g., service water, component cooling water, salt water, etc.) of eleven nuclear power plants for which a NRC Probabilistic Risk Assessment (PRA) was available were reviewed to obtained some basic information on the fundamental safety function each is required to perform following an accident. Table C.1 lists the plants reviewed and each plant's respective cooling water system.

System summary data sheets were filled out for each system considered and are contained herein. The information contained in this appendix was obtained from each plant's respective NRC sponsored PRA as well as NRC-sponsored system source books where available. Note that the systems reviewed are those systems that were modeled in the PRA reviewed.

Table C.1

Plants Reviewed

Plant	Cooling Water system Reviewed
Cooper Nuclear Station	Service Water System Reactor Building Closed Cooling Water System
Quad Cities	Residual Heat Removal Service Water System Diesel Generator Cooling Water system
Peach Bottom	Emergency Service Water system High Pressure Service Water System
Grand Gulf	Standby Service Water System
St. Lucie	Component Cooling Water System Intake Cooling Water System
Calvert Cliff	Salt Water System Component Cooling Water System Service Water System
ANO-1	Service Water System
Point Beach	Service Water System Component Cooling Water System
Turkey Point	Service Water System Component Cooling Water System
Surry	Service Water System Component Cooling Water System
Sequoyah	Service Water System Component Cooling Water System

2.0 COOPER NUCLEAR STATION COOLING WATER SYSTEM SUMMARIES

PLANT: COOPER TYPE: BWR VINTAGE: OLD NO. UNITS: 1

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: RIVER

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4767 TAP A-45

SUCCESS CRITERIA:

Any one of four SWS pumps is assumed to supply sufficient cooling water flow during an accident when the non-critical header has been isolated.

If the non-critical header does not isolate, TAP A-45 assumed that all four SWS pumps are required for success. See Figure C.1.

CROSS-TIES:

Four SW pumps discharge to a common header from which independent piping supplies to safety related cooling water loops and the Turbine Building Closed Cooling Water (TBCCW) heat exchangers which are not safety-related.

SYSTEM VULNERABILITIES:

Failure of non-critical header to isolate (i.e., MOV-MO117 to close) following an accident thereby diverting flow away from safety-related loads.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Manually close non-critical supply MOV (MOV117).

PLANT: COOPER TYPE: BWR VINTAGE: OLD NO. UNITS: 1

SYSTEM: RBCCW OPEN OR CLOSED LOOP: CLOSED SOURCE: N/A

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4767 TAP A-45

SUCCESS CRITERIA:

Following a design basis accident, the following success criteria applies:

- One-out-of-four RBCCW operate successfully,
- Non-critical header isolates,
- The appropriate RBCCW heat exchanger is available, and
- The appropriate train of the service water system is successful.

Note that the service water system is a redundant cooling water source for most of the components served by the RBCCW system, therefore the SW system can perform the same functions as the RBCCW system.

TAP A-45 assumed that if the non-critical header did not isolate, four RBCCW pumps were required for success. See Figure C.2.

CROSS-TIES:

The service water system can be manually connected to supply most of the loads served by the RBCCW system. Since RBCCW success is dependent on SW success, the RBCCW pumps and heat exchangers can be unnecessary under emergency conditions.

SYSTEM VULNERABILITIES:

If the non-critical h r fails to isolate during an accident then some flow will be diverted away from safety-related loads. P A-45 assumed that if the non-critical header fails to isolate, four RBCCW pumps are required uccess.

Failure of RBCCW supply MOVs to ECCS room coolers and pump coolers to open following an accident.

The RBCCW consists of two cross-tied supply headers. Each header is supplied with a normally closed MOV. Common-mode failure of these two valves to open fails RBCCW.

POTENTIAL SYSTEM RECOVERY ACTIONS:

TAP A-45 recovery actions considered:

- Manually isolate non-critical header MOV (MOV700).

- Recovery of the RBCCW system by manually opening connections to the SWS and use the SWS pumps to cool the RBCCW loads.

One combination of failures identified in the analysis involved loss of secondary cooling to the RBCCW heat exchanger 1A and failure of RBCCW valve 714 to open. Based on the RBCCW flowpath arrangement, water from heat exchanger 1B could be routed through valve 711 to the safety loads if heat exchanger 1A is isolated. Isolation of heat exchanger 1A requires closure of MOV 7[illegible] and manual valve 18.

BIBLIOGRAPHY:

1. Steven W. Hatch, et al., Shutdown Decay Heat Removal Analysis of a General Electric BWR4/Mark 1 Case Study, NUREG/CR-4767, SAND86-2419, July 1987.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook Cooper 50-298, SAIC 88/1994.

PLANT: COOPER TYPE: BWR VINTAGE: OLD NO. UNITS: 1

SYSTEM: RHRSW OPEN OR CLOSED LOOP: OPEN SOURCE: SWS

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4776 TAP A-45

SUCCESS CRITERIA:

For RHRSW to be successful:

- One pump per RHRSW train must be available to supply the RHR loop HX selected for CSS, SPC, or SDC.
- SW must be successful supplying the appropriate RHRSW pump train,
- The RHRHX placed in service for CSS, SPC, or SDC, RHRSW outlet MOV must open.

See Figure C.1.

CROSS-TIES:

The two RHRSW headers are cross-tied with normally Locked Closed manual valves.

SYSTEM VULNERABILITIES:

The RHRHX service water outlet MOV, for the selected HX, must open for RHRSW success. Failure defeats one loop of RHR for SPC, SDC, and CSS.

RHRSW is supplied by the SW system. Failure of the SW system defeats RHRSW.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Manually open RHRHX RHRSW outlet MOV.

Open cross-tie manual valves to feed failed RHRSW train.

REFERENCES:

1. Steven W. Hatch, et al., Shutdown Decay Heat Removal Analysis of a General Electric BWR4/Mark 1 Case Study, NUREG/CR-4767, SAND86-2419, July 1987.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook Cooper 50-298, SAIC 88/1994.

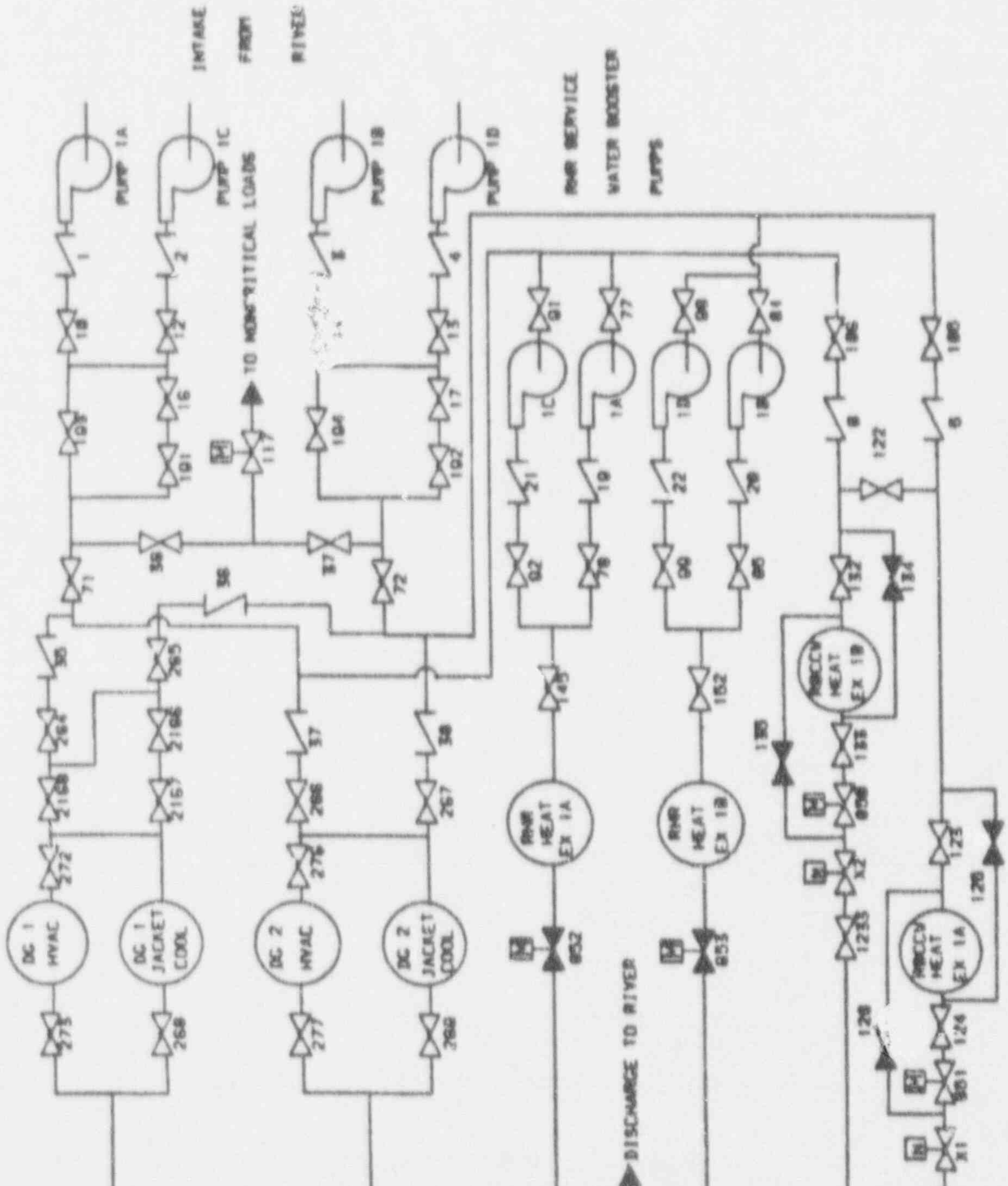

Figure C.1 Cooper Nuclear Station Service Water System

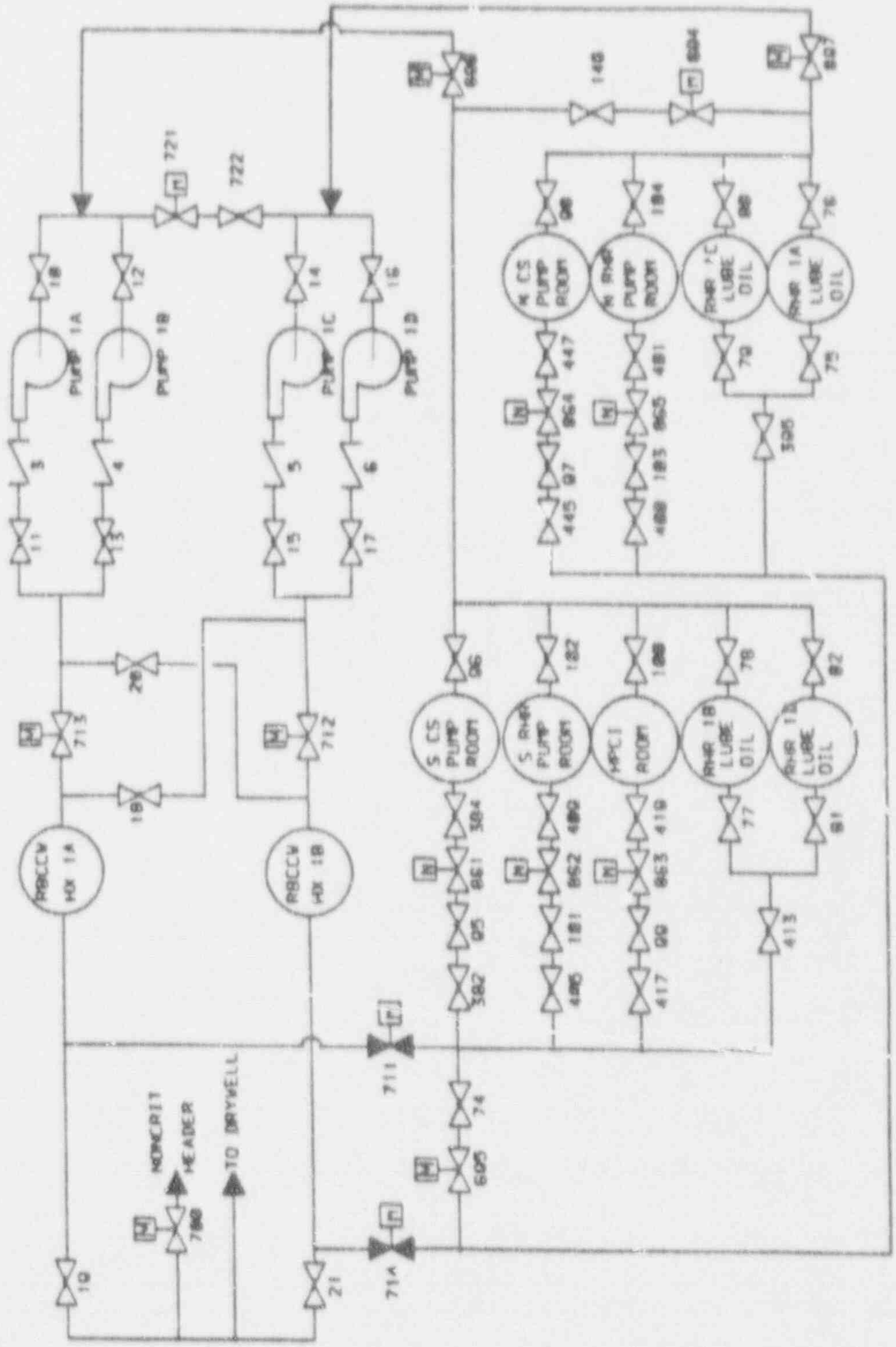

Figure C.2 Cooper Nuclear Station Reactor Building Closed Cooling Water System

3.0 QUAD CITIES NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: QUAD CITIES TYPE: BWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: RHRSW OPEN OR CLOSED LOOP: OPEN SOURCE: RIVER

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4448 TAP A-45

SUCCESS CRITERIA:

The Residual Head Removal Service Water (RHRSW) System success criteria is one pump taking suction from the crib house and supplying cooling water to the RHR heat exchanger in the RHR loop aligned for containment spray, suppression pool cooling, or shutdown cooling. See Figure C.3.

CROSS-TIES:

The RHR service water pump trains are not cross-tied.

SYSTEM VULNERABILITIES:

Failure of RHRHX RHRSW outlet MOV to open in the selected loop will fail HX cooling, thus failing one loop of RHR for CSS, SDC, and SPC.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Recovery actions incorporated in the TAP A-45 study included:

- recovery of pump common mode failure within four hours.
- recovery of pump common mode failure within 24 hours.

BIBLIOGRAPHY:

1. S. W. Hatch, et al., Shutdown Decay Heat Removal Analysis of a General Electric BWR3/Mark 1 Case Study, NUREG/CR-4448, SAND85-2373, March 1987.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook Quad Cities 1 and 2 50-254 and 50-265, SAIC 89/1537.

PLANT: QUAD CITIES   TYPE: BWR   VINTAGE: OLD   NO. UNITS: 2

SYSTEM: DGCW   OPEN OR CLOSED LOOP: OPEN   SOURCE: RIVER

NUMBER OF TRAINS: 3   NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4448 TAP A-45

SUCCESS CRITERIA:

The success criteria for Diesel Generator Cooling Water (DGCW) System is that, for each operating diesel generator, the associated DGCW pump can provide adequate cooling water. See Figure C.4.

If emergency room cooling is necessary, the Unit 1 emergency room air coolers can be supplied with adequate room cooling by either, (a) DGCW train 1, (b) cross-tie to DGCW train 1/2, or (c) the low pressure service water system, if available.

Comparable options exists for Unit 2.

CROSS-TIES:

Units 1 and 2 Room cooling supply headers are each cross-tied to swing DG 1/2 cooling water header through a manual valve.

SYSTEM VULNERABILITIES:

Each of the three diesels has its own independent DGCW pump to provide jacket water and lube oil cooling. Therefore, single failures in the DGCW would defeat the diesel being cooled.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Recovery actions incorporated into the TAP A-45 analysis were:

- recovery of a system subtrain or component from a maintenance outage within 24 hours
- recovery of pump common mode failures within 24 hours
- recovery of pump common mode failures within 4 hours

BIBLIOGRAPHY:

1. S. W. Hatch, et al., Shutdown Decay Heat Removal Analysis of a General Electric BWR3/Mark 1 Case Study, NUREG/CR-4448, SAND85-2373, March 1987.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook Quad Cities 1 and 2 50-254 and 50-265, SAIC 89/1537.

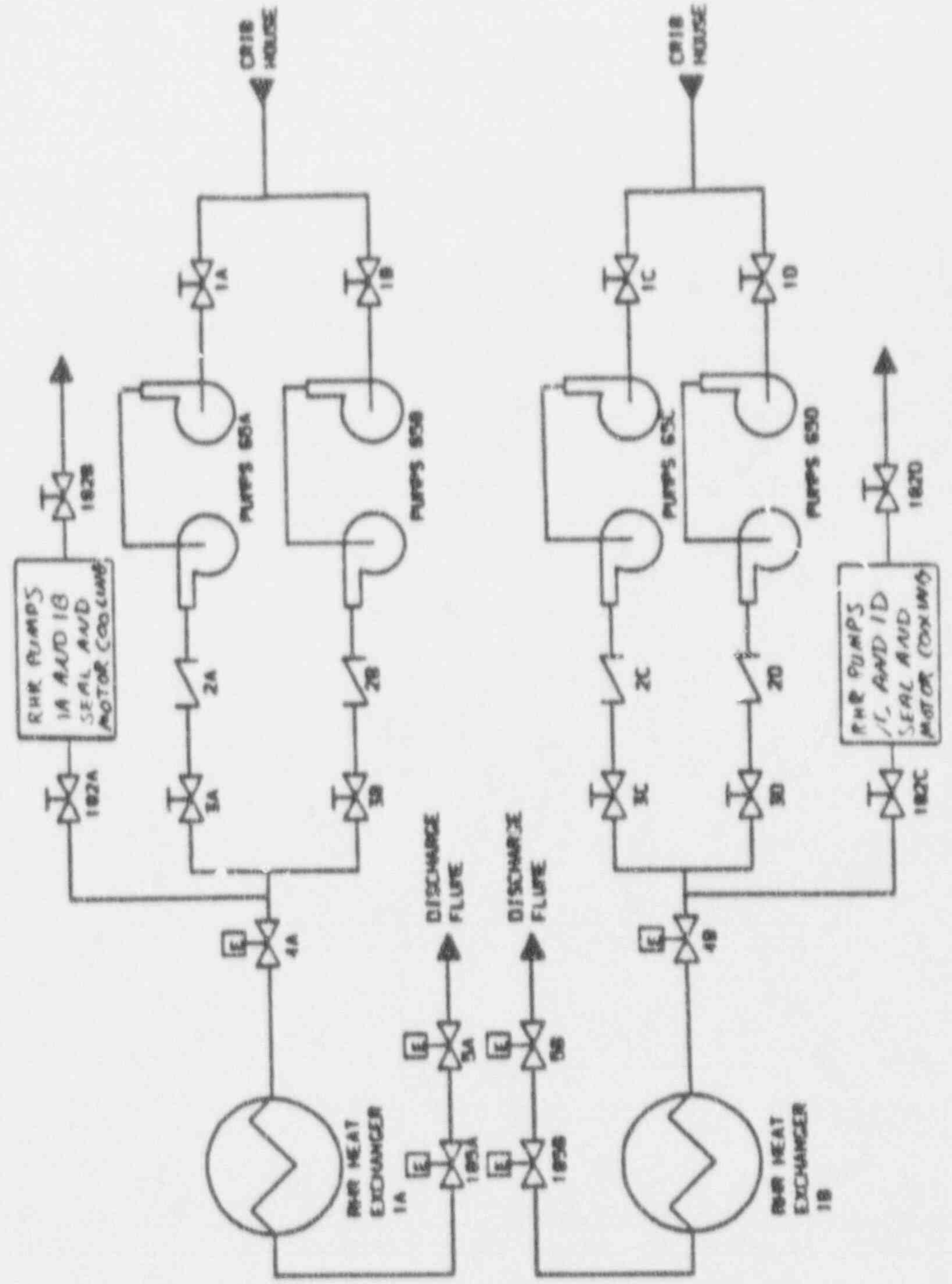

Figure C.3 Quad Cities Residual Heat Removal Service Water System

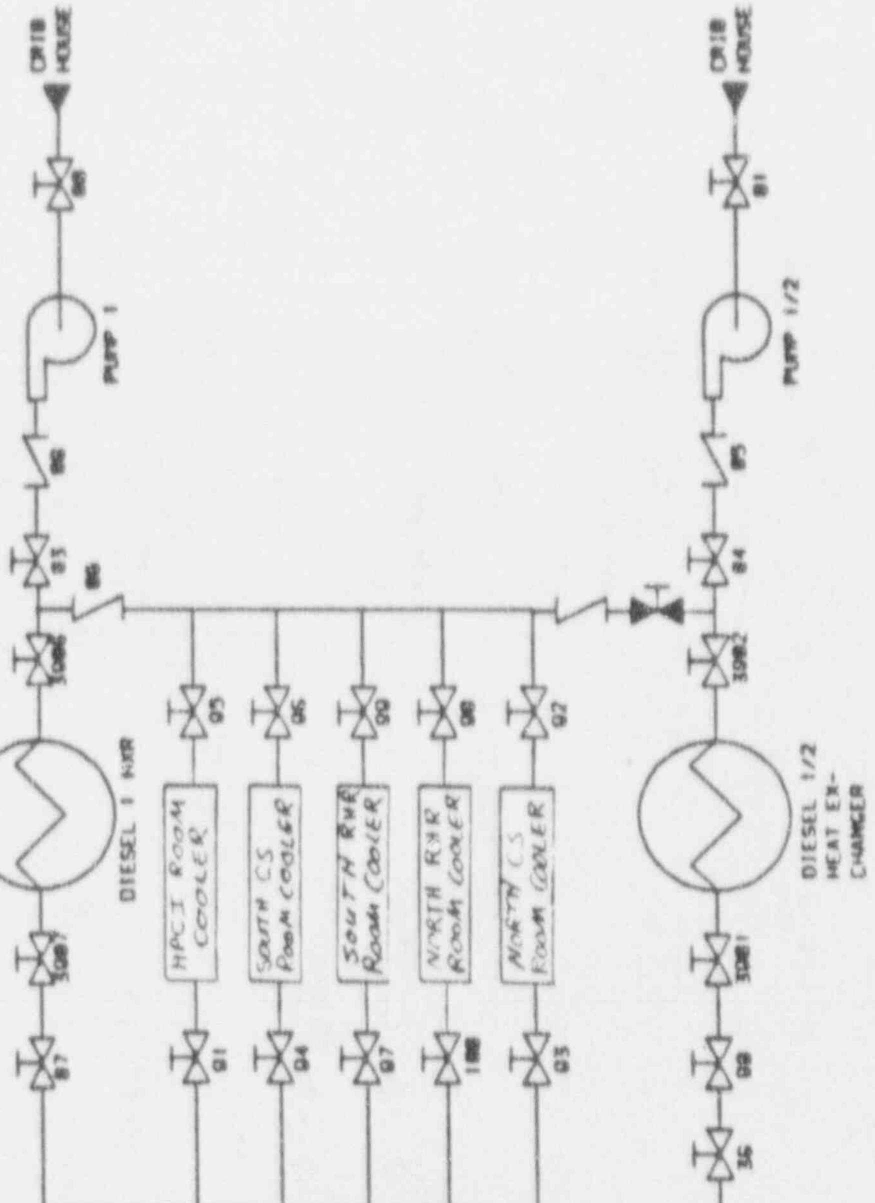

Figure C.4 Quad Cities Diesel Generator Cooling Water System

4.0 PEACH BOTTOM NUCLEAR STATION UNIT 2 COOLING WATER SYSTEM SUMMARIES

PLANT: PEACH BOTTOM UNIT 2 TYPE: BWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: ESW OPEN OR CLOSED LOOP: OPEN/CLOSED SOURCE: RIVER

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

System source book success criteria:

The Emergency Service Water (ESW) system can operate in either of two modes: open-loop or closed-loop. The success criteria for open-loop operation are 1 of 2 ESW pumps must operate and there must be an intact flow path from the pump to the heat loads. The success criteria for closed-loop operation are, (a) 1 of 2 ESW pumps or the emergency cooling water pump must operate, (b) 1 of 2 ESW booster pumps must operate, and (c) there must be an intact closed-loop flow path. If the main ESW pumps are used, the closed loop flow path includes the gravity feed line from the cooling tower reservoir back to the suction wells. If the emergency cooling pump is used, the closed-loop flow path includes the line from this pump to the two ESW supply headers.

NUREG/CR-1150 success criteria:

The success criteria for the ESW system is either of the ESW pumps or the ECW pump supplying cooling water to system heat loads.

See Figure C.5.

CROSS-TIES:

The ESW system consists of two pumps operating in parallel. Both pumps are cross-tied at their discharge through two manual valves.

The ESW is backed up by the emergency cooling water pump. To align the emergency cooling water pump, the normal ESW suction path is isolated by closing the sluice gates in the service water suction wells, the normal ESW discharge path is isolated by closing the MOV to the discharge pond, and an alternate flow path via the emergency cooling towers is established. One emergency cooling tower with one of three fans operating is needed to provide adequate cooling. The emergency cooling water pump takes suction from the emergency cooling tower reservoir and delivers water to the two ESW supply headers through a motor-operated valve. Units 2 and 3 share the ESW system.

SYSTEM VULNERABILITIES:

Dependency on the operator to initiate the emergency heat sink following loss of the ESW pumps.

Failure of the operating ESW pump due to back leakage of the standby ESW discharge check valve.

POTENTIAL SYSTEM RECOVERY ACTIONS:

The significant recovery action to consider is to align the emergency heat sink following loss of cooling water flow from the ESW pumps.

MISCELLANEOUS:

Pumps are self cooled. ESW room cooling was not modeled in 1150 analysis.

BIBLIOGRAPHY:

1. A. M. Kolaczkowski, et al, Analysis of Core Damage Frequency: Peach Bottom, Unit 2 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 4, Rev. 1, Part 1, August 1989.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook, Peach Bottom 2 and 3, 50-277 and 50-278, SAIC 89/1020.

PLANT: PEACH BOTTOM TYPE: BWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: HPSW OPEN OR CLOSED LOOP: OPEN SOURCE: RIVER

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

One High Pressure Service Water (HPSW) pump is required for each RHR heat exchanger that is in service. The HPSW pumps are normally aligned to specific RHR heat exchangers but all pump trains are cross-connected. See Figure C.6.

CROSS-TIES:

Both Units have two trains of HPSW with each train consisting of two pumps. The two trains are cross-connected through a motor-operated valve.

Units 2 and 3 HPSW systems are also cross-connected through manual valves.

SYSTEM VULNERABILITIES:

HPSW system failures do not appear in any of the 4550 analysis dominant cutsets.

The HPSW is susceptible to common mode failure of the RHR heat exchanger air operated valves, which have to open for HPSW success.

POTENTIAL SYSTEM RECOVERY ACTIONS:

The amount of redundancy provided in the HPSW system allows multiple opportunities for recovery of system component failures.

MISCELLANEOUS:

Room cooling not required per 4550 analysis.

BIBLIOGRAPHY:

1. A. M. Kolaczkowski, et al, Analysis of Core Damage Frequency: Peach Bottom, Unit 2 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 4, Rev. 1, Part 1, August 1989.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook, Peach Bottom 2 and 3, 50-277 and 50-278, SAIC 89/1020.

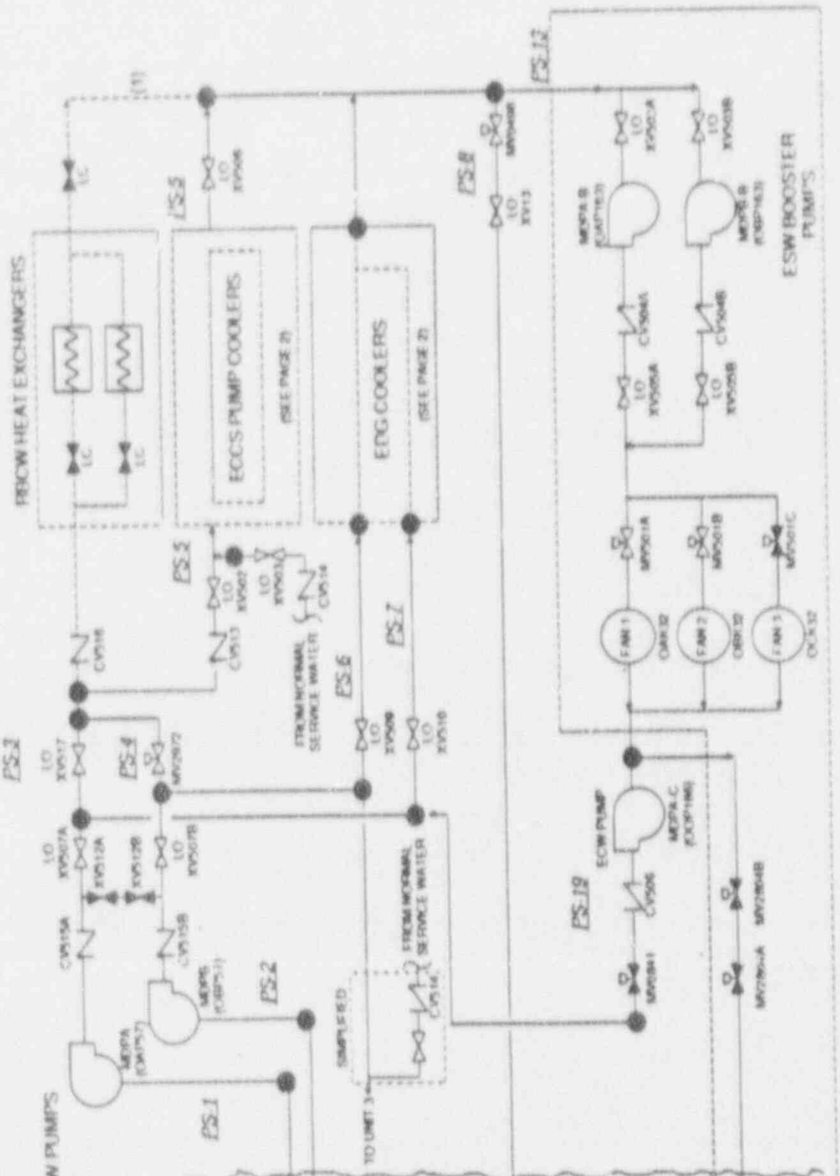

Figure C.5 Peach Bottom Emergency Service Water System (Page 1 of 2)

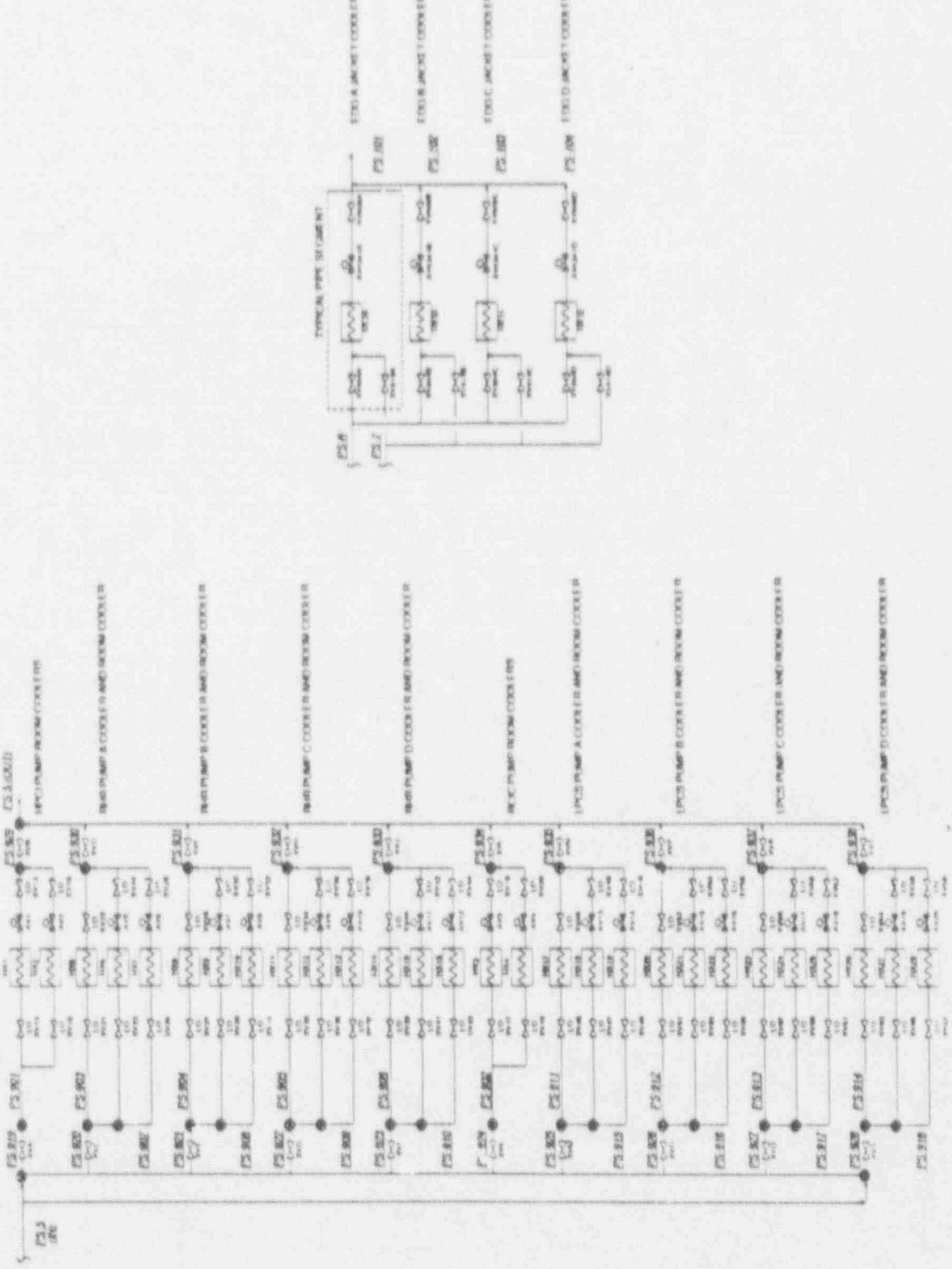

Figure C.5 Peach Bottom Emergency Service Water System (Page 2 of 2)

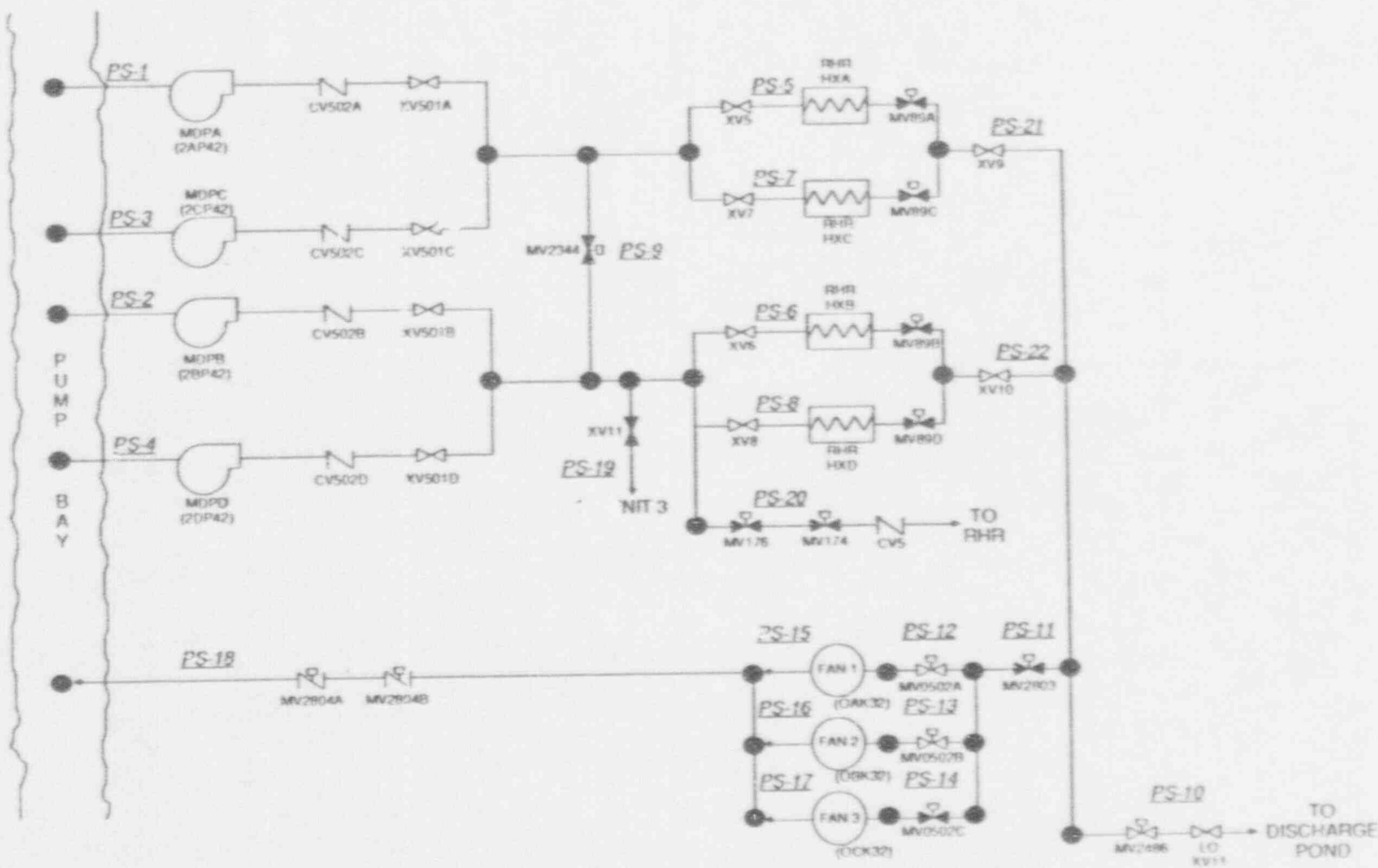

Figure C.6 Peach Bottom High Pressure Service Water System

5.0 GRAND GULF NUCLEAR STATION COOLING WATER SYSTEM SUMMARIES

PLANT: GRAND GULF TYPE: BWR VINTAGE: NEW NO. UNITS: 1

SYSTEM: SSWS OPEN OR CLOSED LOOP: CLOSED SOURCE: COOLING TOWER

NUMBER OF TRAINS: 3 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

The Standby Service Water System (SSWS) is made up of three separate trains. Therefore the success criteria for the SSWS is defined on a per train basis. For each train of SSWS, the SSWS pump must operate, the intertie between the SSWS and the Plant Service Water System (PSWS) must isolate (PSWS is the normal cooling water source for ESF room coolers), and the flow path to the various heat loads must be open. See Figure C.7.

CROSS-TIES:

SSWS Trains A and B can be cross-tied to each other. SSWS train C is dedicated to serving the heat loads associated with the HPCS, and can not be cross-tied to the other SSWS trains.

SYSTEM VULNERABILITIES:

Station blackout sequences dominate the core damage frequency in the 4550 analysis. The SSWS shows up as dominate contributor to the Grand Gulf CDF because the emergency diesel generators are dependent on the SSWS for jacket water cooling.

The dominate failure mode of SSWS is common mode failure of the SSWS pumps.

All other dominate cutsets which contain SSWS events are single SSWS failures coupled with diesel failures, e.g., SSWS pump A fails to start and DG 12 fails to run and DG 13 fails to start.

POTENTIAL SYSTEM RECOVERY ACTIONS:

No SSWS recovery actions were incorporated into the 4550 analysis.

BIBLIOGRAPHY:

1. M. T. Drouin, et al, Analysis of Core Damage Frequency: Grand Gulf, Unit 1 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 6, Rev. 1, Part 1, September 1989.

2. U. S. Nuclear Regulatory Commission, Nuclear Power Plant System Sourcebook Grand Gulf 1 50-416, SAIC 89/1007.

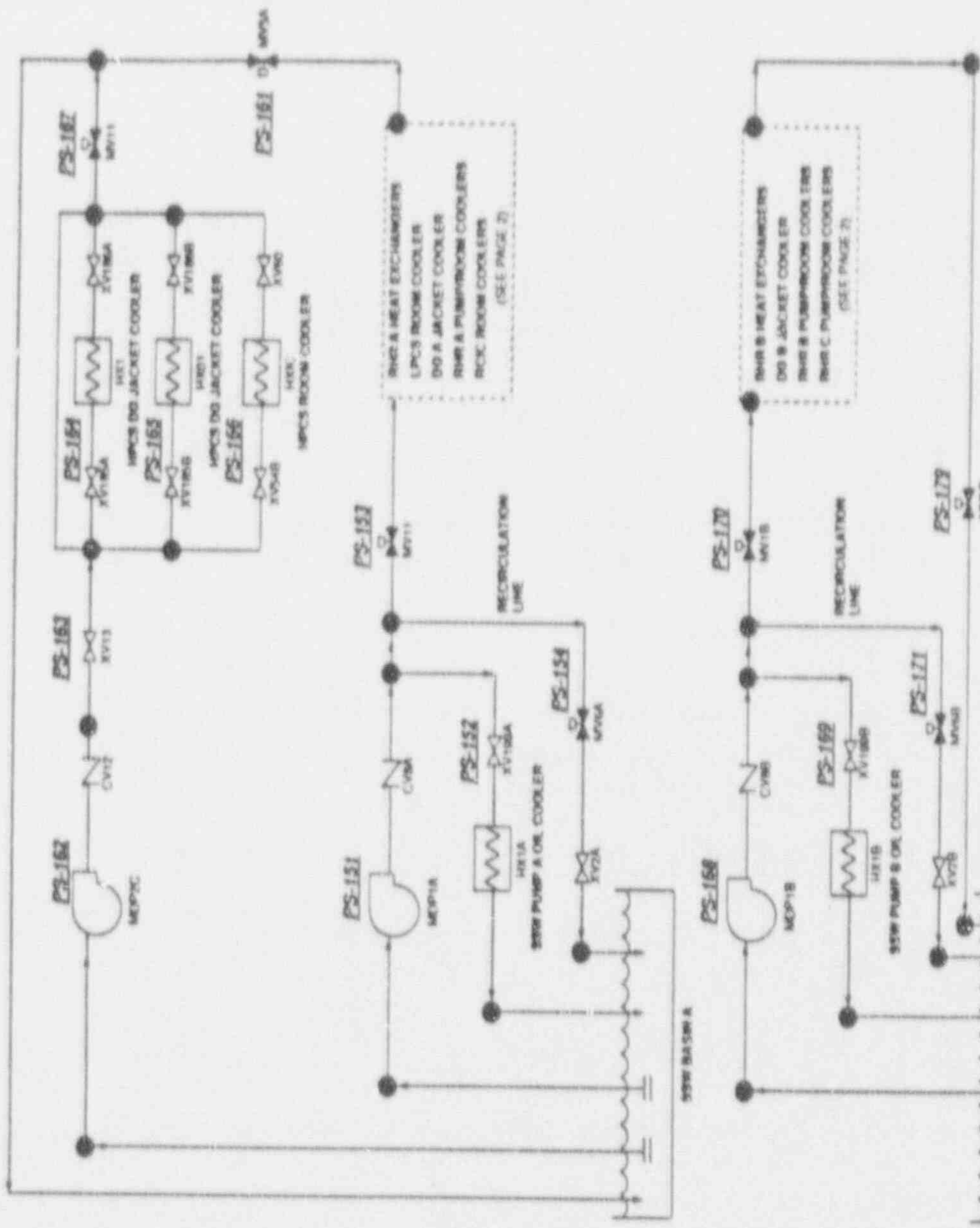

Figure C.7 Grand Gulf Standby Service Water System (Page 1 of 2)

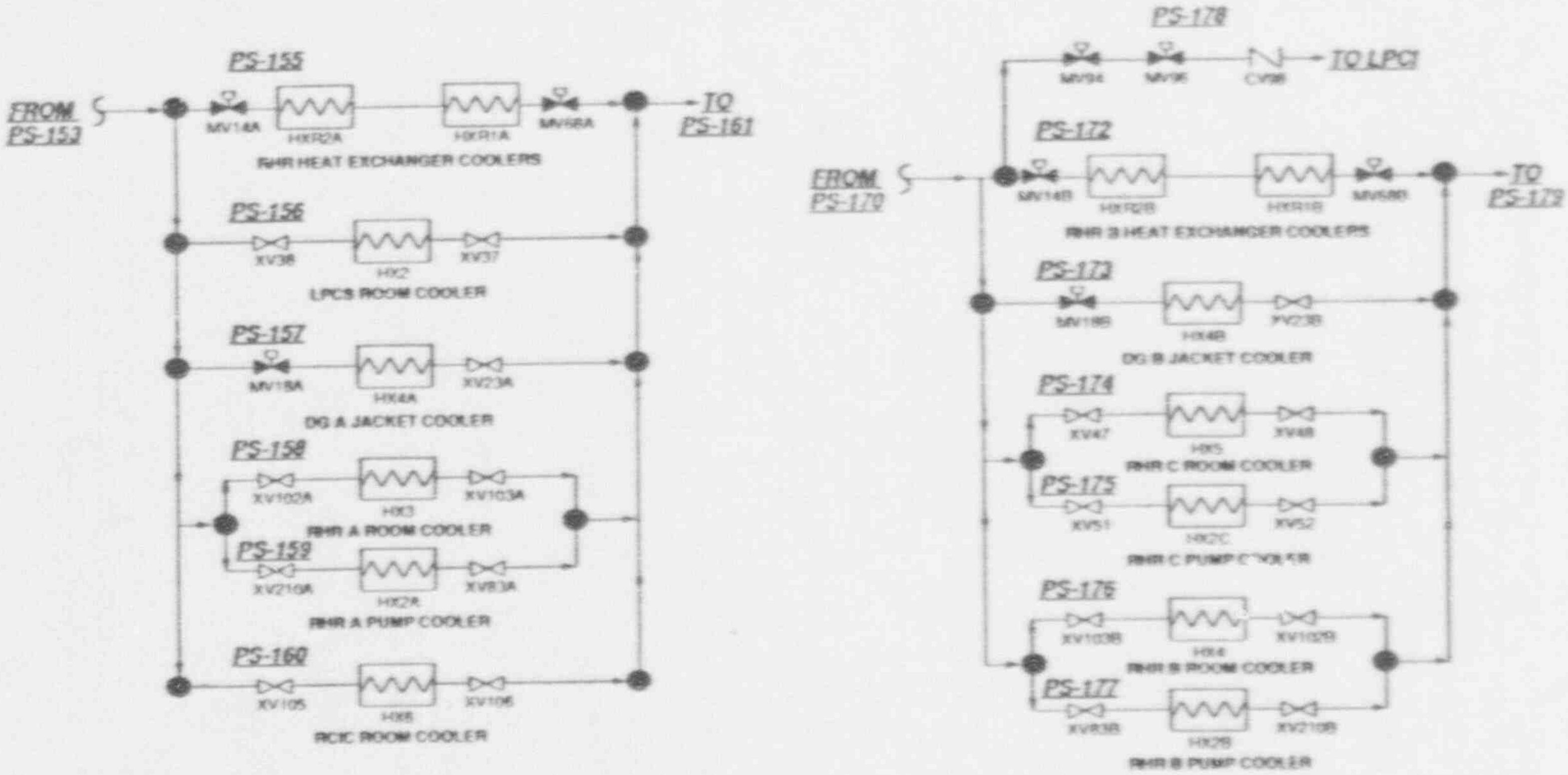

Figure C.7 Grand Gulf Standby Service Water System (Page 2 of 2)

6.0 St. LUCIE NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: St. LUCIE TYPE: PWR VINTAGE: NEW NO. UNITS: 2

SYSTEM: CCWS OPEN OR CLOSED LOOP: CLOSED SOURCE: SURGE TANK

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4710 TAP A-45

SUCCESS CRITERIA:

The success criteria is given on a per loop basis. The success criteria per loop is:

- 1 of 2 CCW pumps per loop must operate (i.e., 1A or 1C in loop A, 1B or 1C in loop B)
- The CCW heat exchanger must be available as a heat sink.

Note that pump 1C can only be aligned to one CCW Loop, A or B. See Figure C.8.

CROSS-TIES:

There are two CCW loops supplying separate loads. Each CCW cooling loop has one dedicated pump. A third pump is available to provide cooling water to either loop should one of these pumps fail.

SYSTEM VULNERABILITIES:

Common mode failure of the CCW pump would result in overheating of the HPI pumps and the LPI pumps and emergency core coolant injection failure after a small LOCA or transient induced LOCA. In addition, the containment spray injection pumps, fan coolers, and shutdown heat exchangers require CCW for successful operation.

No mention is made in TAP A-45 or the System Source Book as to whether the non-critical header supplied by CCW during normal operation is a diversion path should it fail to isolate following a SIAS.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Failure of one CCW pump can be recovered by starting the standby pump and aligning to the failed pumps discharge header.

MISCELLANEOUS:

The Unit 1 and Unit 2 CCWSs are independent systems.

BIBLIOGRAPHY:

1. W. R. Cramond, et al, Shutdown Decay Heat Removal Analysis of a Combustion Engineering 2-Loop Pressurized Water Reactor Case Study, NUREG/CR-4710, SAND86-1797, July 1987.

2. U. S. Nuclear Regulatory Commission. Nuclear Power Plant System Sourcebook, St. Lucie 1 and 2, 50-335 and 389, SAIC 89/1527.

PLANT: St. LUCIE   TYPE: PWR   VINTAGE: NEW   NO. UNITS: 2

SYSTEM: ICWS   OPEN OR CLOSED LOOP: OPEN   SOURCE: OCEAN

NUMBER OF TRAINS: 2   NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4710 TAP A-45

SUCCESS CRITERIA:

The success criteria for the Intake Cooling Water System (ICWS) is given on a per loop basis. The success criteria per loop is:

- 1 of 2 CCW pumps per loop must operate (i.e., 1A or 1C in loop A, 1B or 1C in loop B)
- The CCW heat exchanger must be available as a heat sink.

Note that pump 1C can only be aligned to one CCW loop, A or B. See Figure C.9.

CROSS-TIES:

There are two ICWS loops supplying separate loads. Each ICWS cooling loop has one dedicated pump. A third pump is available to provide cooling water to either loop should one of these pumps fail.

SYSTEM VULNERABILITIES:

Common mode failure of the ICWS pumps prevents adequate heat removal via the CCW heat exchangers. There is no mention in TAP A-45 or the System Source Book as to whether the non-critical header supplied by ICWS during normal operation is a diversion path should it fail to isolate following a SIAS.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Failure of either ICWS pump can be recovered by starting the standby pump and aligning to the failed pumps discharge header.

MISCELLANEOUS:

The Unit 1 and Unit 2 ICWS are independent systems.

BIBLIOGRAPHY:

1. W. R. Cramond, et al, Shutdown Decay Heat Removal Analysis of a Combustion Engineer[illegible] 2-Loop Pressurized Water Reactor Case Study, NUREG/CR-4710, SAND86-1797, Ju[illegible]

2. U. S. Nuclear Regulatory Commission. Nuclear Power Plant System Sourcebook, [illegible] and 2, 50-335 and 389, SAIC 89/1527.

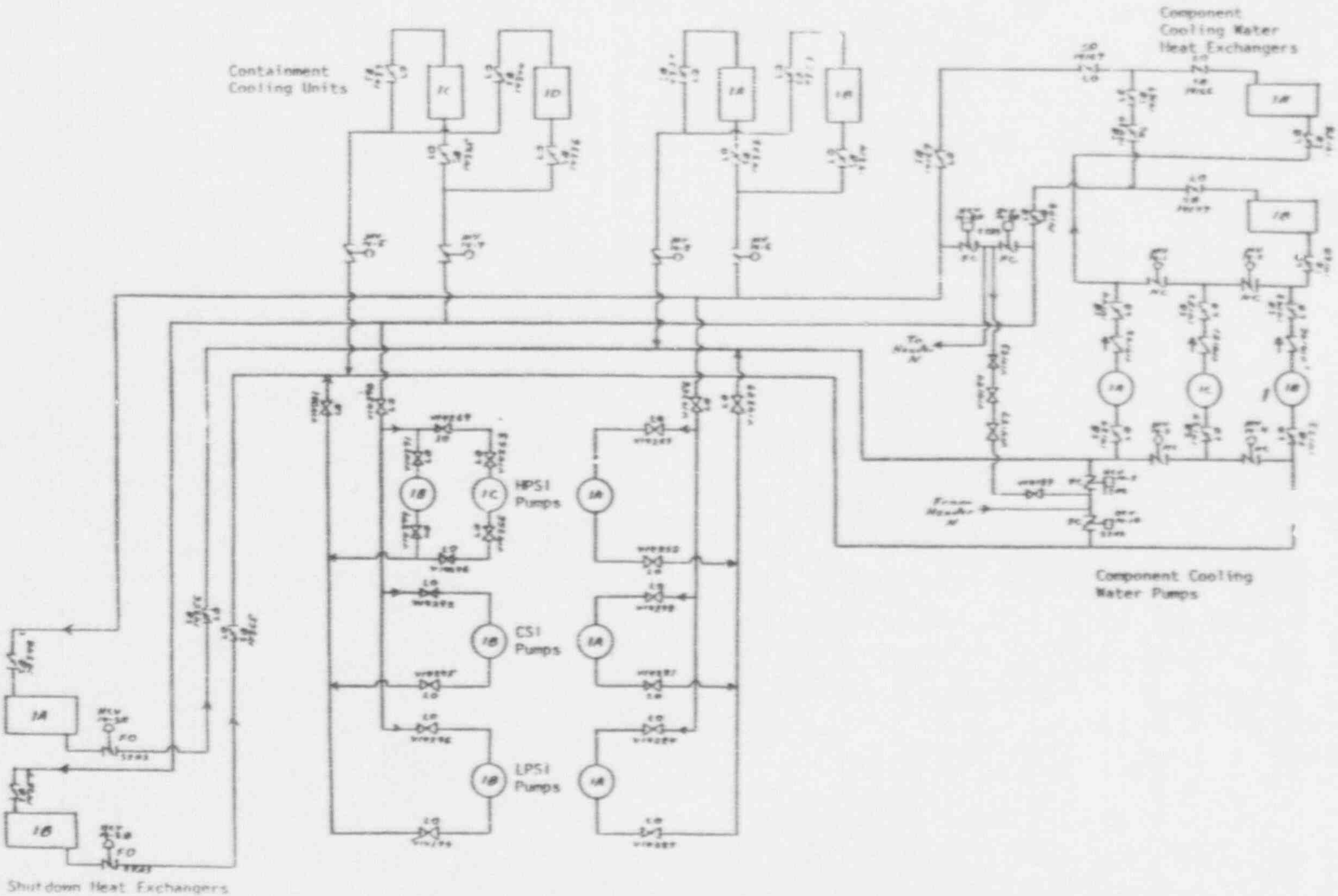

Figure C.8 St. Lucie Component Cooling Water System

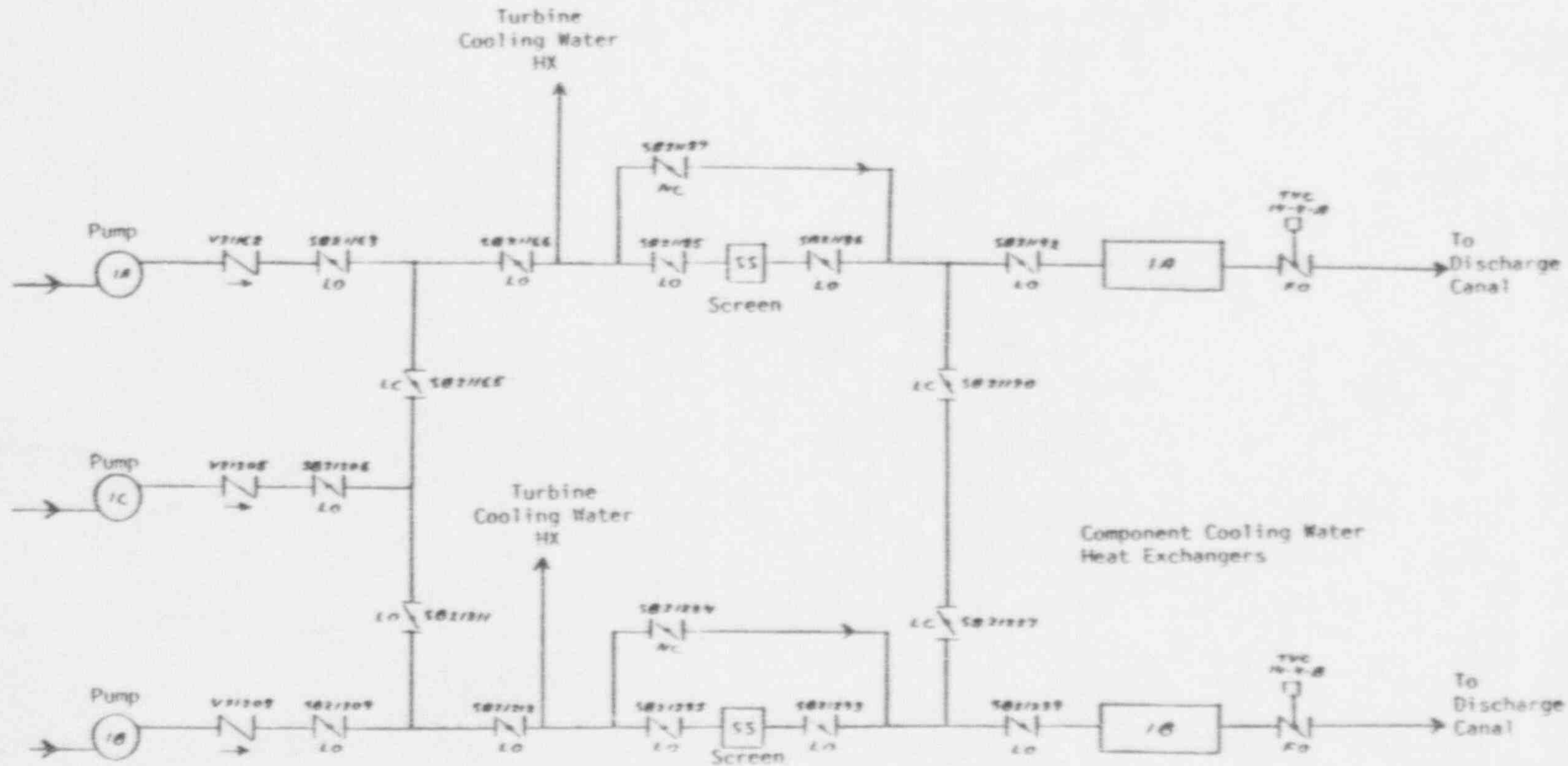

Figure C.9 St. Lucie Intake Cooling Water System

7.0 CALVERT CLIFFS NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: CALVERT CLIFFS TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: OCEAN

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-3511 IREP

SUCCESS CRITERIA:

The success criteria for the Salt Water System (SWS) is given on a per loop basis. The success criteria per loop is:

- 1 of 2 SWS pumps per loop must operate (i.e., pump 11 or 13 in loop 11, pump 12 or 13 in loop 12)
- The SWS heat exchanger must be available as a heat sink.

Note that pump 13 can only be aligned to one SWS loop, A or B. See Figure C.10.

CROSS-TIES:

There are two SWS loops supplying separate loads. Each SWS cooling loop has one dedicated pump. A third pump is available to provide cooling water to either loop should one of these pumps fail.

SYSTEM VULNERABILITIES:

The Calvert Cliff SWS is very similar to the St. Lucie ICWS and CCW systems. In the St. Lucie TAP A-45 study common mode failures of the cooling water pumps dominated cooling water system faults. However, in the Calvert Cliffs IREP analysis there appears to be no modeling of common mode failures which leaves in doubt the amount of contribution made by the SWS to the total CDF.

POTENTIAL SYSTEM RECOVERY ACTIONS:

The only recovery modeled in the PRA was failure of the operator to manually open SWS pneumatic valves following their failure to automatically open.

BIBLIOGRAPHY:

1. Arthur C. Payne, Jr., Interim Reliability Evaluation Program: Analysis of the Calvert Cliffs Unit 1 Nuclear Power Plant Volume 1, Main Report, NUREG/CR-3511/1 of 2, SAND83-2086/1 of 2, September 1983.

PLANT: CALVERT CLIFFS   TYPE: PWR   VINTAGE: OLD   NO. UNITS: 2

SYSTEM: CCWS   OPEN OR CLOSED LOOP: CLOSED   SOURCE: N/A

NUMBER OF TRAINS: 2   NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-3511 IREP

SUCCESS CRITERIA:

Success for the Component Cooling Water (CCW) System was considered to be one CCW pump and one CCW heat exchanger available to remove heat from the CCW loads during accident conditions. See Figure C.11.

CROSS-TIES:

Three CCW pumps discharge to a common header which feeds two separate cross-tied distribution headers.

SYSTEM VULNERABILITIES:

As with SWS, there was no common mode failure of the pumps considered in the analysis. This appears to be a significant oversight.

POTENTIAL SYSTEM RECOVERY ACTIONS:

No recovery modeled for CCW in IREP PRA.

BIBLIOGRAPHY:

1. Arthur C. Payne, Jr., Interim Reliability Evaluation Program: Analysis of the Calvert Cliffs Unit 1 Nuclear Power Plant Volume 1. Main Report, NUREG/CR-3511/1 of 2, SAND83-2086/1 of 2, September 1983.

PLANT: CALVERT CLIFFS TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: SRWS OPEN OR CLOSED LOOP: CLOSED SOURCE: N/A

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-3511 IREP

SUCCESS CRITERIA:

The success criteria for the Service Water System (SRWS) System is given on a subsystem basis. The success criteria is as follows:

- 1 of 2 SRWS pumps per loop must operate (i.e., pump 11 or 13 in loop 11, pump 12 or 13 in loop 12)
- The SWS heat exchanger must be available as a heat sink.

Note that pump 13 can only be aligned to one SWS loop, 11 or 12. See Figure C.12.

CROSS-TIES:

Three SRWS pumps discharge to a common header which feeds two separate cross-tied distribution headers.

SYSTEM VULNERABILITIES:

As with SWS, there was no common mode failure of the pumps considered in the analysis. This appears to be a significant oversight.

POTENTIAL SYSTEM RECOVERY ACTIONS:

No recovery modeled for CCW in IREP PRA.

BIBLIOGRAPHY:

1. Arthur C. Payne, Jr., Interim Reliability Evaluation Program: Analysis of the Calvert Cliffs Unit 1 Nuclear Power Plant Volume 1, Main Report, NUREG/CR-3511/1 of 2, SAND83-2086/1 of 2, September 1983.

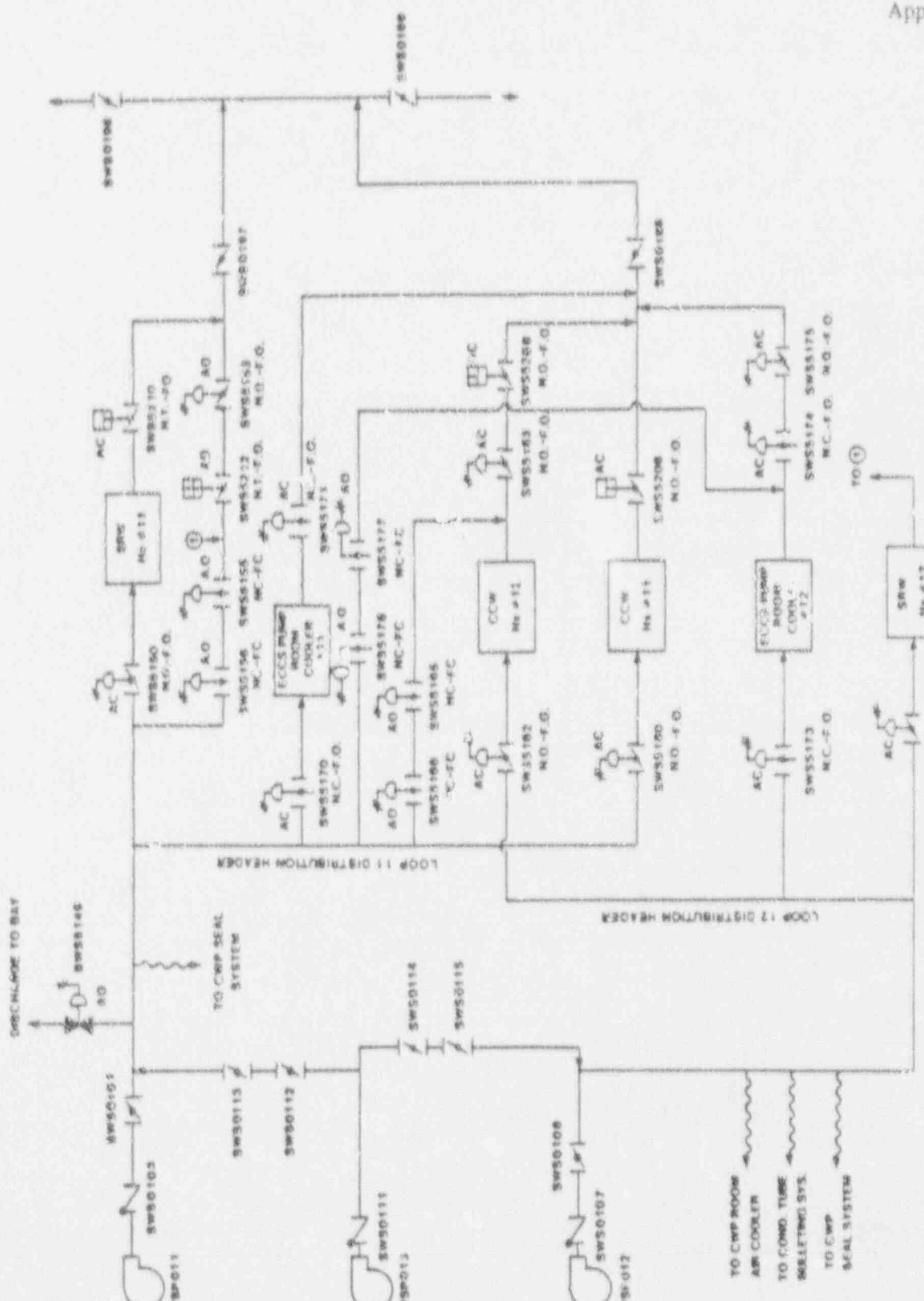

Figure C.30 Calvert Cliffs Salt Water System

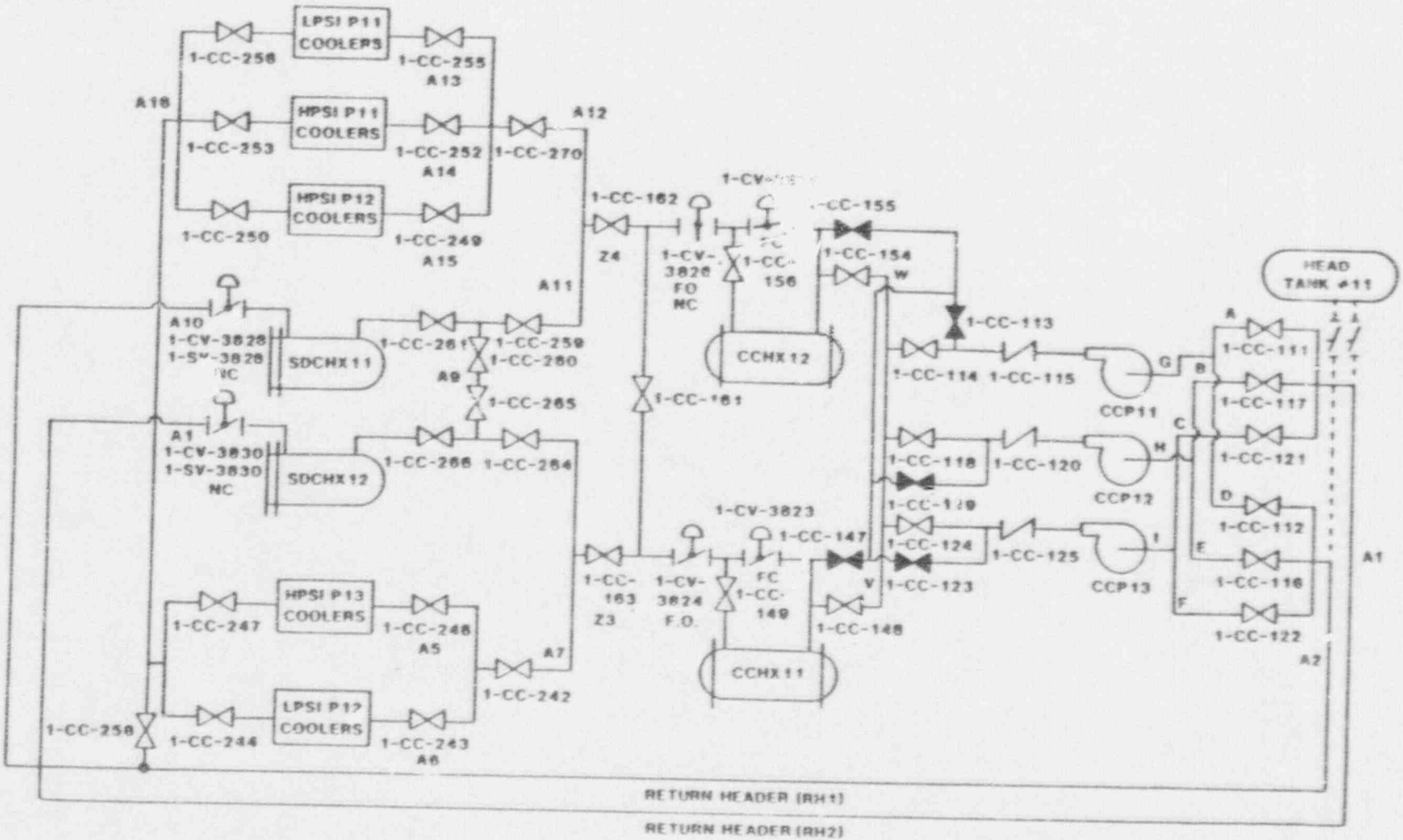

Figure C.11 Calvert Cliffs Component Cooling Water System

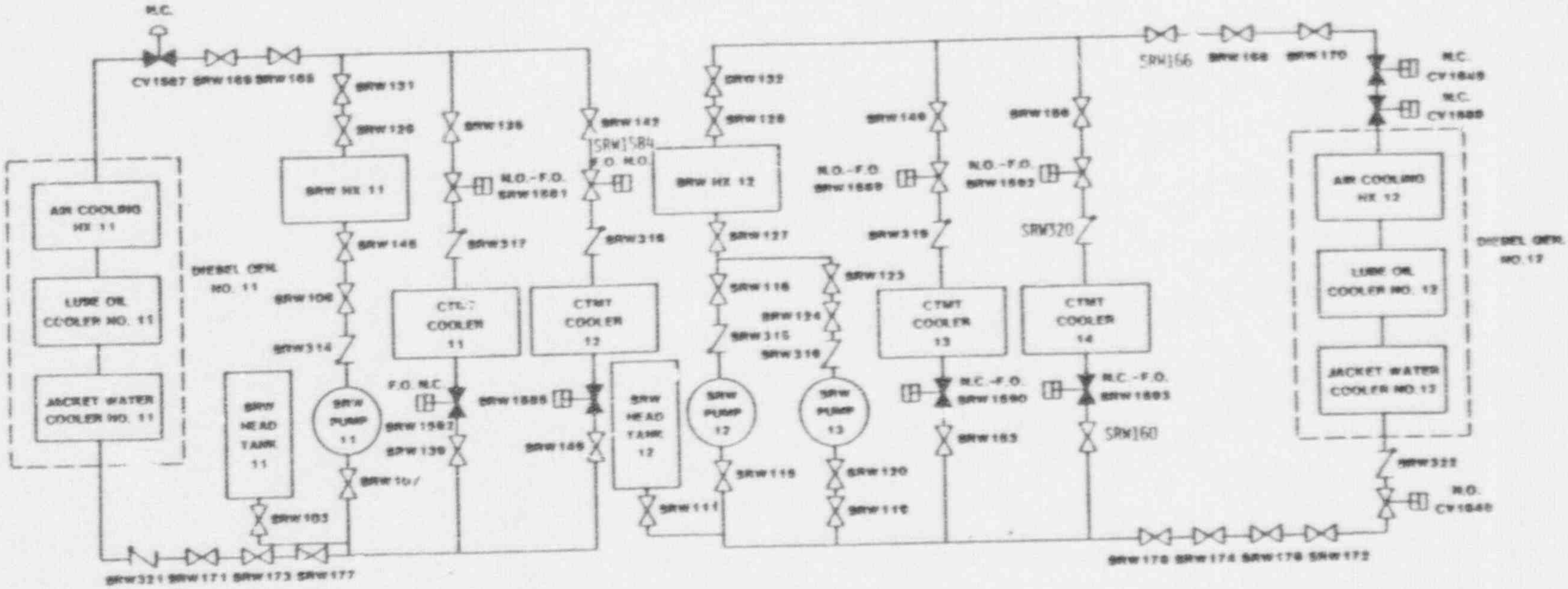

Figure C.12 Calvert Cliffs Service Water System

8.0 ARKANSAS NUCLEAR ONE COOLING WATER SYSTEM SUMMARIES

PLANT: ANO-1 TYPE: PWR VINTAGE: OLD NO. UNITS: 1

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: LAKE

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4713 TAP A-45

SUCCESS CRITERIA:

As defined in the TAP A-45 analysis, the success criteria for the SWS is as follows:

- With an ESAS signal, no credit is given for one loop backing up the other. That is, the loops are designed to isolate on an ESAS, and if they do not, the operator is trained to isolate them. Any diversion from a loop subsequent to the ESAS signal, is assumed to fail the loop.

- For the case without an ESAS condition, credit is given for one loop backing up the other, and diversions to normal plant loads do not fail the SWS because the pre-ESAS loads are not as large.

[illegible] 3.

[illegible]

[illegible] are three SWS pumps. During normal operation, two of them are in use with the third pump in standby. All of the crossover valves in the common-pump-discharge headers are open, but they close upon ESAS actuation. No valve realignment occurs unless an ESAS signal is present.

SYSTEM VULNERABILITIES:

Due to the redundancy provided, common mode failures dominate SWS failure. However, a single valve failure (i.e., plug) can obstruct the common SWS discharge line back to the lake.

POTENTIAL SYSTEM RECOVERY ACTIONS:

No recovery actions were found in the TAP A-45 cutsets that applied directly to the SWS. This is not surprising since all of the SWS events found were common mode failures of valves or pumps.

BIBLIOGRAPHY:

1. W. R. Cramond, et al, Shutdown Decay Heat Removal Analysis of a Babcock and Wilcox Pressurized Water Reactor Case Study, NUREG/CR-4713, SAND86-1832, March 1987.

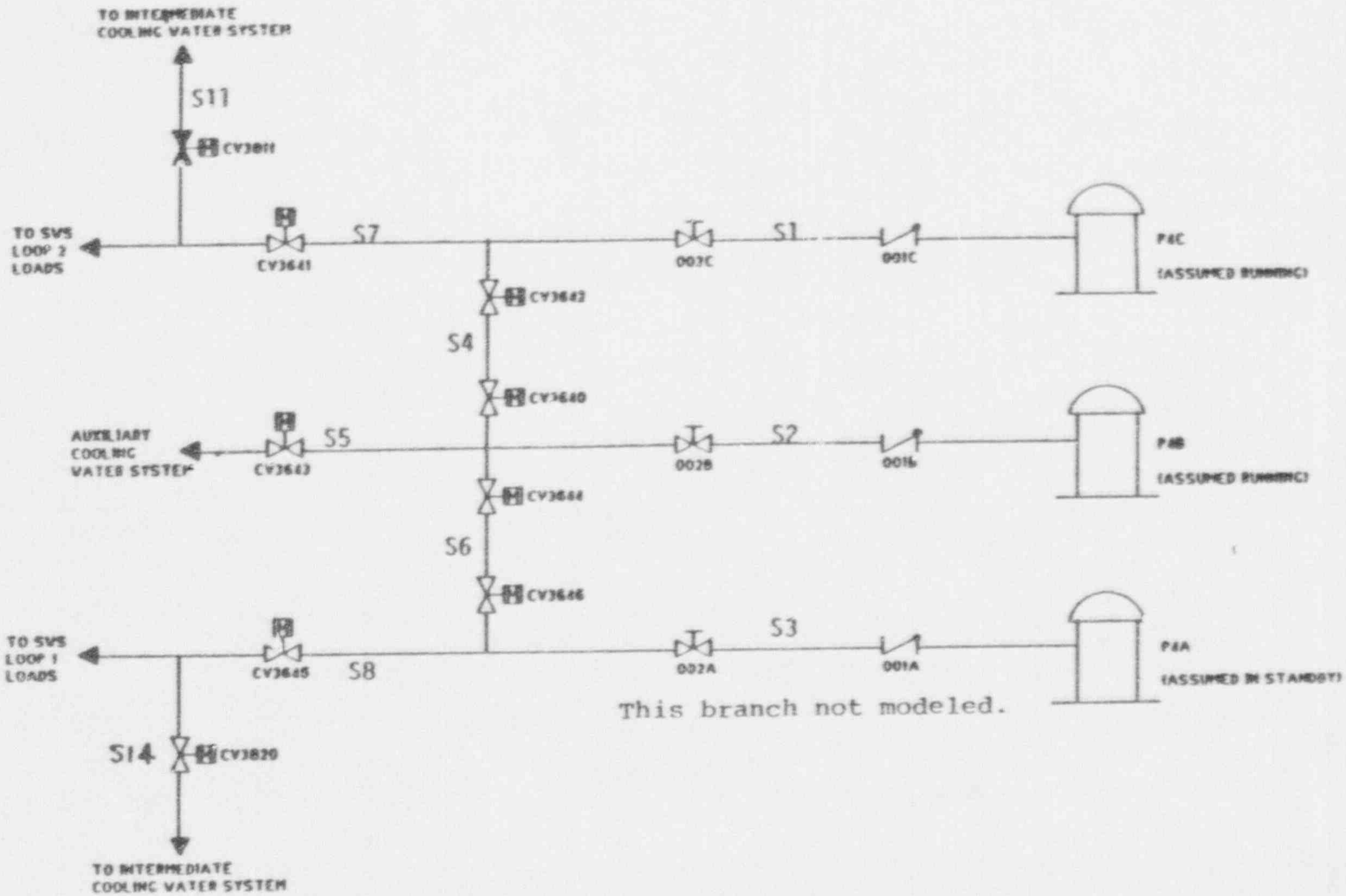

Figure C.13 ANO-1 Service Water System

9.0 POINT BEACH NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: POINT BEACH TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: LAKE

NUMBER OF TRAINS: 2 NUMBER OF PUMPS/TRAIN: 3

PRA: NUREG/CR-4458 TAP A-45

SUCCESS CRITERIA:

Three of the six Service Water System (SWS) pumps are required for successful cooling of all loads during accident conditions. See Figure C.14.

CROSS-TIES:

Six SWS pumps are shared between units 1 and 2. Two sets of three pumps are provided. Each set of three pumps discharge to a common header. The two SWS supply headers are cross-tied and are redundant to each other.

SYSTEM VULNERABILITIES:

Due to the redundancy provided, the SWS only shows up in the dominant cutsets due to pump common mode failures.

BIBLIOGRAPHY:

1. W. R. Cramond, et al, Shutdown Decay Heat Removal Analysis of a Westinghouse 2-Loop Pressurized Water Reactor Case Study, NUREG/CR-4458, SAND86-2496, March 1987.

PLANT: POINT BEACH TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: CCW OPEN OR CLOSED LOOP: CLOSED SOURCE: CCW TANK

NUMBER OF TRAINS: 1 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4458 TAP A-45

SUCCESS CRITERIA:

Successful operation of the Component Cooling Water (CCW) System requires the operation of one pump and one heat exchanger to provide sufficient cooling of all emergency loads. See Figure C.15.

CROSS-TIES:

The CCW system consists of two pumps operating in parallel discharging to a common header to supply the loads.

SYSTEM VULNERABILITIES:

Vulnerabilities identified in the TAP A-45 study were:

- Failure of ECC recirculation due to RHR pump cooling due to CCW valve failure. The low pressure pumps CCW discharge flow from each pumps passes through a single manual valve (XOV-30). The unavailability of this valve due to maintenance or plugging would defeat both the high pressure recirculation and the low pressure recirculation modes of operation.

- Failure of ECC injection due to CCW system failure caused by loss of cooling from the SWS through the CCW heat exchanger. This event consist of SWS flow blockage to the CCW heat exchanger in service or failure of any of the manual valves used to isolate the heat exchanger due to plugging.

- Failure of CCW pumps. Fails cooling to the ECC system pumps.

Note that the TAP A-45 study states that Point Beach was implementing a modification to add a fourth CCW heat exchanger and suggests that there would be one dedicated CCW heat exchanger per unit with two swing CCW heat exchangers. However, the study did not account for this modification in the analysis.

POTENTIAL SYSTEM RECOVERY ACTIONS:

No recovery actions were found in the TAP A-45 analysis for the CCW system.

However, an obvious recovery action is to align the standby pump or standby CCW heat exchanger for operation should the normally operating pump or heat exchanger fail.

BIBLIOGRAPHY:

1. W. R. Cramond, et al, Shutdown Decay Heat Removal Analysis of a Westinghouse 2-Loop Pressurized Water Reactor Case Study, NUREG/CR-4458, SAND86-2496, March 1987.

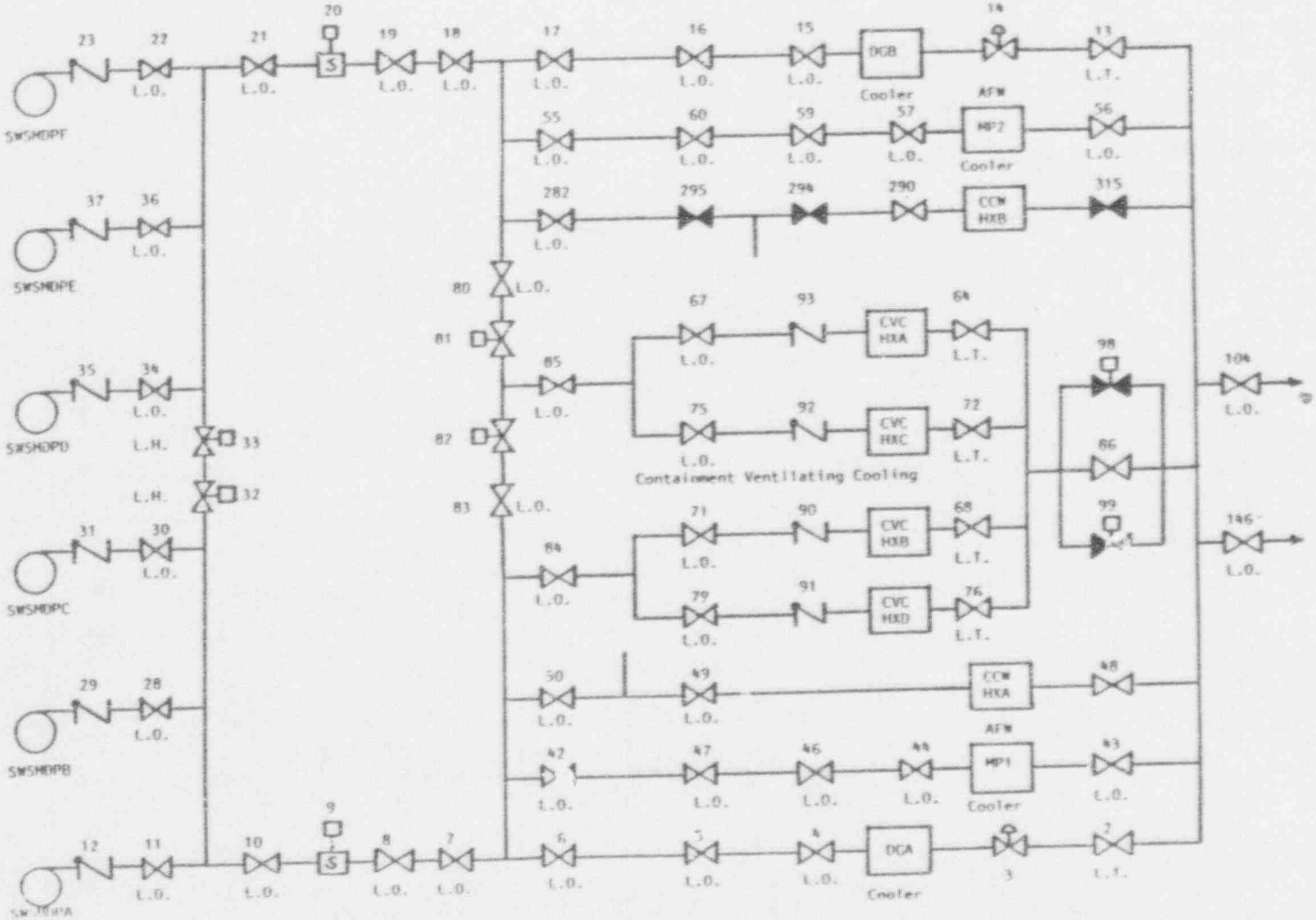

Figure C.14 Point Beach Service Water System

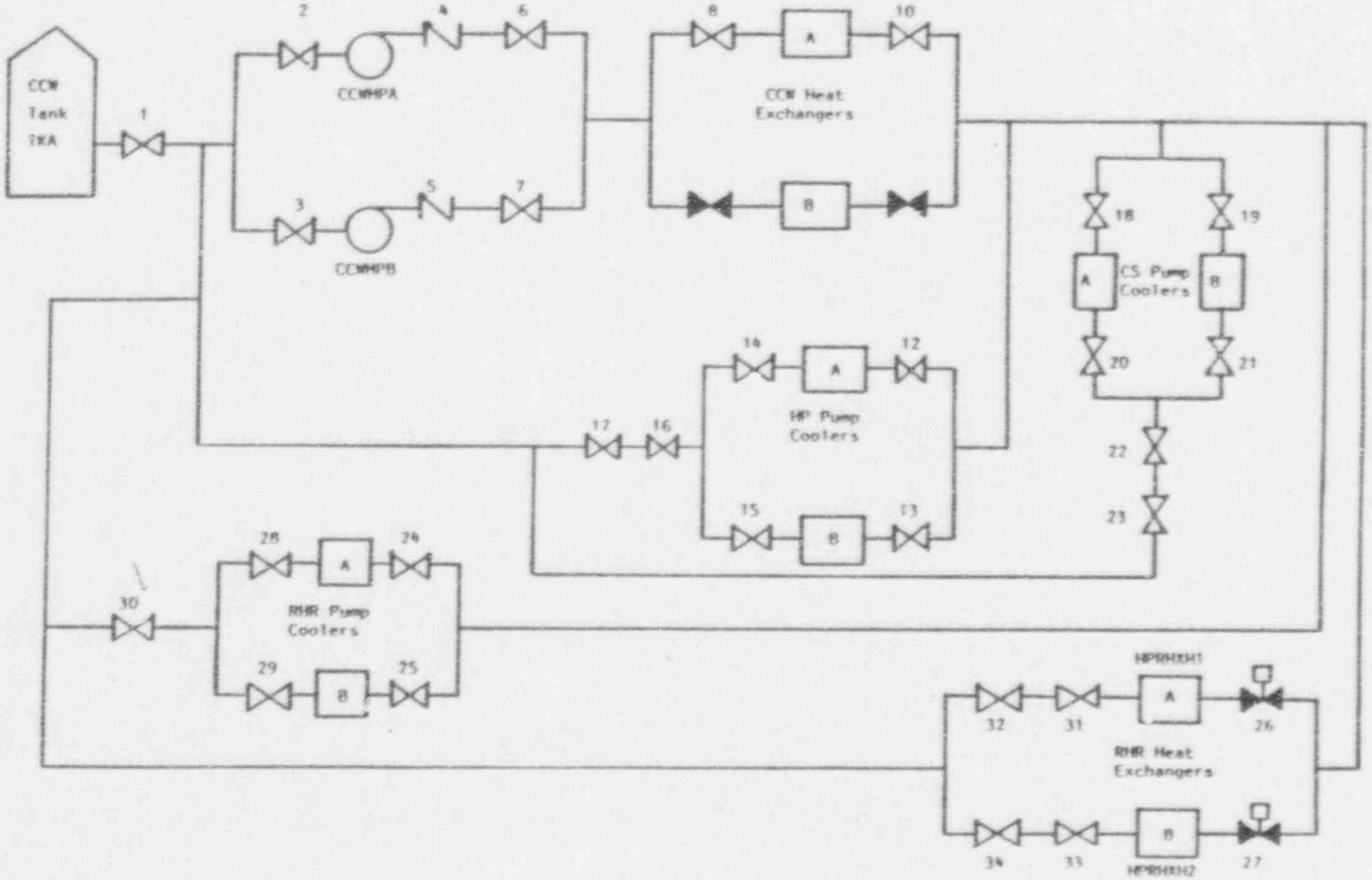

Figure C.15 Point Beach Component Cooling Water System

10.0 TURKEY POINT NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: TURKEY POINT TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: OCEAN

NUMBER OF TRAINS: 3 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4762 TAP A-45

SUCCESS CRITERIA:

Three intake Service Water System (SWS) pumps are provided per unit. For accident conditions, one pump is required for success providing cooling water to the CCW heat exchangers and the non-essential loads isolated. See Figure C.16.

CROSS-TIES:

During normal operation, two of the three SWS pumps are operating, discharging to two redundant (cross-tied) headers.

SYSTEM VULNERABILITIES:

From the cutsets given in the TAP A-45 study the SWS is vulnerable to common mode failure of the pumps and failure of the non-essential header to isolate during accident conditions. Common mode failure of the service water pumps will prevent adequate heat removal via the component cooling water system heat exchangers. This, in turn, will lead to overheating of the high pressure injection pumps and emergency core coolant injection failure.

Pneumatic-hydraulic valve CV-2201 is normally open to allow service water to flow to non-safety systems. Following LOCAs, this valve receives a signal to close from safety injection signal train A. Failure of this valve to close will divert adequate water from the safety related components.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Recovery actions considered in TAP A-45 include:

- locally opening the alternate SWS discharge path should the discharge path in use fail.
- start an idle pump from the control room should the normally operating pump fail.

BIBLIOGRAPHY:

1. G. A. Sanders, et al, Shutdown Decay Heat Removal Analysis of a Westinghouse 3-Loop Pressurized Water Reactor Case Study, NUREG/CR-4762, SAND86-2377, March 1987.

PLANT: TURKEY POINT TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: CCW OPEN OR CLOSED LOOP: CLOSED SOURCE: N/A

NUMBER OF TRAINS: 3 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4762 TAP A-45

SUCCESS CRITERIA:

The success criteria for the CCW system is two of three pumps and two of three heat exchangers providing the necessary cooling for the safety related loads. See Figure C.17.

CROSS-TIES:

The system consists of three cross-tied pumps operating in parallel, discharging to a common distribution header.

SYSTEM VULNERABILITIES:

The CCW system is vulnerable to common mode failure of the pumps as identified in the TAP A-45 study. Common mode failure of the CCW pumps results in the overheating of the HPI and LPI pumps and emergency core coolant injection failure after a small LOCA.

POTENTIAL SYSTEM RECOVERY ACTIONS:

The only recovery action considered in the TAP A-45 analysis was recovery of a CCW pump suction valve failure. There are two return headers to the CCW pumps from the CCW loads. Failure of a return header manual valve would result in the loss of one-half of the safety systems dependant on CCW. The return headers are cross-tied, and therefore, failure of one of the return header valves could be recovered.

BIBLIOGRAPHY:

1. G. A. Sanders, et al, Shutdown Decay Heat Removal Analysis of a Westinghouse 3-Loop Pressurized Water Reactor Case Study, NUREG/CR-4762, SAND86-2377, March 1987.

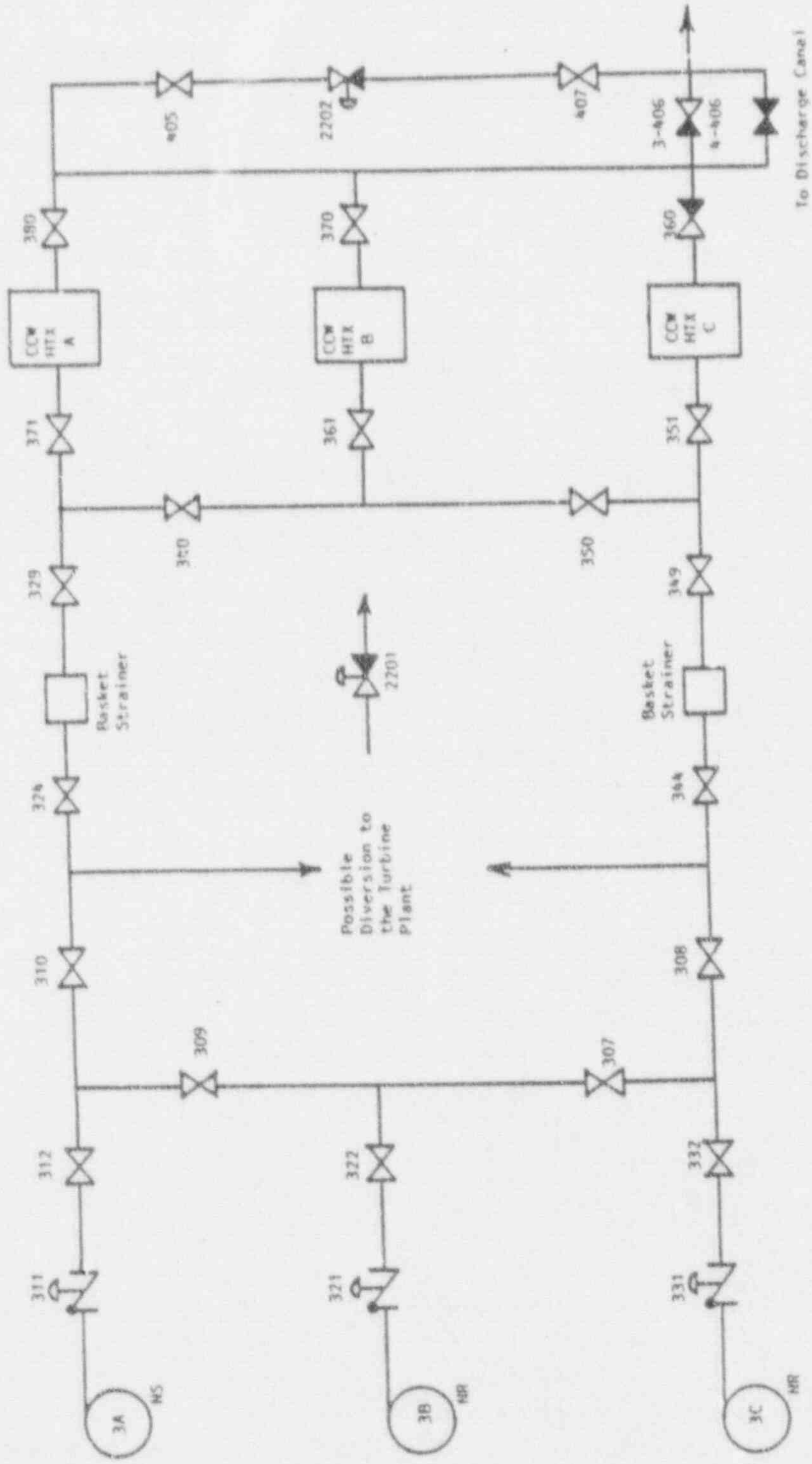

Figure C.16 Turkey Point Service Water System

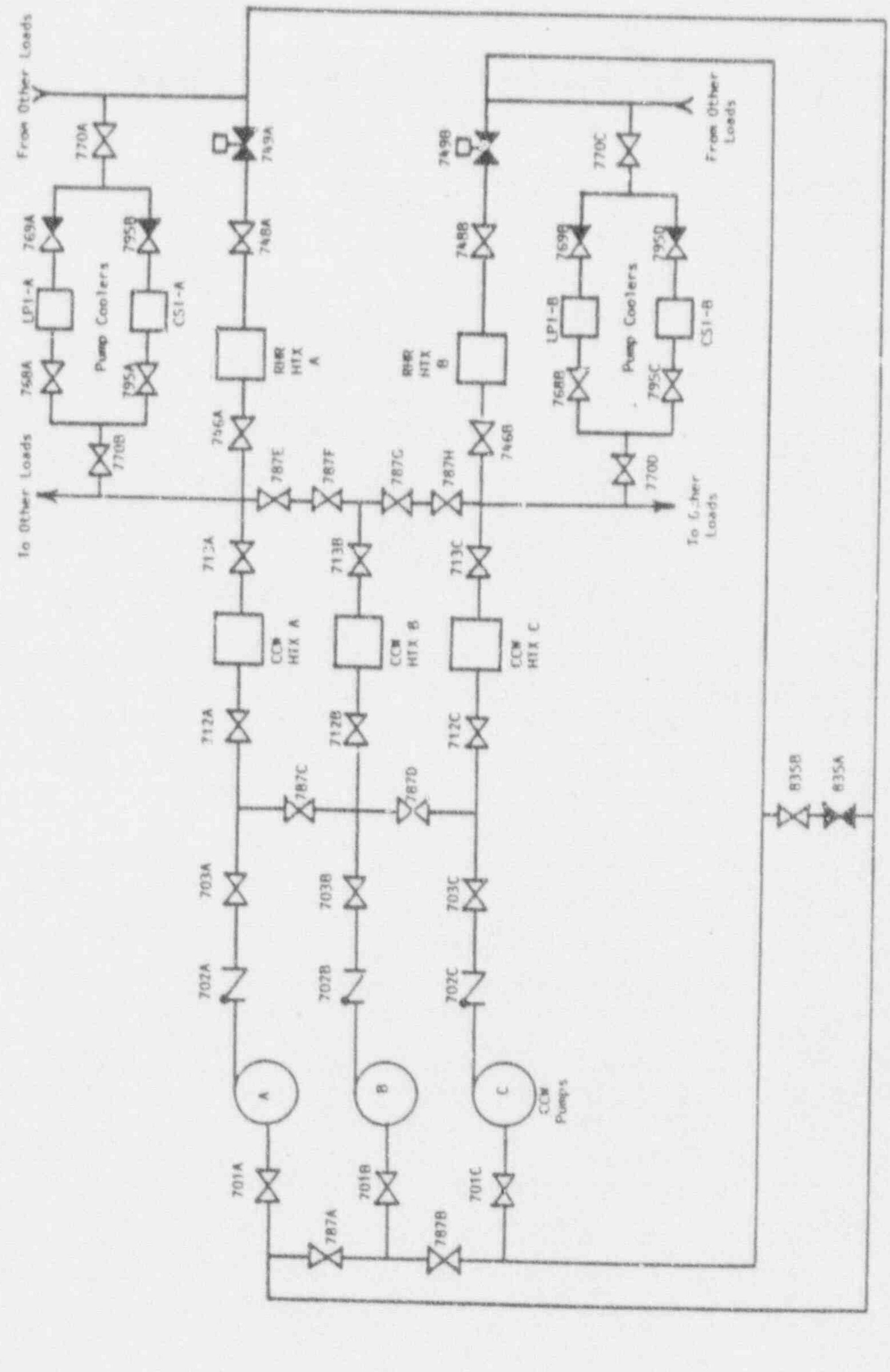

Figure C.17 Turkey Point Component Cooling Water System

11.0 SURRY NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: SURRY 1 TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: CANAL

NUMBER OF TRAINS: 2 NUMBER OF PUMPS: 0

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

The success criteria as defined in NUREG-4550 is sufficient flow through the Inside Spray Recirculation (ISR) System and Outside Spray Recirculation (OSR) System heat exchangers. See Figure C.18.

CROSS-TIES:

The SWS consists of two parallel headers taking suction from a canal. The two headers are crosstied via two normally open motor-operated valves in series such that flow from either inlet line can be used to cool all four ISR and OSR heat exchangers.

SYSTEM VULNERABILITIES:

Common mode failure of the service water valves due to corrosion from exposure to brackish water.

POTENTIAL SYSTEM RECOVERY ACTIONS:

The only components required to change state are the service water intake motor-operated valves. These valves can be recovered by manually opening them.

BIBLIOGRAPHY:

1. R. C. Bertucio and J. A. Julius, Analysis of Core Damage Frequency: Surry, Unit 1 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 3, Rev. 1, Part 1, April 1990.

PLANT: SURRY 1 TYPE: PWR VINTAGE: OLD NO. UNITS: 2

SYSTEM: CCW OPEN OR CLOSED LOOP: CLOSED SOURCE: N/A

NUMBER OF TRAINS: 1 NUMBER OF PUMPS: 2

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

The success criterion for Surry Unit 1 CCW system is that continued CCW flow is provided to the RCP pump thermal barriers, RHR pumps, and RHR heat exchangers following reactor shutdown.

Following station blackout at Unit 1, Unit 2 CCW system provides the cooling to the RCS pump thermal barriers.

Both CCW pumps and heat exchangers are required for success. See Figure C.19.

CROSS-TIES:

The Unit 1 and Unit 2 CCW systems are cross-tied through manual valves downstream of their respective pumps and heat exchangers.

SYSTEM VULNERABILITIES:

Common mode failure of the pumps to run.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Failure of the CCW for one unit can be recovered by lining up the CCW of the other unit to provide the heat sink.

BIBLIOGRAPHY:

1. R. C. Bertucio and J. A. Julius, Analysis of Core Damage Frequency: Surry, Unit 1 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 3, Rev. 1, Part 1, April 1990.

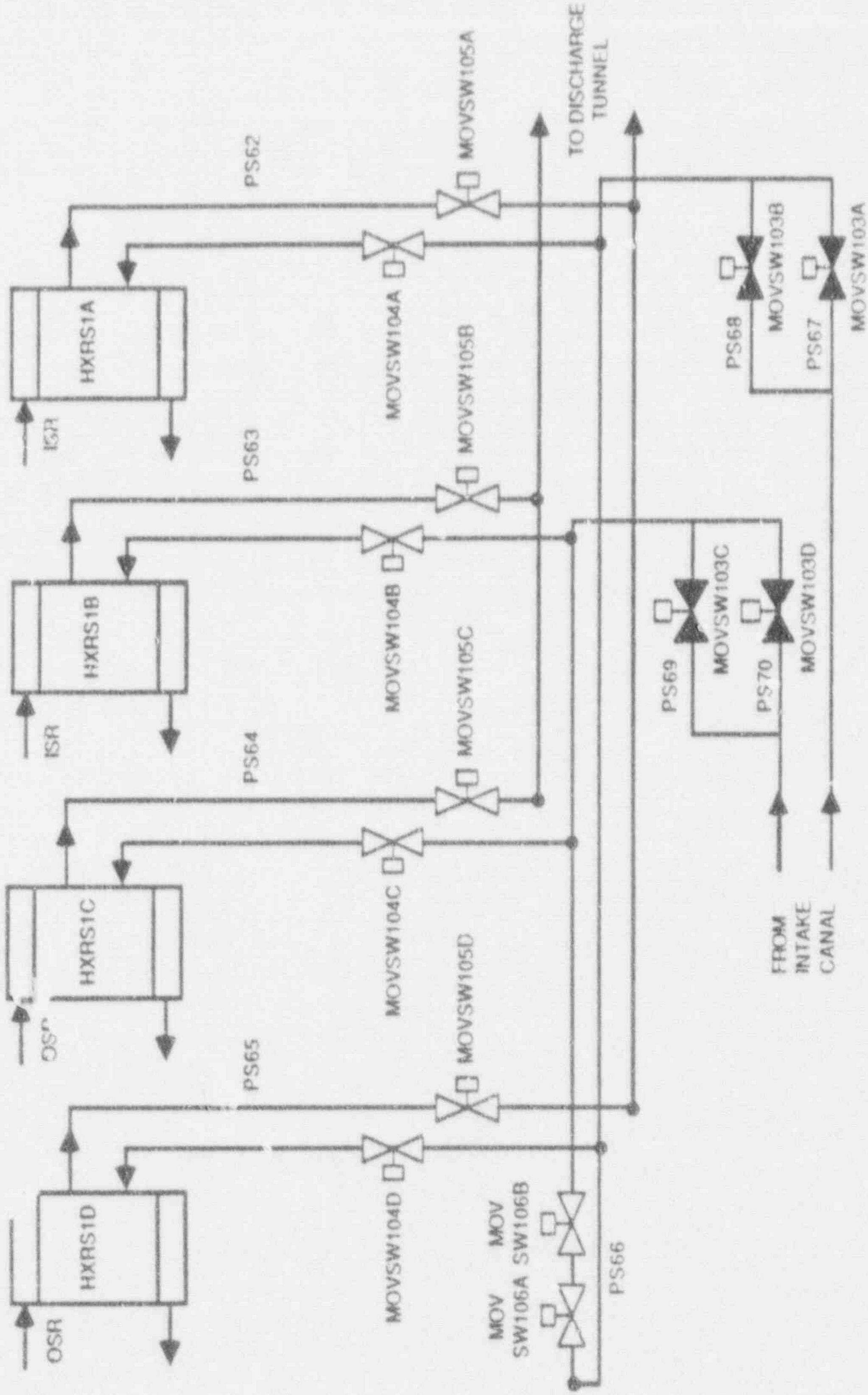

Figure C.18 Surry Service Water System

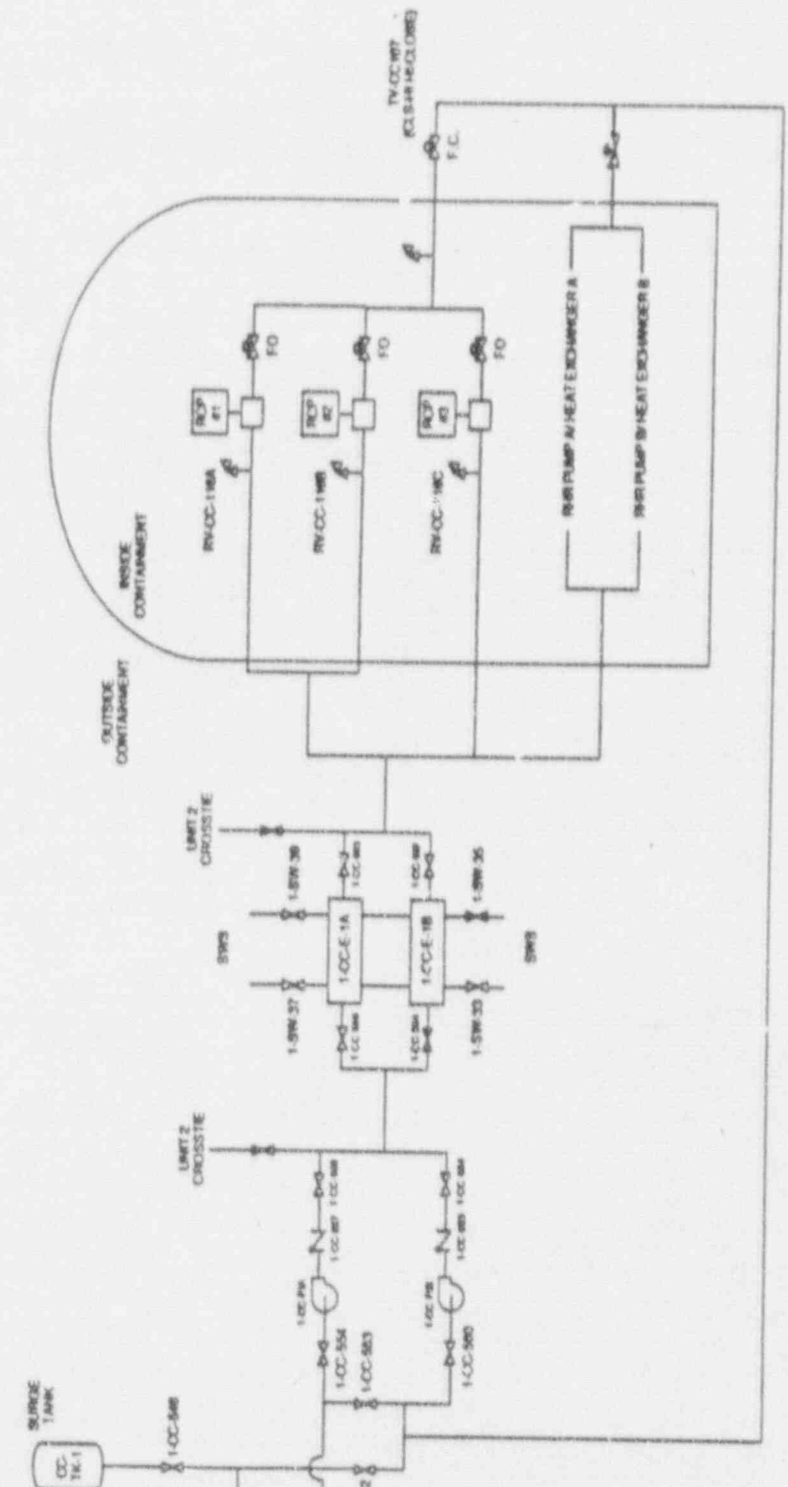

Figure C.19 Surry Component Cooling Water System

12.0 SEQUOYAH NUCLEAR STATION UNIT 1 COOLING WATER SYSTEM SUMMARIES

PLANT: SEQUOYAH 1 TYPE: PWR VINTAGE: NEW NO. UNITS: 2

SYSTEM: SWS OPEN OR CLOSED LOOP: OPEN SOURCE: RIVER

NUMBER OF TRAINS: 4 NUMBER OF PUMPS/TRAIN: 2

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

For each Service Water system (SWS) header (A or B) three of the four available pumps must operate to provide flow to the loads dependant on the header. See Figure C.20.

CROSS-TIES:

The SWS system consists of four trains of pumps consisting of two pumps per train. The SWS pump trains are cross-connected to effectively makeup two service water supply systems (A and B), where SWS A is fed from two cross-tied pump trains and SWS B is fed from the other two cross-tied pumps trains. From the SWS fault tree, three of the four pumps feeding a particular SWS train must be available for success.

SYSTEM VULNERABILITIES:

SWS does not show up as an important contributor to core damage in the 1150 analysis.

BIBLIOGRAPHY:

1. R. C. Bertucio and S.R. Brown, Analysis of Core Damage Frequency: Sequoyah, Unit 1 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 5, Rev. 1, Part 1, April 1990.

PLANT: SEQUOYAH 1 TYPE: PWR VINTAGE: NEW NO. UNITS: 2

SYSTEM: CCW OPEN OR CLOSED LOOP: CLOSED SOURCE: N/A

NUMBER OF TRAINS: 5 NUMBER OF PUMPS/TRAIN: 1

PRA: NUREG/CR-4550

SUCCESS CRITERIA:

The success criteria, in terms of the number of Component Cooling Water (CCW) pumps needed for Unit 1 and the status of the spent fuel heat exchangers are different, depending on whether ESFs are in the injection mode or in the recirculation mode. If the RHR HX are not required, one CCW pump will provide sufficient flow to train 1A and the RCP thermal barriers, regardless of whether or not spent fuel pool heat exchangers have been transferred to Unit 2. After activation of the RHR HXs, in the recirculation mode, one CCW pump will provide sufficient cooling only if the spent fuel pool HXs have been transferred to Unit 2, but both CCW pumps 1A-A and 1B-B are required if the spent fuel pit HXs have not been transferred. See Figure C.21.

CROSS-TIES:

The CCW system contains five pumps and three heat exchangers serving both Units 1 and 2. Unit 1 is normally served by CCW pump 1A-A and CCW HX A, which also serves the RCP thermal barriers in the Unit 1 reactor building. Train 2A is normally served by CCW Pump 2A-A and CCW HX B. The B trains at both units are normally served by CCW pump C-S and CCW HX C.

Of the pumps and heat exchangers that are normally aligned to serve Unit 1 (i.e., Pumps 1A-A, 1B-B, and C-S and HXs A and C), pumps 1A-A and C-S and both heat exchangers are normally in operation. CCW pump 1B-B is normally in a standby condition but starts automatically on low pressure at the combined discharge header of pumps 1A-A and 1B-B.

SYSTEM VULNERABILITIES:

Valve failures that result the loss of the RHR heat exchangers dominate during the recirculation.

POTENTIAL SYSTEM RECOVERY ACTIONS:

Recovery action taken credit for in the PRA concerned recovery of failed CCW valves that results in the failure of the RHR heat exchangers.

Due to the redundancy provided, a failed CCW pump could be recovered by aligning the standby pump for operation.

BIBLIOGRAPHY:

1. R. C. Bertucio and S.R. Brown, Analysis of Core Damage Frequency: Sequoyah, Unit 1 Internal Events, NUREG/CR-4550, SAND86-2084, Volume 5, Rev. 1, Part 1, April 1990.

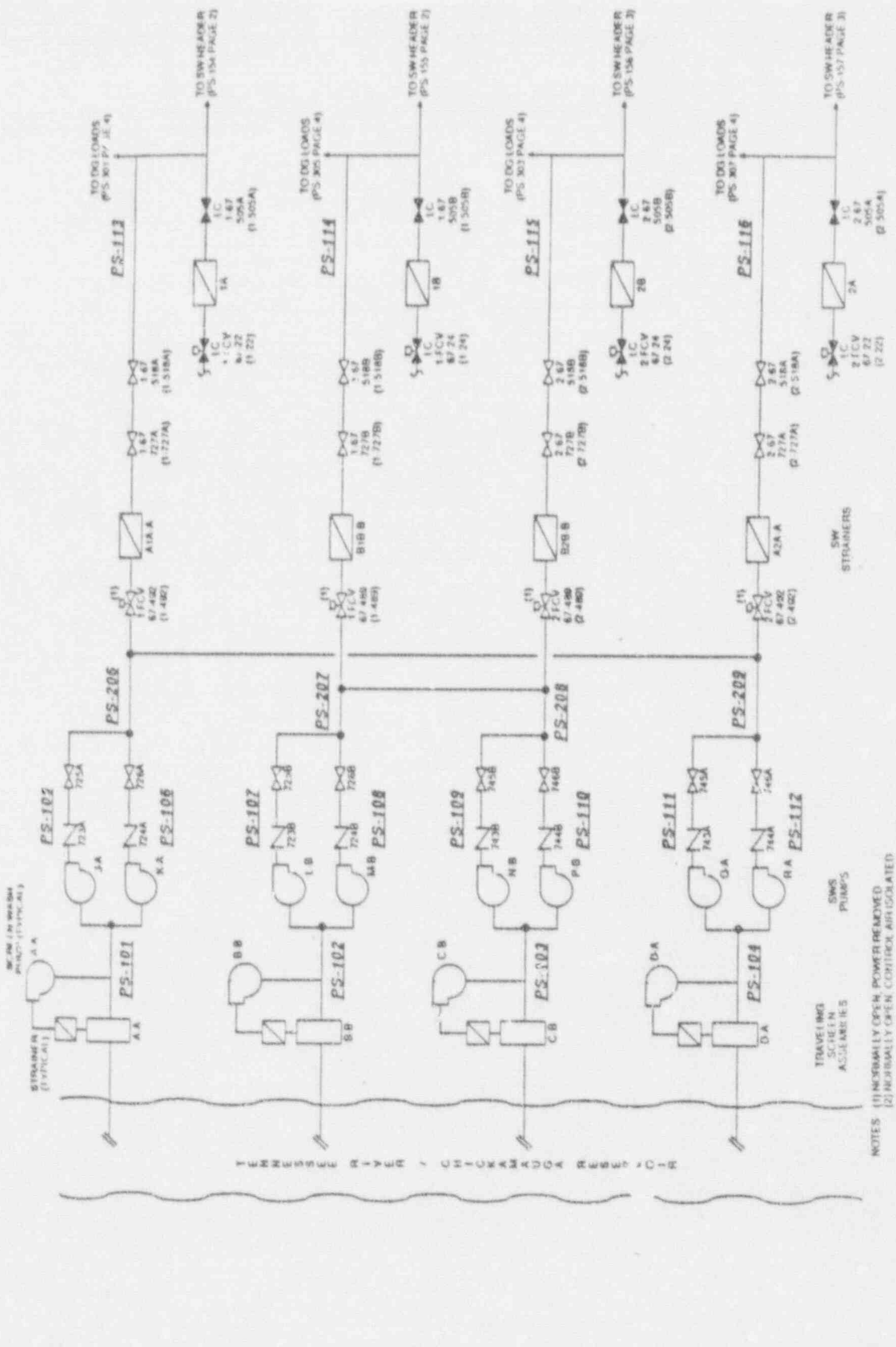

Figure C.20 Sequoyah Service Water System (Page 1 of 4)

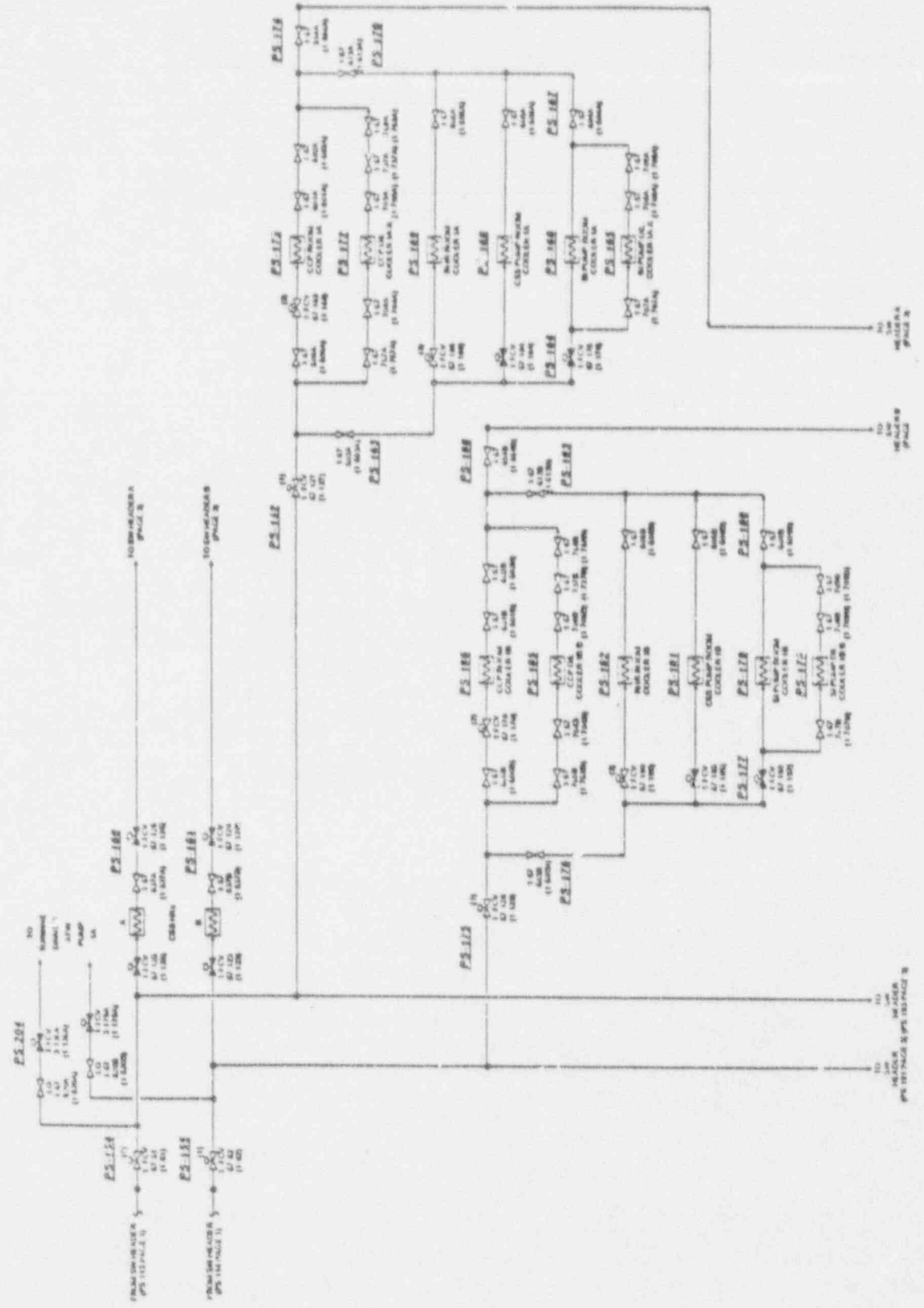

Figure C.20 Sequoyah Service Water System (Page 2 of 4)

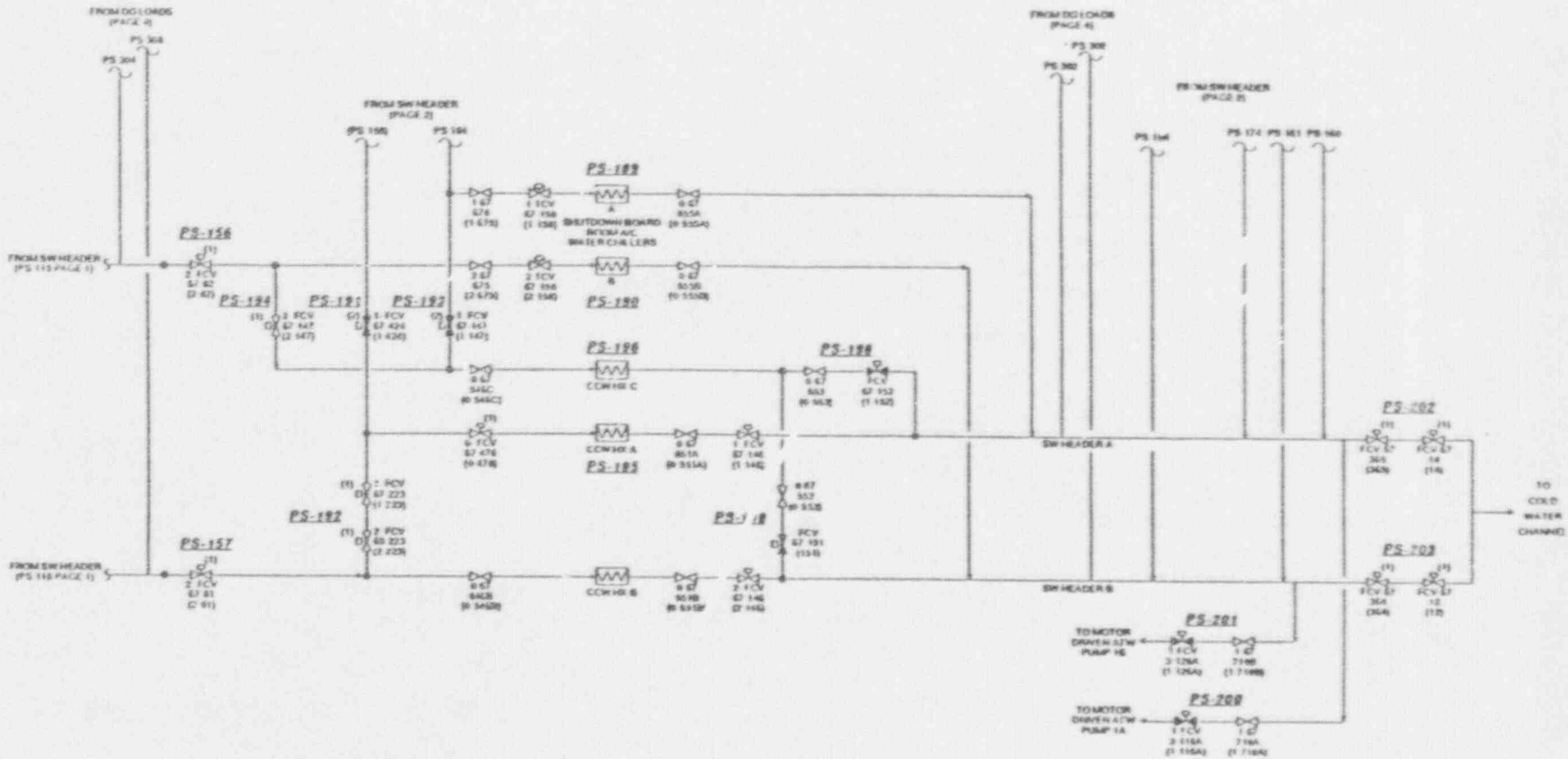

Figure C.20 Sequoyah Service Water System (Page 3 of 4)

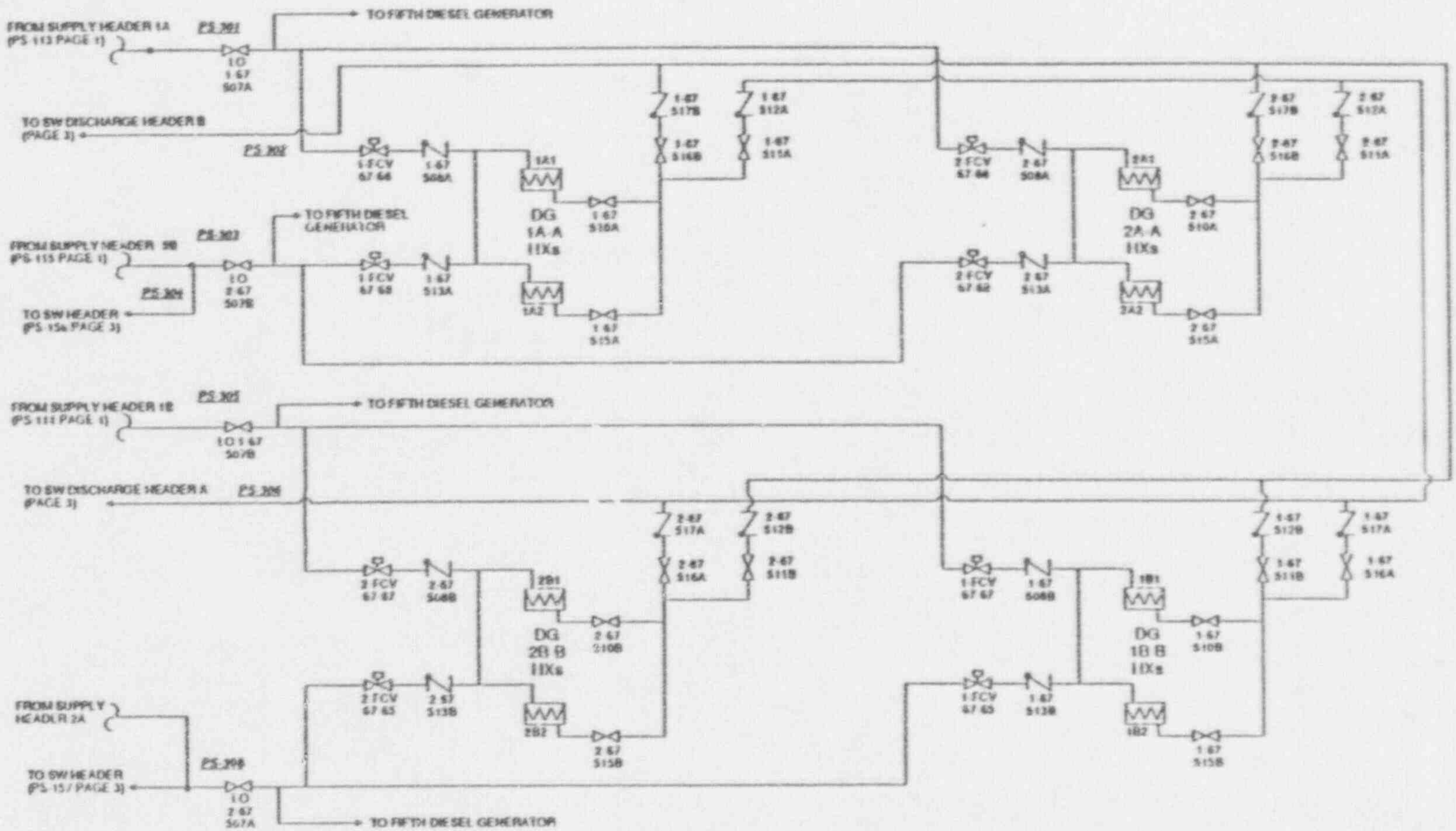

Figure C.20 Sequoyah Service Water System (Page 4 of 4)

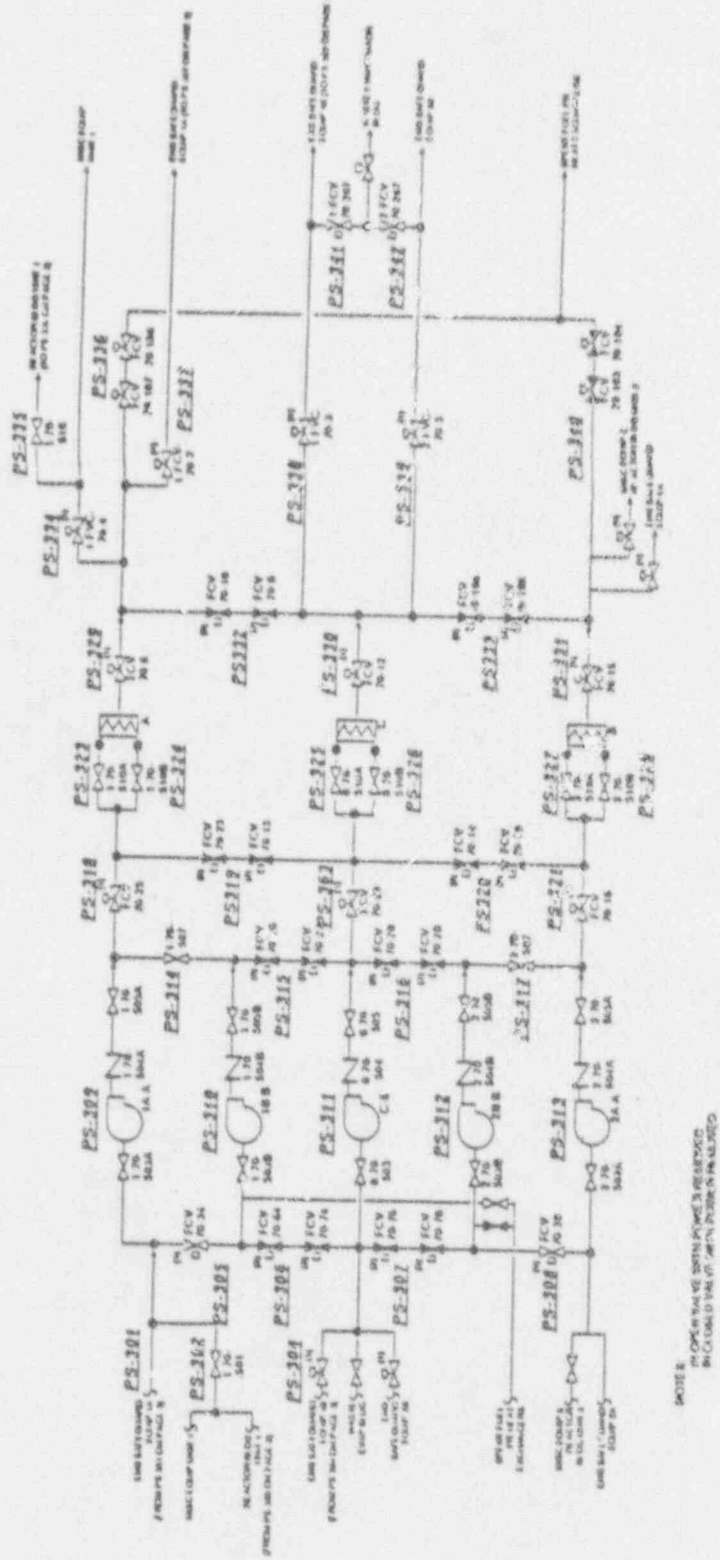

Figure C.21 Sequoyah Component Cooling Water System (Page 1 of 3)

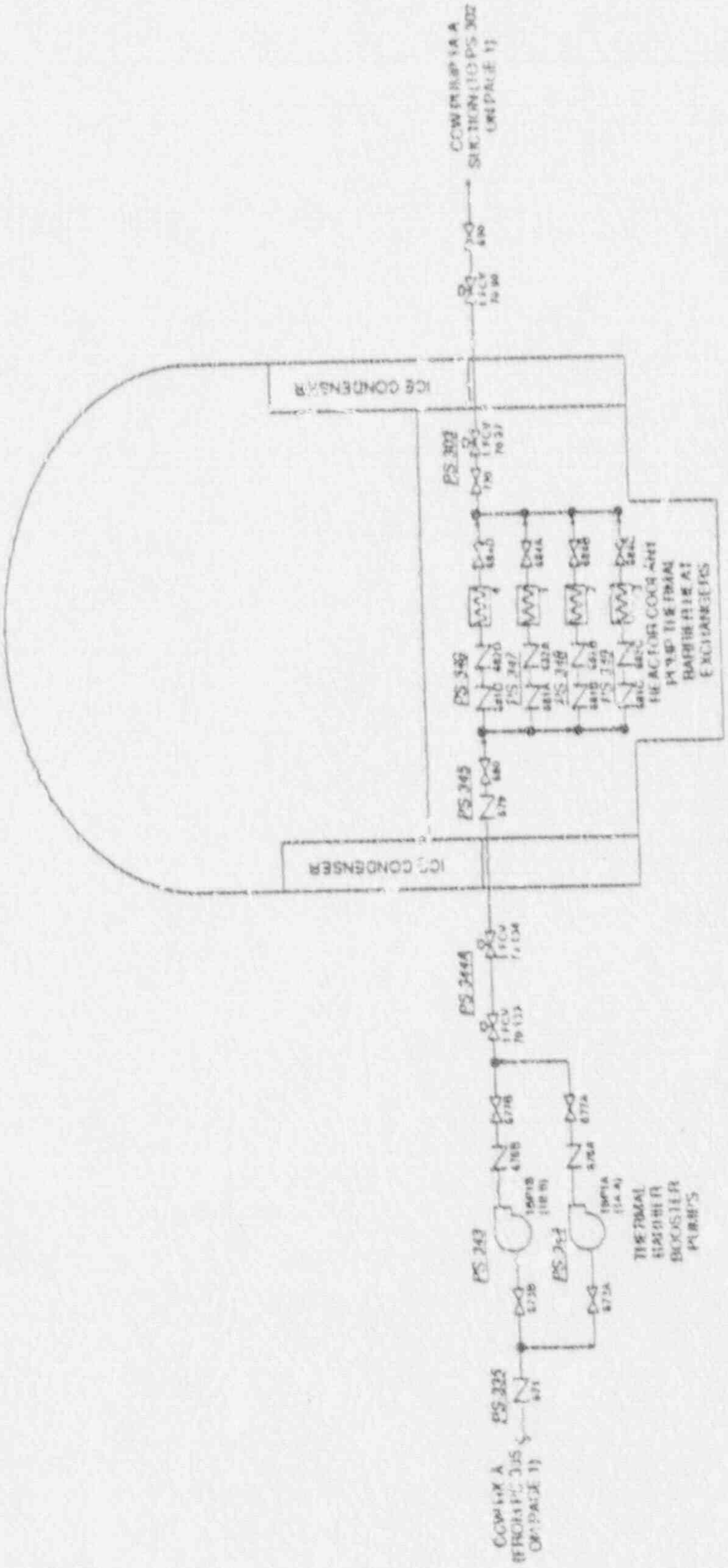

Figure C.21 Sequoyah Component Cooling Water System (Page 2 of 3)

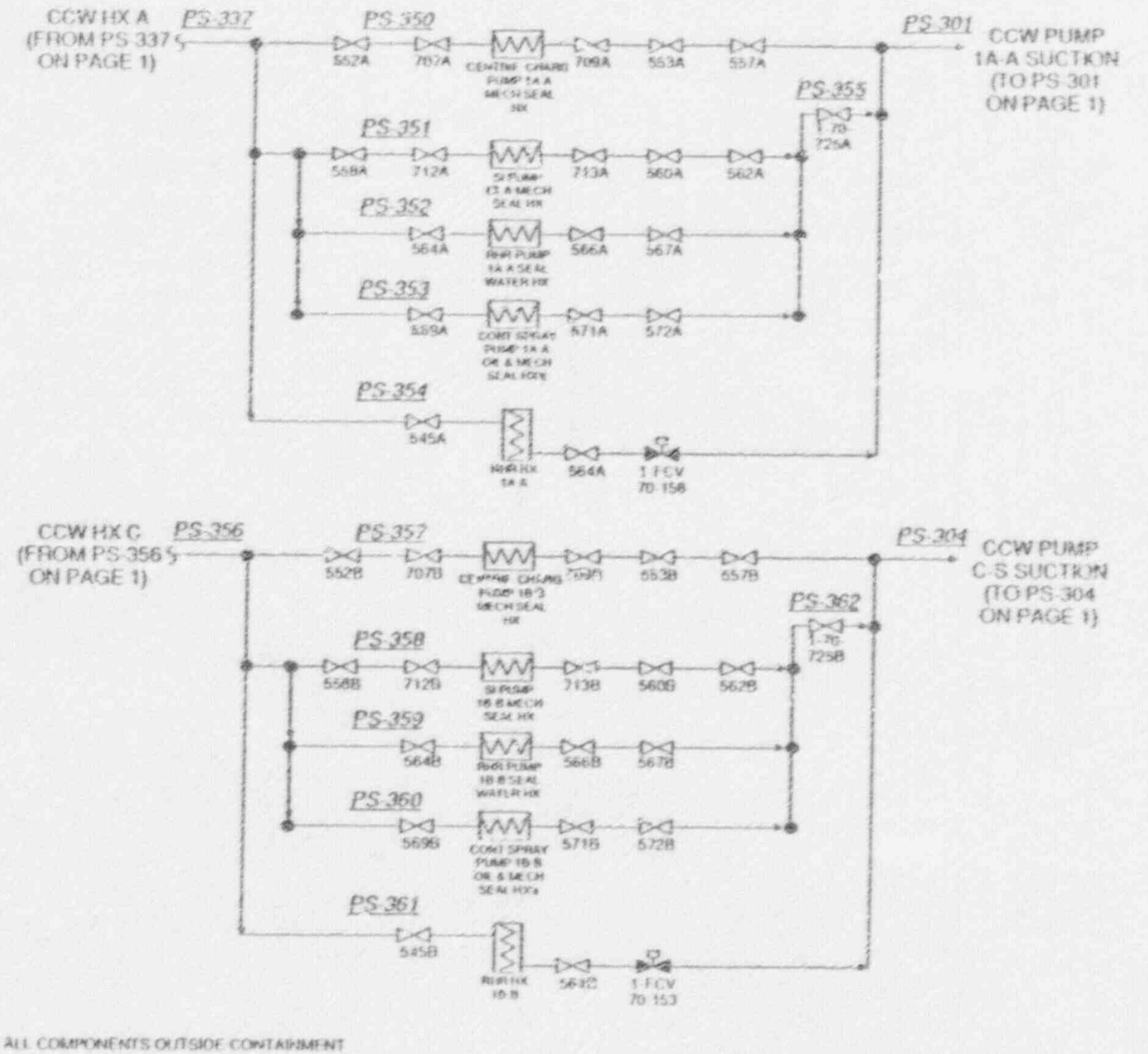

Figure C.21 Sequoyah Component Cooling Water System (Page 3 of 3)

APPENDIX D

SERVICE WATER SYSTEM DEPENDENCY DIAGRAMS

Dependency diagrams in terms of the safety functions that are served by each of the systems reviewed for the scoping study are presented in this Appendix. The BWRs are presented first followed by the PWRs.

The acronyms used are defined below.

AFW	auxiliary feedwater
CCP	centrifugal charging pump
CCW	component cooling water
CSS	containment spray system
DG	diesel generator
DGCW	diesel generator cooling water
HPCI	high pressure core injection
HPCS	high pressure core spray
HPIS	high pressure injection system
HPSW	high pressure service water
HX	heat exchanger
LPCS	low pressure core spray
LPIS	low pressure injection system
RCIC	reactor core isolation cooling
RHR	residual heat removal
RHRSW	residual heat removal service water
SRW	service water (Calvert Cliffs)
SWS	salt water system (Calvert Cliffs)
SWS	service water system

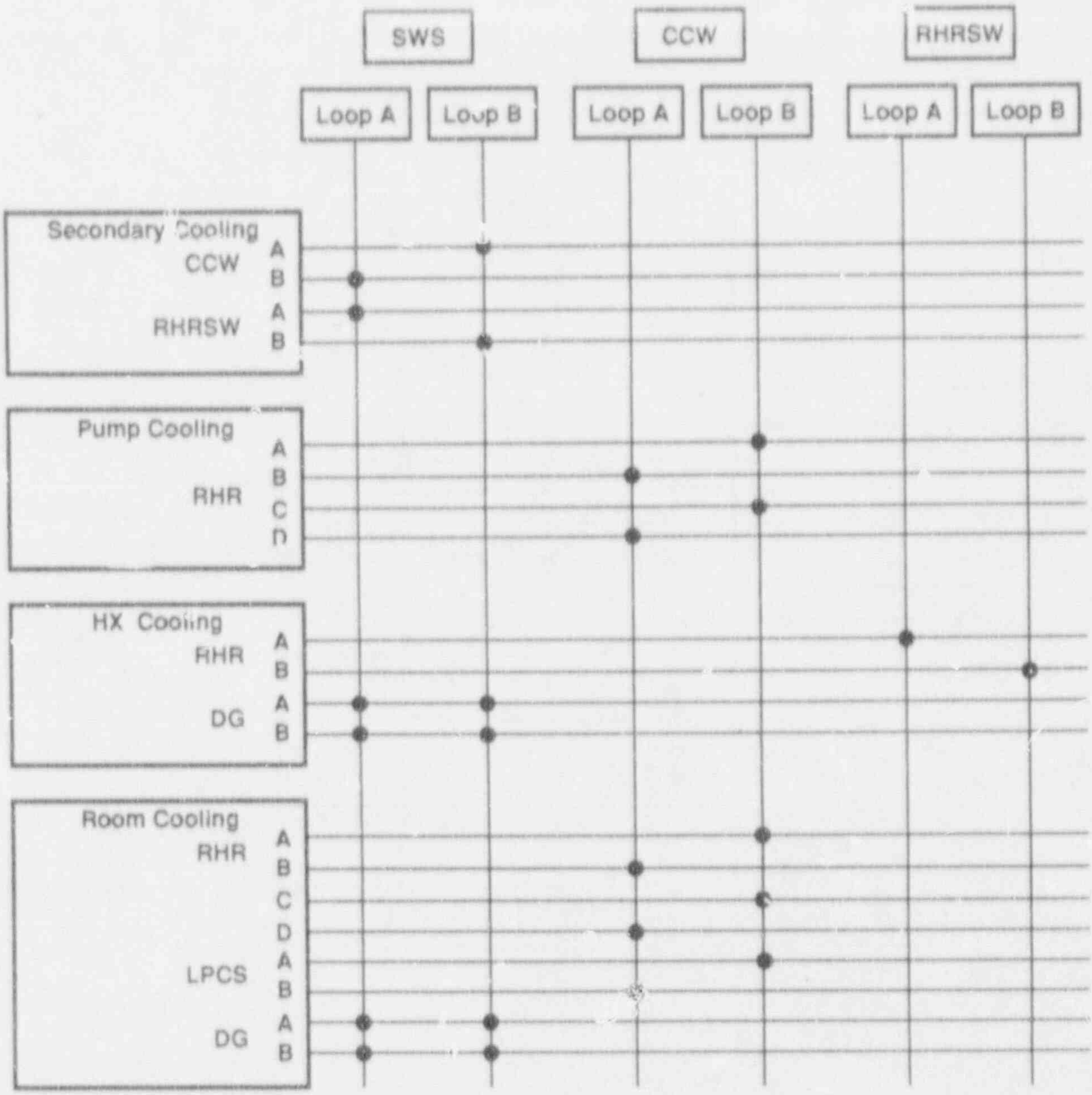

Figure D.1 Cooper Service Water Dependency Diagram

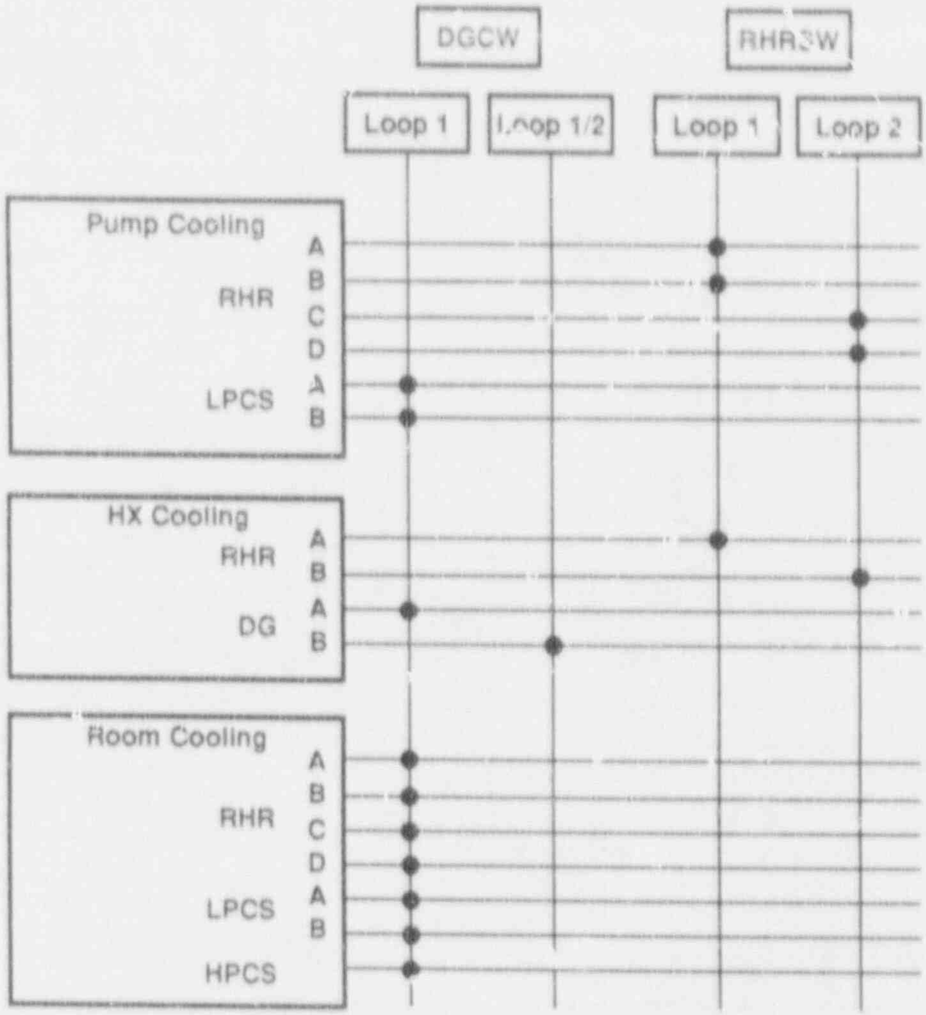

Figure D.2 Quad Cities Service Water Dependency Diagram

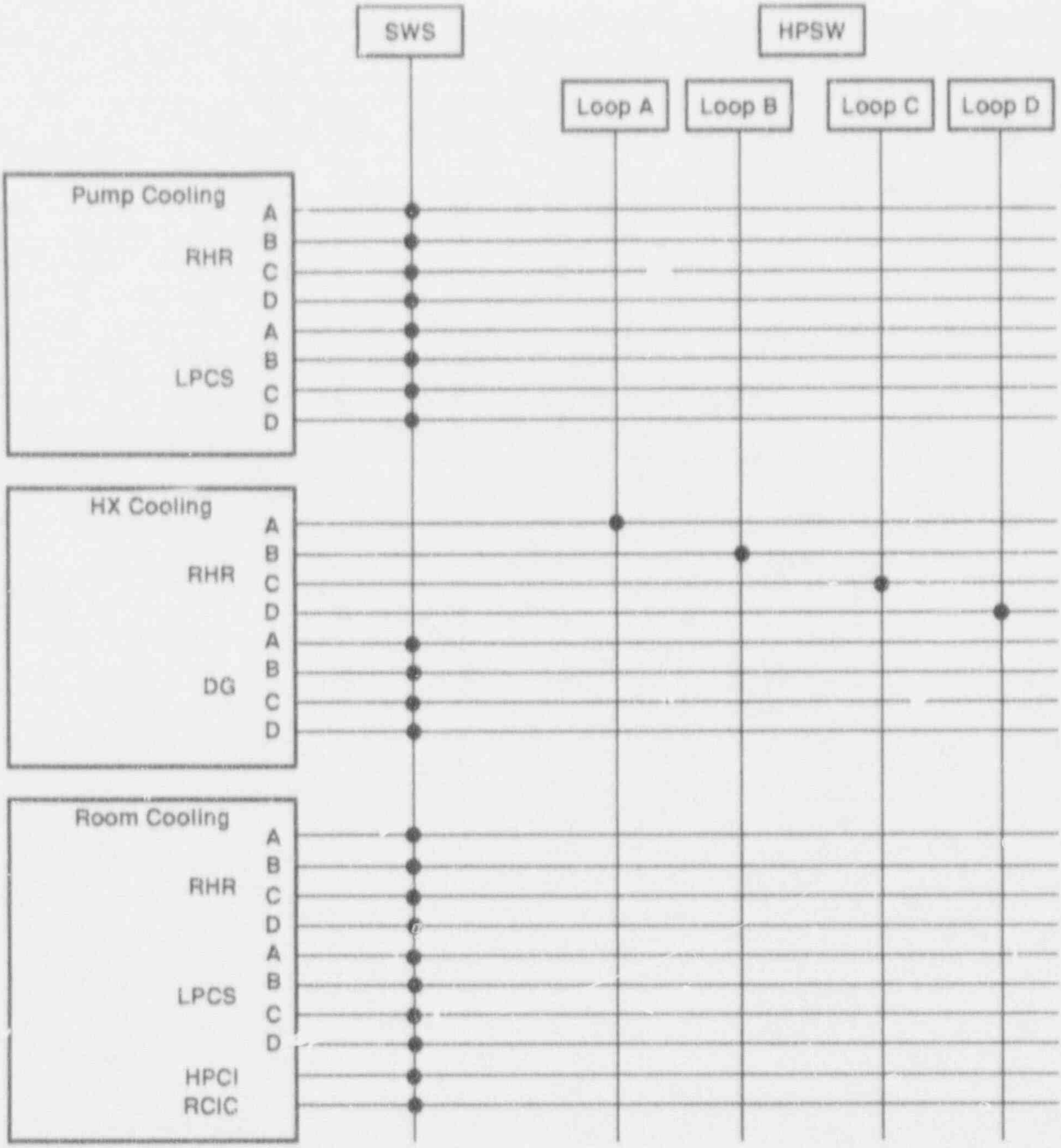

Figure D.3 Peach Bottom Service Water Dependency Diagram

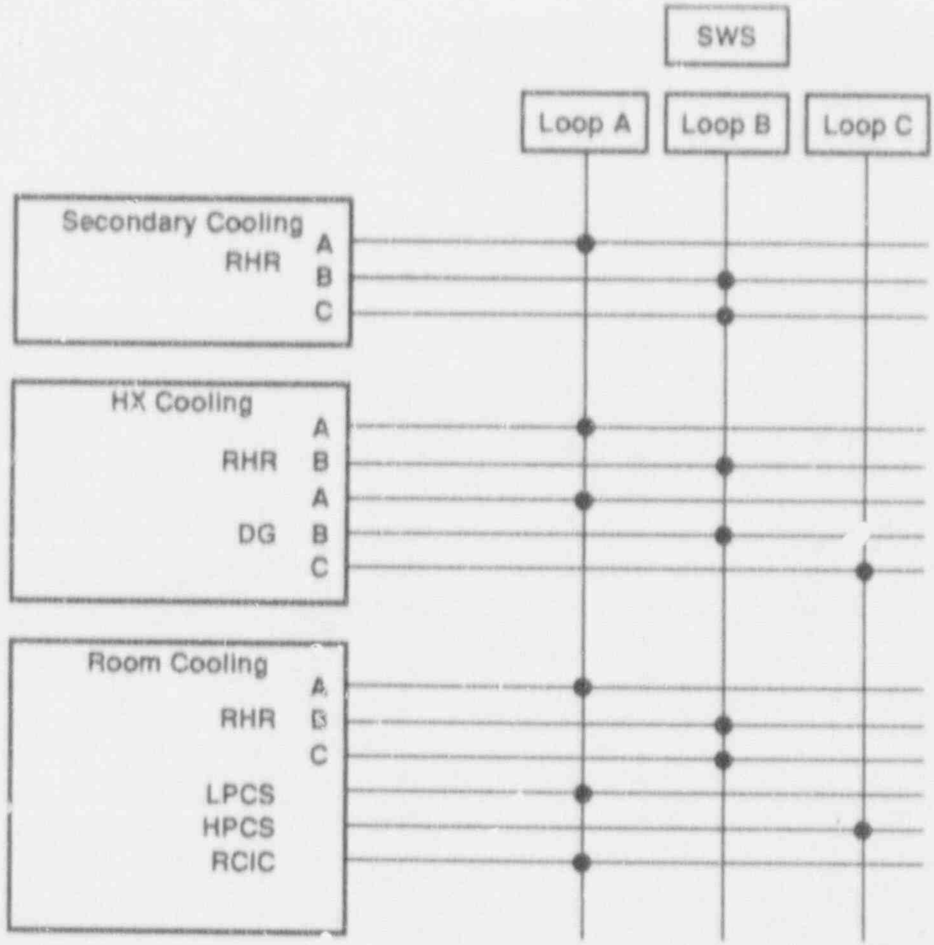

Figure D.4 Grand Gulf Service Water Dependency Diagram

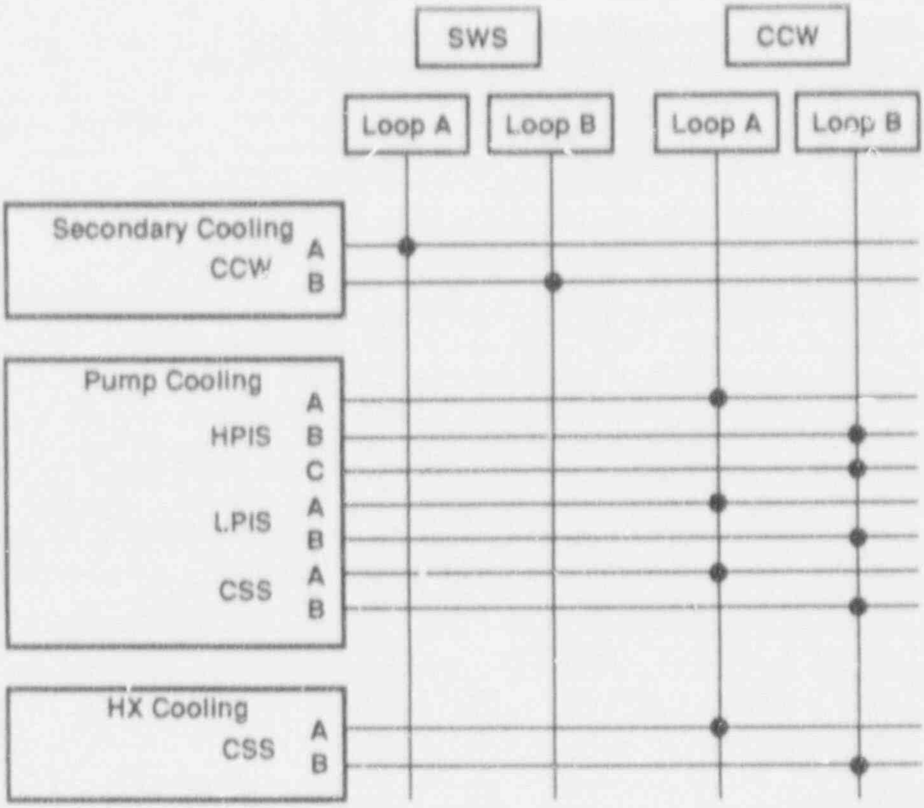

Figure D.5 St. Lucie Service Water Dependency Diagram

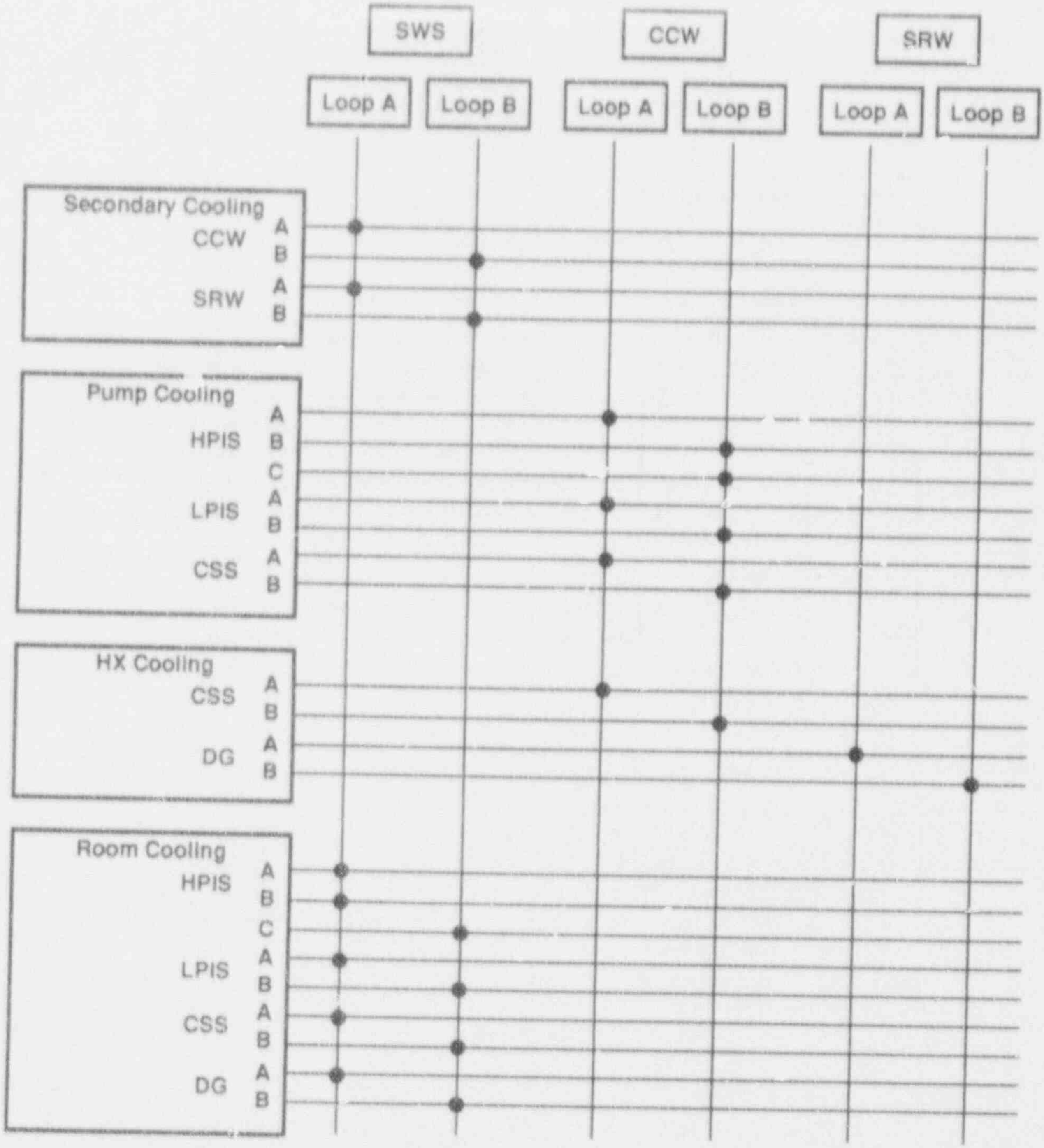

Figure D.6 Calvert Cliffs Service Water Dependency Diagram

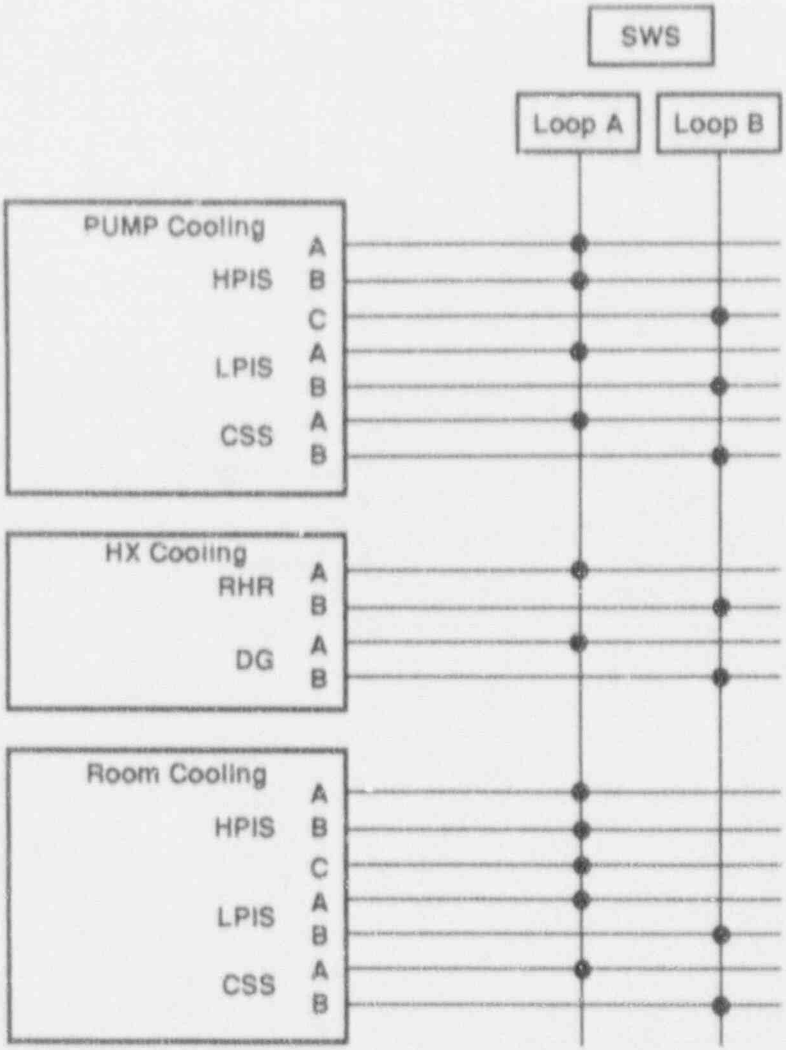

Figure D.7 ANO-1 Service Water Dependency Diagram

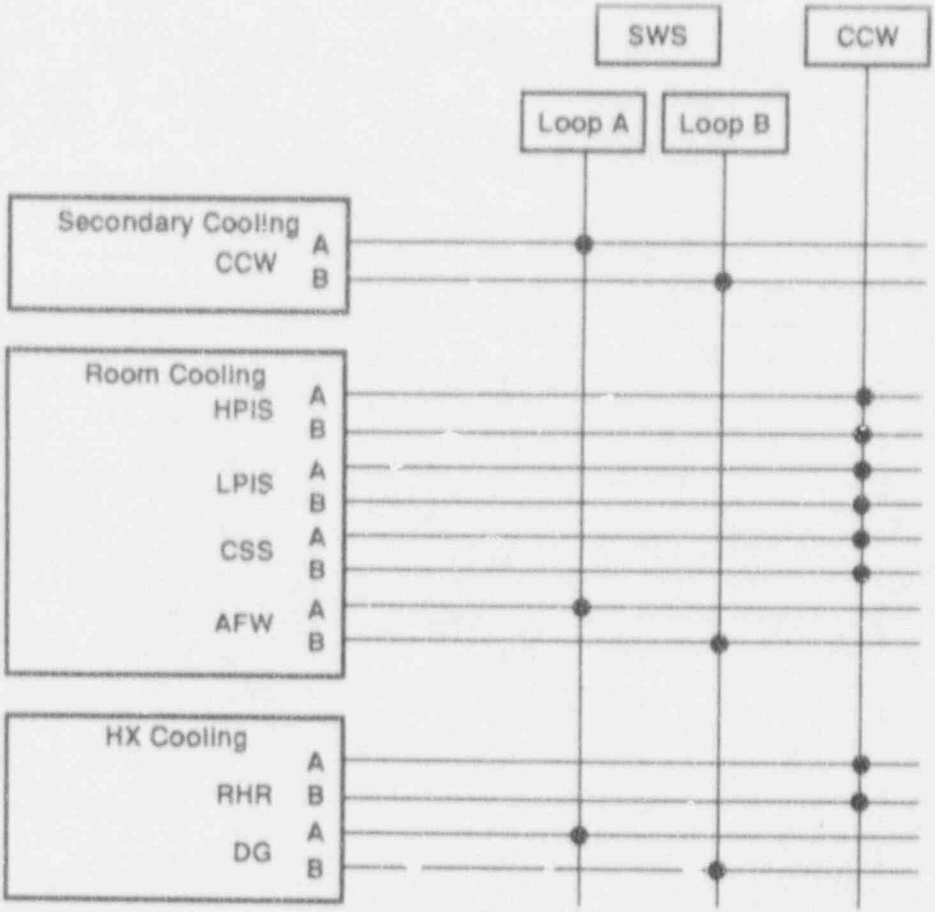

Figure D.8 Point Beach Service Water Dependency Diagram

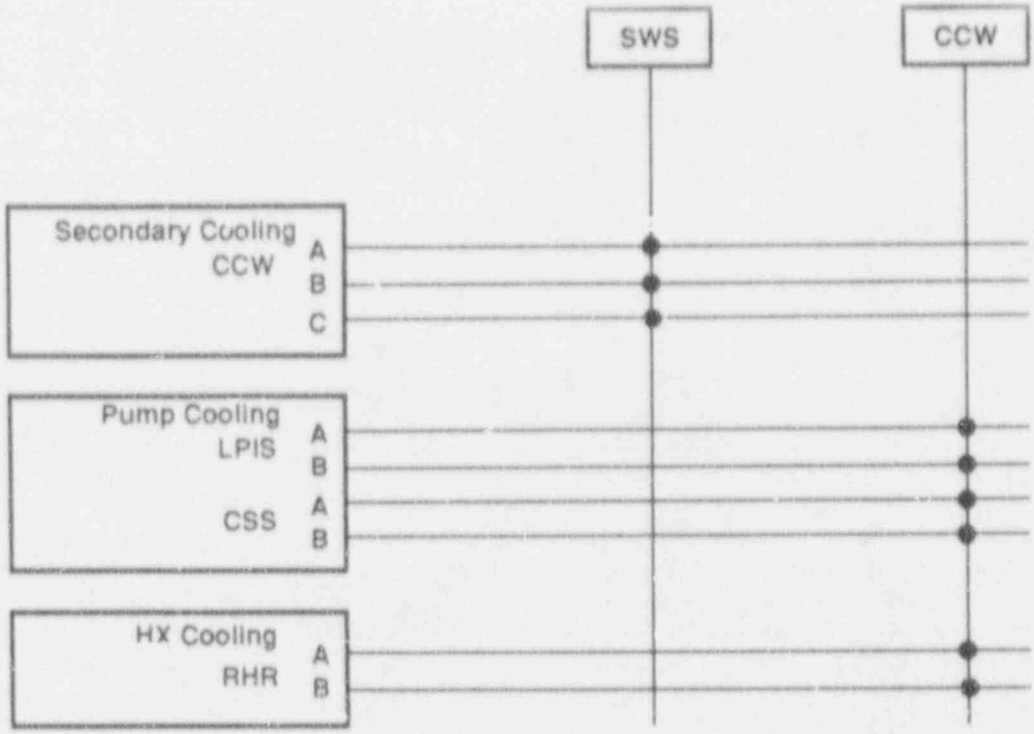

Figure D.9 Turkey Point Service Water Dependency Diagram

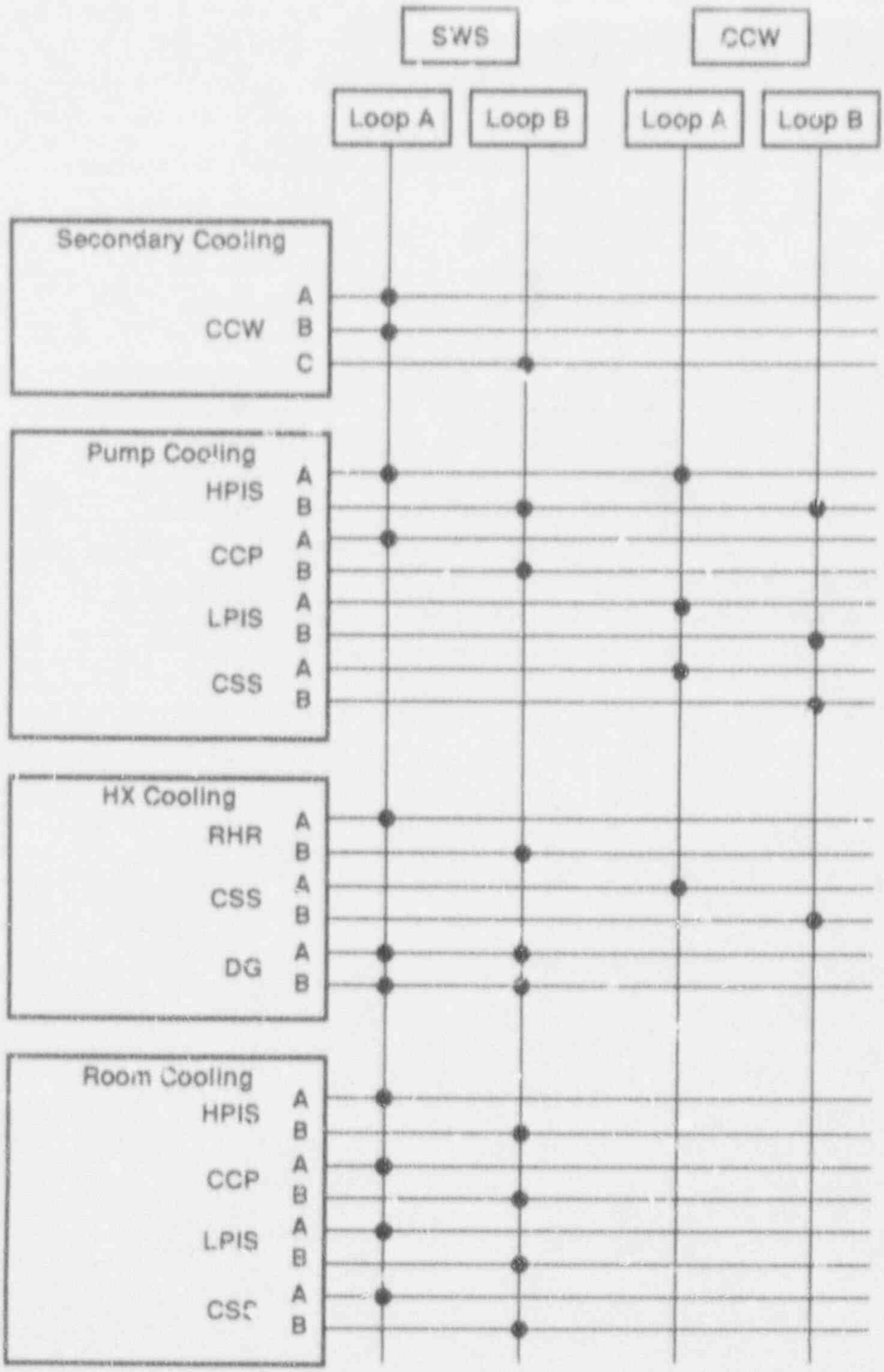

Figure D.10 Sequoyah Service Water Dependency Diagram

APPENDIX E

SWS CONTRIBUTION TO CORE DAMAGE FREQUENCY: SUMMARY OF NRC SPONSORED PRA RESULTS

Table of Contents

Table of Contents

List of Tables

1.0 INTRODUCTION

This appendix documents the review of those NRC sponsored PRAs listed in Table C.1 to determine the contribution cooling water systems (e.g., service water, component cooling water, etc.) make to the total core damage frequency found for each respective PRA.

Table E.1

NRC Sponsored PRAs Reviewed

Plant	Study
Cooper	TAP A-45
Quad Cities 1	TAP A-45
Peach Bottom 2	NUREG/CR-4550
Grand Gulf	NUREG/CR-4550
St. Lucie 1	TAP A-45
Calvert Cliffs 1	IREP
ANO-1	TAP A-45
Point Beach 1	TAP A-45
Turkey Point 1	TAP A-45
Surry 1	NUREG/CR-4550
Sequoyah 1	NUREG/CR-4550

The following sections give for each plant and associated PRA listed a summary of the PRA results in terms of the dominant cooling water events contributing to the core damage frequency and a discussion of the accident sequences in which the events contribute to core damage and the contribution made.

2.0 COOPER NUCLEAR STATION: TAP A-45 STUDY

2.1 COOPER NUCLEAR STATION: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Service Water System (SWS) and Reactor Building Closed Cooling Water (RBCCW) System) which were found to be major contributors to the total core damage frequency (CDF) at the Cooper Nuclear Station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
SWS-LOOP2-UTM	1.40E-05	1
SWS117-VOO-LF	4.81E-06	2
SWS117-VOO-LF*SWS1D-PMS-LF*RA11B	2.90E-06	4
SWS653-VCC-LF*SWS652-VCC-LF	1.59E-06	8
SWS152-XOC-LF	1.20E-07	1
SWS72-XOC-LF	1.20E-07	1
SWS653-VCC-LF	2.38E-08	2
SWS652-VCC-LF	2.38E-08	2
SWS117-VOO-LF*SWS1C-PMS-LF*RA11B	1.70E-08	1
SWS653-VCC-LF*SWS145-XOC-LF	1.30E-08	1
SWS653-VCC-LF*SWS71-XOC-LF	6.80E-09	2
RBC700-VCC-LF	4.34E-05	6
RBC714-VCC-LF	2.90E-05	2
RBC711-VCC-LF*RBC714-VCC-LF	2.42E-05	7
RBC-LOOP2-UTM	2.14E-05	4
RBC700-VOO-LF*RBC1D-PMS-LF	1.86E-05	4
RBC700-VOO-LF*RBC-LOOP1-UTM	1.06E-05	4
RBC700-VOO-LF*RBC-LOOP2-UTM	1.06E-05	4
RBC700-VOO-LF*RBC1C-PMS-LF	2.92E-06	2
RBC700-VOO-LF*RBC1B-PMS-LF	2.92E-06	2
RBC413-XOC-LF	1.20E-07	1
Total SWS Contribution	1.87E-04	
Internal Events Total CDF	2.90E-04	
External Events Total CDF	1.48E-04	
Total CDF	4.38E-04	

Cooper Event Descriptions:

RA11B -	The probability that RBSW valve 117 is not manually isolated within four hours.
RBC-LOOP1-UTM -	Reactor Building Closed Cooling Water system loop 1 unavailable due to maintenance outage.
RBC-LOOP2-UTM -	Reactor Building Closed Cooling Water system loop 2 unavailable due to maintenance outage.
RBC1B-PMS-LF -	Local fault of Reactor Building Closed Cooling Water system pump 1B.
RBC1CD-PMS-LF -	Local fault of Reactor Building Closed Cooling Water system pump 1C.
RBC1D-PMS-LF -	Local fault of Reactor Building Closed Cooling Water system pump 1D.
RBC413-XOC-LF -	Local fault of Reactor Building Closed Cooling Water system manual valve 413.
RBC700-VCC-LF -	Local fault of Reactor Building Closed Cooling Water system valve 700 to isolate nonsafety loads.
RBC711-VCC-LF -	Local fault of Reactor Building Closed Cooling Water system valve 711 to open.
RBC714-VCC-LF -	Local fault of Reactor Building Closed Cooling Water system valve 714 to open.
SWS-LOOP2-UTM -	Reactor Building Service Water system loop 2 unavailable due to a maintenance outage.
SWS1C-PMS-LF -	Local fault of Reactor Building Service Water system pump 1C.
SWS1D-PMS-LF -	Local fault of Reactor Building Service Water system pump 1D.
SWS117-VOO-LF -	Local fault of Reactor Building Service Water system valve 117 to isolate nonsafety loads.
SWS145-XOC-LF -	Local fault of Reactor Building Service Water system valve 145.
SWS152-XOC-LF -	Local fault of service water inlet valve for RHR heat exchanger 1B.
SWS652-VCC-LF -	Local fault of service water outlet valve for RHR heat exchanger 1A
SWS653-VCC-LF -	Local fault of service water outlet valve for RHR heat exchanger 1B.
SWS71-XOC-LF -	Local fault of Reactor Building Service Water system valve 71.
SWS72-XOC-LF -	Local fault of service water header outlet manual valve 72.

2.2 COOPER ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Service Water System (SWS) and Reactor Building Closed Cooling Water (RBCCW) System events appear along with the contribution SW and RBCCW makes to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represents less than 50% of the total sequence frequency.

Sequence T1YZ

This sequence is initiated by a loss-of-offsite power transient (T1) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z). Feedwater injection and the condenser are assumed to be lost following the LOSP.

1.4E-06 Mean CDF <1% of the Total CDF

SSW Basic Events:

SWS653-VCC-LF*SWS652-VCC-LF	5.5E-07
SWS653-VCC-LF*LPCI-LOOP1-UTM	5.8E-08
SWS652-VCC-LF*LPCI-LOOP2-UTM	5.8E-08

These basic events represent failures of the SWS to cool the RHR heat exchangers, i.e., loss of suppression pool cooling.

CDF Contribution = 6.7E-07 which is <1% of the total CDF (2.9E-04)

Sequence T2YZ

This sequence is initiated by a loss of feedwater transient (T2) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

2.6E-06 Mean CDF 1% of the Total CDF

SWS Basic Events:

SWS653-VCC-LF*SWS652-VCC-LF	5.2E-07
SWS653-VCC-LF*LPCI-LOOP1-UTM	1.5E-07
SWS652-VCC-LF*LPCI-LOOP2-UTM	1.5E-07
SWS653-VCC-LF*SWS145-XOC-LF	1.3E-08

These failures represent loss of SPC due to RHR service water valve faults and maintenance outages of LPCI.

CDF Contribution = 8.3E-07 which is <1% of the total CDF (2.9E-04).

Sequence T3YZ

This sequence is initiated by some miscellaneous transient that does not cause feedwater to trip or otherwise affect any safety systems (T3) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

5.0E-07 Mean CDF <1% of the Total CDF

SWS Basic Events:

SWS653-VCC-LF*SWS652-VCC-LF	2.1E-07
SWS653-VCC-LF*LPCI-LOOP1-UTM	2.2E-08
SWS652-VCC-LF*LPCI-LOOP2-UTM	2.2E-08
SWS653-VCC-LF*SWS71-XOC-LF	5.2E-09

These failures represent loss of SPC due to RHR service water valve faults and maintenance outages of LPCI.

CDF Contribution = 2.6E-07 which is <1% of the total CDF (2.9E-04).

Sequence T1YZE

This sequence is initiated by a loss-of-offsite power transient (T1) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E). Feedwater injection and the condenser are assumed to be lost following the LOSP.

4.6E-05 Mean CDF — 16% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	3.2E-06
RBC700-VOO-LF*RBC1C-PMS-LF	2.9E-06
RBC700-VOO*RBC1B-PMS-LF	2.9E-06

These failures represent loss of ECCS room cooling due to RBCCW faults resulting in loss of all ECCS.

CDF Contribution = 9.1E-06 which is 3% of the total CDF (2.9E-04).

Sequence T1YPZE

This sequence is initiated by a loss-of-offsite power transient (T1) followed by a relief valve sticking open (P) and loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E). Feedwater injection and the condenser are assumed to be lost following the LOSP.

3.7E-07 Mean CDF — <1% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	2.6E-08
RBC700-VOO-LF*RBC1C-PMS-LF	2.3E-08
RBC700-VOO-LF*RBC1B-PMS-LF	2.3E-08

These failures represent loss of ECCS room cooling and/or RHR pump seal cooling due to RBCCW faults resulting in loss of all ECCS.

CDF Contribution = 7.2E-08 which is <1% of the total CDF (2.9E-04).

Sequence T2YZE

This sequence is initiated by a loss of feedwater transient (T2) and is followed by loss of the main condenser as a heat sink (Y) failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E).

7.9E-05 Mean CDF 27% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	1.9E-05
RBC700-VOO-LF*RBC1D-PMS-LF	1.7E-05
RBC700-VOO-LF*RBC-LOOP2-UTM	9.7E-06
RBC700-VOO-LF*RBC-LOOP1-UTM	9.7E-06
SWS117-VOO-LF*SWS1D-PMS-LF*RA11B	2.8E-06

These failures represent loss of ECCS room cooling and/or RHR pump seal cooling due to SWS and RBCCW faults resulting in loss of all ECCS. Recovery action RA11B represents failure of the operators to manually isolate the SWS non-critical header (P = 0.1).

CDF Contribution = 5.8E-05 which is 20% of the total CDF (2.9E-04).

Sequence T2PYZE

This sequence is initiated by a loss of feedwater transient (T2) and is followed by a relief valve sticking open (P), loss of the main condenser as a heat sink (Y) failure of all suppression pool cooling (Z) long-term failure of all emergency core cooling (E).

6.4E-07 Mean CDF <1% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	1.6E-07
RBC700-VOO-LF*RBC1D-PMS-LF	1.4E-07
RBC700-VOO-LF*RBC-LOOP2-UTM	7.8E-08
RBC700-VOO-LF*RBC-LOOP1-UTM	7.8E-08
SWS117-VOO-LF*SWS1D-PMS-LF*RA11B	2.3E-08

These failures represent loss of ECCS room cooling and/or RHR pump seal cooling due to RBCCW and SWS faults resulting in loss of all ECCS . Recovery action RA11B represents failure of the operators to manually isolate the SWS non-critical header (P = 0.1).

CDF Contribution = 4.8E-07 which is <1% of the total CDF (2.9E-04).

Sequence T3YZE

This sequence is initiated by some miscellaneous transient that does not cause feedwater to trip or otherwise affect any safety systems (T3) and is followed by loss of the main condenser as a heat sink (Y) failure of all suppression pool cooling (Z), and long-term failure of all emergency core cooling (E).

6.3E-06 Mean CDF 2% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	1.2E-06

RBC700-VOO-LF*RBC1D-PMS-LF	1.1E-06
RBC700-VOO-LF*RBC-LOOP2-UTM	6.2E-07
RBC700-VOO-LF*RBC-LOOP1-UTM	6.2E-07

These failures represent loss of ECCS room cooling due to RBCCW faults resulting in loss of all ECCS.

CDF Contribution = 4.5E-06 which is 2% of the total CDF (2.9E-04).

Sequence SZ

This sequence is initiated by a small loss of coolant accident (S) and is followed by failure of all suppression pool cooling (Z). It was assumed that the main condenser was not available for heat removal following a small LOCA.

1.5E-07 Mean CDF <1% of the Total CDF

SWS Basic Events:

SWS653-VCC-LF*SWS652-VCC-LF	6.3E-08
SWS653-VCC-LF*LPCI-LOOP1-UTM	6.8E-09
SWS652-VCC-LF*LPCI-LOOP2-UTM	6.8E-09
SWS653-VCC-LF*SWS71-XOC-LF	1.6E-09

These failures represent loss of SPC due to failures of RHR service water valves and maintenance outages of LPCI.

CDF Contribution = 7.7E-08 which is <1% of the total CDF (2.9E-04).

Sequence SZE

This sequence is initiated by a small loss of coolant accident (S) and is followed by failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E).

1.5E-06 Mean CDF <1% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	3.7E-07
RBC700-VOO-LF*RBC1D-PMS-LF	3.3E-07
RBC700-VOO-LF*RBC-LOOP2-UTM	1.9E-07
RBC700-VOO-LF*RBC-LOOP1-UTM	1.9E-07
SWS117-VOO-LF*SWS1D-PMS-LF*RA11B	5.6E-08

These failures represent loss of ECCS room cooling, RHR pump seal cooling, or RHR heat exchanger cooling due to SWS and RBCCW faults resulting in loss of all ECCS. Recovery action RA11B represents failure of the operators to manually isolate the SWS non-critical header (p = 0.1).

CDF Contribution = 1.1E-06 which is <1% of the total CDF (2.9E-04).

Sequence T-AC-YZ

This sequence is initiated by a loss of 4160 VAC bus 1F (T-AC) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z). Feedwater injection and the main condenser are assumed to be lost following the initiator

1.7E-06 Mean CDF	1% of the Total CDF

SWS Basic Events:

SWS152-XOC-LF	1.2E-07
SWS72-XOC-LF	1.2E-07
RBC413-XOC-LF	1.2E-07

These failures represent loss of suppression pool cooling due to failures in the SWS and RBCCW system.

CDF Contribution = 3.6E-07 which is <1% of the total CDF (2.9E-04).

Sequence T-AC-YZE

This sequence is initiated by a loss of 4160 VAC bus 1F (T-AC) and is followed by loss of the main condenser as a heat sink (Y), failure of all suppression pool cooling (Z) and long-term emergency core cooling (E). Feedwater injection and the main condenser are assumed to be lost following the initiator

9.5E-05 Mean CDF	33% of the Total CDF

SWS Basic Events:

RBC714-VCC-LF	2.9E-05
RBC700-VOO-LF	2.9E-05
SWS-LOOP2-UTM	1.4E-05
RBC-LOOP2-UTM	1.4E-05
SWS117-VOO-LF*RA11B	4.8E-06

These failures represent loss of ECCS room cooling, RHR pump seal cooling, or RHR heat exchanger cooling due to SWS and RBCCW faults resulting in loss of all ECCS. Recovery action RA11B represents failure of the operators to manually isolate the SWS non-critical header (p = 0.1).

CDF Contribution = 9.1E-05 which is 31% of the total CDF (2.9E-04).

Sequence T-AC-D

This sequence is initiated by a loss of 4160 VAC bus 1F (T-AC) and is followed by immediate failure of all emergency core cooling (D). Feedwater injection was assumed to be lost following this initiator.

2.3E-07 Mean CDF	<1% of the Total CDF

SWS Basic Events:

SWS117-VOO-LF	1.2E-08
RBC714-VCC-LF	2.2E-08
RBC700-VOO-LF	2.2E-08

These failures represent loss of RHR pump seal cooling due to SWS and RBCCW faults.

CDF Contribution = 5.6E-08 which is <1% of the total CDF (2.9E-04).

Sequence T-DC-YZ

This sequence is initiated by a loss of 125 VDC Battery Bus 1A (T-DC) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

1.2E-07 Mean CDF	<1% of the Total CDF

SWS Basic Events:

SWS653-VCC-LF*SWS652-VCC-LF	1.9E-08
SWS653-VCC-LF*LCI1CB-PMS-LF	1.7E-08
SWS652-VCC-LF*LCI1DB-PMS-LF	1.7E-08

These basic events are failures of RHR heat exchangers, i.e., loss of suppression pool cooling due to SWS faults.

CDF Contribution = 5.3E-08 which is <1% of the total CDF (2.9E-04).

Sequence T-DC-YZE

This sequence is initiated by a loss of 125 VDC Battery Bus 1A (T-DC) and is followed by loss of the main condenser as a heat sink (Y), failure of all suppression pool cooling (Z), and long-term emergency core cooling(E). Feedwater injection and the condenser are assumed to be lost following the initiator.

2.2E-05 Mean CDF	8% of the Total CDF

SWS Basic Events:

RBC711-VCC-LF*RBC714-VCC-LF	1.2E-07
RBC700-VOO-LF	1.4E-05
RBC-LOOP2-UTM	7.2E-06
SWS117-VOO-LF*SWS1C-PMS-LF*RA11B	1.7E-08
SWS117-VOO-LF*SWS1D-PMS-LF*RA11B	1.7E-08

These failures represent loss of ECCS room cooling and or pump cooling resulting in loss of all ECCS. Recovery action RA11B represents failure of the operators to manually isolate the SWS non-critical header (P = 0.1).

CDF Contribution = 2.1E-05 which is 7% of the total CDF (2.9E-04).

Sequence T-DC-D

This sequence is initiated by a loss of 125 VDC Battery Bus 1A (T-DC) and is followed by immediate failure of all emergency core cooling. Feedwater injection is assumed to be lost following the initiator.

9.8E-07 Mean CDF	<1% of the Total CDF

SWS Basic Events:

RBC700-VOO-LF	3.6E-07
RBC-LOOP2-UTM	1.8E-07

These failures represent loss of RHR pump lube oil cooling resulting in loss of RHR.

CDF Contribution = 5.4E-07 which is <1% of the total CDF (2.9E-04).

3.0 QUAD CITIES: TAP A-45 STUDY

3.1 QUAD CITIES: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Residual Heat Removal Service Water System (SWS) and Diesel Generator Cooling Water (DGCW) System) which were found to be major contributors to the total core damage frequency (CDF) at the Quad Cities nuclear station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
RSW-LOOP1-UTM	1.90E-05	3
DSW39031-PMS-LF	2.31E-06	3
RSW-PUMP-CM	2.11E-06	2
DSW3903S-PMS-LF	1.91E-06	3
DSW-PUMP-CM*RA12B	1.86E-06	3
RSW182BX-XOC-LF	9.60E-07	1
RSW182AX-XOC-LF	9.60E-07	1
RSW-PUMP-CM*DSW39031-PMS-LF*RA12B	5.00E-07	1
RSW-PUMP-CM*RA12C	2.68E-07	3
RSW-PUMP-CM*DSW-DGN1-UTM*RA12B	8.50E-08	1
DSW-DGN1-UTM	8.50E-08	1
RSW-LOOP2-UTM	3.60E-08	1
RSW-LOOP2-UTM*RA3C	2.64E-08	2
RSW182DX-XOC-LF	1.80E-09	1
RSW-LOOP2-UTM*DSW3903S-PMS-LF	4.40E-09	1
RSW-LOOP2-UTM*RSW182AX-XOC-LF	6.50E-09	1
Total	3.01E-05	

Internal Events CDF	9.90E-05
External Events CDF	9.74E-05
Total	1.96E-04

Quad Cities Event Descriptions:

DSW-DGN1-UTM - Diesel Generator Service Water System Loop 1 unavailable due to maintenance outage.

DSW-PUMP-CM - Common mode failure of all Diesel Generator Service Water pumps.

DSW3903S-PMS-LF - Local fault of Diesel Generator 1/2 Service Water pump.

DSW39031-PMS-LF - Local fault of Diesel Generator Service Water pump 1.

RA3C - The probability of not recovering a system subtrain or a component from a maintenance outage within 24 hours.

RA12B - The probability that a pump common-mode failure is not recovered within four hours.

RA12C - The probability that a pump common-mode failure is not recovered within twenty four hours.

RSW-LOOP1-UTM - RHR Service Water System Loop 1 unavailable due to maintenance outage.

RSW-LOOP2-UTM - RHR Service Water System Loop 2 unavailable due to maintenance outage.

RSW-PUMP-CM - Common mode failure of all RHR Service Water pumps.

RSW182AX-XOC-LF - Local fault of RHR Service Water System seal cooling inlet valve 1001-182A.

RSW182BX-XOC-LF - Local fault of RHR Service Water System seal cooling outlet valve 1001-182B.

RSW182DX-XOC-LF - Local fault of RHR Service Water System seal cooling outlet valve 1001-182D.

3.2 QUAD CITIES ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Residual Heat Removal Service Water (RHRSW) System and Diesel Generator Service Water (DGSW) System events appear along with the contribution RHRSW and DGSW makes to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represents less than 50% of the total sequence frequency.

Sequence T1YZ

This sequence is initiated by a loss-of-offsite power transient (T1) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

1.1E-06 Mean CDF 1% of the Total CDF

SWS Basic Events:

RSW-PUMP-CM	5.1E-07
RSW-LOOP2-UTM*RA3C	2.4E-08
RSW-LOOP2-UTM*DSW3903S-PMS-LF	4.4E-09

These basic events are failures of RHR service water pumps, i.e., loss of suppression pool cooling. Recovery action RA3C represents failure of the operator to restoring RSW loop 2 from maintenance within 24 hours.

CDF Contribution = 5.4E-07 which is <1% of the total CDF (9.9E-05).

Sequence T2YZ

This sequence is initiated by a loss of feedwater transient (T2) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

3.4E-06 Mean CDF 3% of the Total CDF

SWS Basic Events:

RSW-PUMP-CM	1.6E-06
RSW-LOOP1-UTM	1.3E-08
RSW-LOOP2-UTM*RSW182AX-XOC-LF	6.5E-09

These failures represent loss of SPC due to common mode failure of the RHR service water pumps and failures of RHR service water and LPCI valve faults and maintenance outages of an RHR service water loop.

CDF Contribution = 1.6E-06 which is 2% of the total CDF (9.9E-05).

Sequence T3YZ

This sequence is initiated by some miscellaneous transient that does not cause feedwater to trip or otherwise affect any safety systems (T3) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

4.1E-07 Mean CDF <1% of the Total CDF

SWS Basic Events:

RSW-PUMP-CM*RA12C	1.9E-07
RSW-LOOP2-UTM*RA3C	4.4E-09

These failures represent loss of SPC due to common cause failure of RHR service water pumps and maintenance outages of one loop of RHR service water along with diesel generator faults. Recovery action RA3C represents failure of the operator to restoring RSW loop 2 from maintenance within 24 hours. Recovery action RA12C represents failure to recover common mode failure of the pumps within twenty four hours.

CDF Contribution = 1.9E-07 which is <1% of the total CDF (9.9E-05).

Sequence T1YZE

This sequence is initiated by a loss-of-offsite power transient (T1) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E). Feedwater injection and the condenser are assumed to be lost following the LOSP.

2.3E-05 Mean CDF	23% of the Total CDF

SWS Basic Events:

DSW3903S-PMS-LF	1.8E-06
DSW39031-PMS-LF	1.8E-06
DSW-PUMP-CM*RA12B	1.2E-06

These failures represent faults of the diesel generator service water system. Recovery action RA12B represents failure of the operator to recover common mode failure of the DSW pumps within 4 hours.

CDF Contribution = 4.8E-06 which is 5% of the total CDF (9.9E-05).

Sequence T1PYZE

This sequence is initiated by a loss-of-offsite power transient (T1) followed by a relief valve sticking open (P) and loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E). Feedwater injection and the condenser are assumed to be lost following the LOSP.

1.9E-07 Mean CDF	<1% of the Total CDF

SWS Basic Events:

DSW3903S-PMS-LF	1.5E-08
DSW39031-PMS-LF	1.5E-08
DSW-PUMP-CM*RA12B	1.0E-08

These failures represent faults of the diesel generator service water system. Failure of the diesel cooling water pump fails ECCS room cooling. Recovery action RA12B represents failure of the operator to recover common mode failure of the DSW pumps within 4 hours.

CDF Contribution = 4.0E-08 which is <1% of the total CDF (9.9E-05).

Sequence T2YZE

This sequence is initiated by a loss of feedwater transient (T2) and is followed by loss of the main condenser as a heat sink (Y) failure of all suppression pool cooling (Z) and long-term failure of all emergency core cooling (E).

1.3E-06 Mean CDF 1% of the Total CDF

SWS Basic Events:

RSW-PUMP-CM*DSW39031-PMS-LF*RA12B	5.0E-07
DSW39031-PMS-LF	5.0E-07
RSW-PUMP-CM*DSW-DGN1-UTM*RA12B	8.5E-08
DSW-DGN1-UTM	8.5E-08

These failures represent faults of the diesel generator service water system and common mode failure of the RHR service water pumps. Failure of the diesel cooling water pump fails ECCS room cooling. Recovery action RA12B represents failure to recover common mode failure of the pumps within four hours.

CDF Contribution = 1.2E-06 which is 1% of the total CDF (9.9E-05).

Sequence T3YZE

This sequence is initiated by some miscellaneous transient that does not cause feedwater to trip or otherwise affect any safety systems (T3) and is followed by loss of the main condenser as a heat sink (Y) failure of all suppression pool cooling (Z), and long-term failure of all emergency core cooling (E).

1.1E-06 Mean CDF 1% of the Total CDF

SWS Basic Events:

DSW-PUMP-CM*RA12B	6.5E-07
DSW39031-PMS-LF	9.9E-08
DSW3903S-PMS-LF	9.9E-08

These failures represent diesel generator failures due to diesel generator service water faults and common mode DSW pump faults. Recovery action RA12B represents failure of the operator to recover common mode failure of the DSW pumps within 4 hours.

CDF Contribution = 8.5E-07 which is 1% of the total CDF (9.9E-05).

Sequence SZ

This sequence is initiated by a small loss of coolant accident (S) and is followed by failure of all suppression pool cooling (Z). It was assumed that the main condenser was not available for heat removal following a small LOCA.

1.3E-07 Mean CDF <1% of the Total CDF

SWS Basic Events:

RSW-PUMP-CM*RA12C	6.0E-08

This failure represents loss of SPC due to common mode failure of RHR service water pumps. Recovery action RA12C represents failure of the operator to recover common mode failure of the RSW pumps within 24 hours.

CDF Contribution = 6.0E-08 which is < 1% of the total CDF (9.9E-05).

Sequence T-AC-YZE

This sequence is initiated by a loss of 4160 VAC bus 14-1 (T-AC) and is followed by loss of the main condenser as a heat sink (Y), failure of all suppression pool cooling (Z) and long-term emergency core cooling (E). Feedwater injection and the main condenser are assumed to be lost following the initiator.

3.7E-05 Mean CDF	37% of the Total CDF

SWS Basic Events:

RSW-LOOP1-UTM	1.9E-05
RSW182AX-XOC-LF	9.6E-07
RSW182BX-XOC-LF	9.6E-07

These failures represent loss of a service water loop due to maintenance outage or loop valve faults which fail one-half of SPC. One-half of SPC is lost by the initiator.

CDF Contribution = 2.1E-05 which is 21% of the total CDF (9.9E-05).

Sequence T-DC-YZ

This sequence is initiated by a loss of 125 VDC Battery Bus 1 (T-DC) and is followed by loss of the main condenser as a heat sink (Y) and failure of all suppression pool cooling (Z).

1.1E-07 Mean CDF	< 1% of the Total CDF

SWS Basic Events:

RSW-LOOP2-UTM	3.6E-08
RSW-PUMP-CM*RA12C	1.8E-08
RSW182DX-XOC-LF	1.8E-09

These basic events represent RHR Service Water unavailabilities which fail SPC.

CDF Contribution = 5.6E-08 which is < 1% of the total CDF (9.9E-05).

4.0 PEACH BOTTOM: NUREG/CR-4550

4.1 PEACH BOTTOM UNIT 2 : 4550 ANALYSIS SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Emergency Service Water (ESW) System) found to be major contributors to the total core damage frequency (CDF) at the Peach Bottom Unit 2 nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events

Basic Event	Contribution to CDF	# Cutsets
ESW-XHE-FO-EHS	6.20E-07	795
ESW-CKV-CB-C515A	9.84E-08	175
ESW-CKV-CB-C515B	9.84E-08	175
ESW-AOV-CC-CCF	9.75E-08	35
ESW-MDP-FS-MDPA	8.29E-09	75
ESW-MDP-FS-MDPB	8.29E-09	75
ESW-PTF-RE-DGC	7.88E-09	40
ESW-PTF-RE-DGB	7.88E-09	40
ESW-PTF-RE-MDPA	4.62E-09	35
ESW-PTF-RE-MDPB	4.62E-09	35
ESW-MDP-MA-MDPA	4.[illegible]9E-09	65
ESW-MDP-MA-MDPB	4.39E-09	65
ESW-CKV-HW-CV513	4.25E-0[illegible]	2
ESW-MDP-FS-CCF*BETA-2SWPS	2.0[illegible]E-09	35
ESW-XVM-PG-XV502	1.58E-09	1
ESW-AOV-CC-0241B	1.26E-09	95
ESW-AOV-CC-0241C	1.26E-09	95
ESW-MDP-FR-MDPA	9.17E-10	85
ESW-MDP-FR-MDPB	9.17E-10	85
ESW-MDP-FS-ECW	5.51E-1	10
NSW-SYS-FO-NSW-1	3.00E-10	1
ESW-MDP-MA-ECW	2.50E-10	5
ESW-AOV-MA-0241B	3.56E-11	10
ESW-AOV-MA-0241C	3.56E-11	10
ESW-XVM-PG-XV505B	1.41E-11	5
ESW-XVM-PG-XV505C	1.41E-11	5
ESW-CKV-HW-C515A	1.11E-11	10
ESW-CKV-HW-C515B	1.11E-11	10
ESW-XVM-PG-XV510	1.01E-12	5
ESW-XVM-PG-XV509	1.01E-12	5
ESW-XVM-PG-XV507A	1.01E-12	5
ESW-XVM-PG-XV507B	1.01E-12	5
Total	9.78E-07	
Internal Events CDF	4.50E-06	
External Events CDF	9.70E-05	
Total	1.02E-04	

Peach Bottom Event Descriptions:

ESW-AOV-CC-CCF -	Common cause failure of air operated valves (various valves) to open.
ESW-AOV-CC-0241B -	Air operated valve 0241B fails to open.
ESW-AOV-CC-0241C -	Air operated valve 0241C fails to open.
ESW-AOV-MA-0241B -	Valve 0241B out for maintenance.
ESW-AOV-MA-0241C -	Valve 0241C out for maintenance.
ESW-CKV-CB-C515A -	Check valve 515A fails due to back leakage.
ESW-CKV-CB-C515B -	Check valve 515B fails due to back leakage.
ESW-CKV-HW-CV513 -	Check valve 513 fails to open.
ESW-CKV-HW-C515A -	Check valve 515A fails to open.
ESW-CKV-HW-C515B -	Check valve 515b fails to open.
ESW-MDP-FR-MDPA -	ESW pump A fails to run.
ESW-MDP-FR-MDPB -	ESW pump B fails to run.
ESW-MDP-FS-CCF -	Common mode failure of ESW pumps to start.
ESW-MDP-FS-ECW -	Emergency cooling water pump fails to start.
ESW-MDP-FS-MDPA -	ESW pump A fails to start.
ESW-MDP-FS-MDPB -	ESW pump B fails to start.
ESW-MDP-MA-ECW -	Emergency cooling water pump out for maintenance.
ESW-MDP-MA-MDPA -	ESW pump A out for maintenance.
ESW-MDP-MA-MDPB -	ESW pump B out for maintenance.
ESW-PTF-RE-DGC -	Failure to restore DGN C cooling components after maintenance.
ESW-PTF-RE-DGB -	Failure to restore DGN B cooling components after maintenance.
ESW-PTF-RE-MDPA -	Failure to restore ESW pump A trains after maintenance.
ESW-PTF-RE-MDPB -	Failure to restore ESW pump B trains after maintenance.
ESW-XHE-FO-EHS -	Failure of operator to initiate emergency heat sink.
ESW-XVM-PG-XV502 -	Manual valve 502 fails due to plugging.

Peach Bottom Event Descriptions (Continued):

ESW-XVM-PG-XV505B - Manual valve 505B fails due to plugging.

ESW-XVM-PG-XV505C - Manual valve 505C fails due to plugging.

ESW-XVM-PG-XV507A - Manual valve 507A fails due to plugging.

ESW-XVM-PG-XV507B - Manual valve 507B fails due to plugging.

ESW-XVM-PG-XV509 - Manual valve 509 fails due to plugging.

ESW-XVM-PG-XV510 - Manual valve 510 fails due to plugging.

NSW-SYS-FO-NSW-1 - Normal Service Water fails to operate given PCS failed or isolated.

4.2 PEACH BOTTOM ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS NUREG/CR-4550 ANALYSIS

The following presents the NUREG/CR-4550 accident sequences in which Emergency Service Water (ESW) System events appear along with the contribution ESW makes to the total CDF for the given accident sequence.

SEQUENCE T1-BNU11

This accident sequence is initiated by a loss of offsite power (T1) with subsequent failure of all diesel generators (B), which results in a station blackout.

1.64E-06 Mean CDF 36.4% of the Total CDF

SWS Basic Events:

ESW-XHE-FO-EHS	5.36E-07
ESW-CKV-CB-C515A	8.53E-08
ESW-CKV-CB-C515B	8.57E-08
ESW-AOV-CC-CCF	8.18E-08
ESW-PTF-RE-DGB	7.20E-09
ESW-PTF-RE-DGC	7.20E-09
ESW-MDP-FS-MDPA	7.10E-09
ESW-MDP-FS-MDPB	7.10E-09
ESW-PTF-RE-MDPA	4.20E-09
ESW-PTF-RE-MDPB	4.20E-09
ESW-MDP-MA-MDPA	3.80E-09
ESW-MDP-MA-MDPB	3.80E-09
ESW-MDP-FS CCF*BETA-2SWPS	2.07E-09
ESW-AOV-CC-0241B	1.10E-09
ESW-AOV-CC-0241C	1.10E-09
ESW-MDP-FR-MDPA	9.00E-10
ESW-MDP-FR-MDPB	9.00E-10
ESW-AOV-MA-0241B	4.00E-11
ESW-AOV-MA-0241C	4.00E-11
ESW-CKV-HW-C515A	1.00E-11
ESW-CKV-HW-C515B	1.00E-11

These basic events represent failure of the operator to initiate the emergency heat sink and ESW faults which prevent the ESW from meeting its success criteria for cooling the emergency diesel generators and HPCI pump room cooler, thus resulting in the loss of onsite power and long term failure of HPCI.

CDF Contribution = 8.39E-07 which is 19% of the total CDF (4.5E-06).

SEQUENCE T1-P1BNU11

This accident sequence is initiated by a loss of offsite power (T1) followed by one stuck open relief valve (P1). Subsequent failure of all diesel generators (B) results in a station blackout.

1.31E-07 Mean CDF 2.9% of the Total CDF

Basic Events:

ESW-XHE-FO-EHS	4.51E-08
ESW-AOV-CC-CCF	7.85E-09
ESW-CKV-CB-C515A	7.75E-09
ESW-CKV-CB-C515B	7.75E-09
ESW-PTF-RE-DGB	7.00E-10
ESW-PTF-RE-DGC	7.00E-10
ESW-MDP-FS-MDPA	6.50E-10
ESW-MDP-FS-MDPB	6.50E-10
ESW-PTF-RE-MDPA	4.00E-10
ESW-PTF-RE-MDPB	4.00E-10
ESW-MDP-MA-MDPA	3.50E-10
ESW-MDP-MA-MDPB	3.50E-10
ESW-AOV-CC-0241B	1.10E-10
ESW-AOV-CC-0241C	1.10E-10
ESW-MDP-FR-MDPA	8.00E-11
ESW-MDP-FR-MDPB	8.00E-11

These basic events represent failure of the operator to initiate the emergency heat sink and ESW faults which prevent the ESW from meeting its success criteria for cooling the emergency diesel generators and HPCI room coolers, thus resulting in the loss of onsite power and long term failure of HPCI.

CDF Contribution = 7.34E-08 which is 2% of the total CDF (4.5E-06).

T1-BU11NU21

This sequence is initiated by a loss of offsite power (T1), followed by loss of all diesels (B) which results in a station blackout.

1.25E-07 Mean CDF	2.7% of the Total CDF

Basic Events:

ESW-XHE-FO-EHS	3.89E-08
ESW-AOV-CC-CCF	7.85E-09
ESW-CKV-CB-C515A	5.18E-09
ESW-CKV-CB-C515B	5.18E-09
ESW-MDP-FS-MDPA	5.40E-10
ESW-MDP-FS-MDPB	5.40E-10
ESW-MDP-MA-MDPA	1.90E-10
ESW-MDP-MA-MDPB	1.90E-10
ESW-PTF-RE-MDPA	2.00E-12
ESW-PTF-RE-MDPB	2.00E-12

These basic events represent failure of the operator to initiate the emergency heat sink and ESW faults which prevent the ESW from meeting its success criteria for cooling the emergency diesel generators and RCIC room coolers, thus resulting in the loss of onsite power and long term failure of RCIC.

CDF Contribution = 5.88E-08 which is 1% of the total CDF (4.5E-06).

T1-P2V234NU11B

This is a loss of offsite power transient (T1) not leading to a station blackout.

8.73E-08 Mean CDF	1.9% of the Total CDF

Basic Events:

ESW-CKV-HW-CV513	3.95E-09
ESW-XVM-PG-XV502	1.58E-09

These basic events represent failure of the ESW to provided ECCS pump cooling and ECCS room cooling. This loss of cooling results in failure of the low pressure systems (i.e., LPCI and LPCS) when demanded.

CDF Contribution = 5.5E-09 which is <1% of the total CDF (4.5E-06).

5.0 GRAND GULF: NUREG/CR-4550

5.1 GRAND GULF UNIT 1: 1150 ANALYSIS SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Standby Service Water (SSW) System) found to be major contributors to the total core damage frequency (CDF) at the Grand Gulf nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
BETA-3SSW*SSW-MDP-FS-CM	1.68E-07	52
SSW-MDP-FS-MDP2C	6.00E-08	292
SSW-MOV-CC-MV11	6.00E-08	290
SSW-MOV-CC-MV1A	3.50E-08	234
SSW-MDP-FS-MDP1A	3.50E-08	232
SSW-MOV-CC-MV5A	3.50E-08	232
SSW-MOV-CC-MV5B	3.49E-08	231
SSW-MOV-CC-MV18B	3.49E-08	231
SSW-MDP-FS-MDP1B	3.49E-08	231
SSW-MOV-CC-MV1B	3.49E-08	231
SSW-MOV-CC-MV18A	3.49E-08	231
SSW-MDP-MA-MDP2C	3.37E-08	183
SSW-XHE-RE-TAB2	1.97E-08	184
SSW-XHE-RE-TAB4	1.97E-08	183
SSW-MDP-MA-MDP1A	1.85E-08	148
SSW-MDP-MA-MDP1B	1.83E-08	142
SSW-MDP-FR-MDP2C	9.35E-09	87
SSW-MOV-MA-MV11	8.17E-09	31
SSW-MDP-FR-MDP1A	4.84E-09	72
SSW-MDP-FR-MDP1B	4.84E-09	69
SSW-XHE-RE-SSWC	4.21E-09	34
SSW-MOV-MA-MV1A	3.45E-09	23
SSW-MOV-MA-MV5A	3.45E-09	23
SSW-MOV-MA-MV5B	3.44E-09	20
SSW-MOV-MA-MV18A	3.44E-09	20
SSW-MOV-MA-MV1B	3.44E-09	20
SSW-MOV-MA-MV18B	3.44E-09	20
SSW-XHE-RE-SSWA	1.08E-09	19
SSW-XHE-RE-SSWB	1.08E-09	19
SSW-CKV-HW-CV12	8.05E-10	15
SSW-HTX-PG-HX1	6.70E-10	15
SSW-HTX-PG-HX01	6.70E-10	15
SSW-HTX-PG-HX1C	4.59E-10	1
SSW-HTX-PG-HX4A	3.05E-10	10
SSW-HTX-PG-HX4B	3.05E-10	10
SSW-HTX-PG-HX1A	3.05E-10	10
SSW-HTX-PG-HX1B	3.05E-10	10
SSW-CKV-HW-CV8A	2.16E-10	9
SSW-CKV-HW-CV8B	2.16E-10	9
SSW-XVM-PG-XV13	1.36E-10	3
SSW-XVM-PG-XV60	1.31E-10	1
SSW-XVM-PG-XV54B	1.31E-10	1
SSW-XVM-PG-V186A	5.02E-12	2
SSW-XVM-PG-V186B	5.02E-12	2
SSW-XVM-PG-V185A	5.02E-12	2
SSW-XVM-PG-V185B	5.02E-12	2
SSW-XVM-PG-XV23A	2.21E-12	1
SSW-XVM-PG-XV23B	2.21E-12	1
SSW-XVM-PG-V199A	2.21E-12	1

SSW-XVM-PO-V199B	2.21E-12	1
Total	5.6E-07	
CDF INTERNAL EVENTS	4.05E-06	

Grand Gulf Event Descriptions:

BETA-3SSW -	Common cause beta factor for three motor driven pumps to start.
SSW-CKV-HW-CV8A -	SSW pump 1A discharge check valve 8A fails to open.
SSW-CKV-HW-CV8B -	SSW pump 1B discharge check valve 8B fails to open.
SSW-CKV-HW-CV12 -	SSW pumps 2C discharge check valve 12 fails to open.
SSW-HTX-PG-HX1 -	Heat exchanger HX1 fails due to plugging.
SSW-HTX-PG-HX01 -	Heat exchanger HX01 fails due to plugging.
SSW-HTX-PG-HX1A -	Heat exchanger HX1A fails due to plugging.
SSW-HTX-PG-HX1B -	Heat exchanger HX1B fails due to plugging.
SSW-HTX-PG-HX1C -	Heat exchanger HX1C fails due to plugging.
SSW-HTX-PG-HX4A -	Heat exchanger HX4A fails due to plugging.
SSW-HTX-PG-HX4B -	Heat exchanger HX4B fails due to plugging.
SSW-MDP-FR-MDP1A -	Motor-driven pump 1A fails to run.
SSW-MDP-FR-MDP1B -	Motor-driven pump 1B fails to run.
SSW-MDP-FR-MDP2C -	Motor-driven pump 2C fails to run.
SSW-MDP-FS-CM -	Common cause failure of motor driven pumps to start.
SSW-MDP-FS-MDP1A -	Motor-driven pump 1A fails to start.
SSW-MDP-FS-MDP1B -	Motor-driven pump 1B fails to start.
SSW-MDP-FS-MDF2C -	Motor-driven pump 2C fails to start.
SSW-MDP-MA-MDP1A -	Motor-driven pump 1A unavailable due to maintenance.
SSW-MDP-MA-MDP1B -	Motor-driven pump 1B unavailable due to maintenance.
SSW-MDP-MA-MDP2C -	Motor-driven pump 2C unavailable due to maintenance.
SSW-MOV-CC-MV1A -	Motor-operated valve 1A fails to open.
SSW-MOV-CC-MV1B -	Motor-operated valve 1B fails to open.
SSW-MOV-CC-MV11 -	Motor-operated valve 11 fails to open.
SSW-MOV-CC-MV5A -	Motor-operated valve 5A fails to open.

Grand Gulf Event Descriptions (Continued):

SSW-MOV-CC-MV5B - Motor-operated valve 5B fails to open.

SSW-MOV-CC-MV18A - Motor-operated valve 18A fails to open.

SSW-MOV-CC-MV18B - Motor-operated valve 18B fails to open.

SSW-MOV-MA-MV1A - Motor-operated valve 1A unavailable due to maintenance.

SSW-MOV-MA-MV1B - Motor-operated valve 1B unavailable due to maintenance.

SSW-MOV-MA-MV5A - Motor-operated valve 5A unavailable due to maintenance.

SSW-MOV-MA-MV5B - Motor-operated valve 5B unavailable due to maintenance.

SSW-MOV-MA-MV11 - Motor-operated valve 11 unavailable due to maintenance.

SSW-MOV-MA-MV18A - Motor-operated valve 18A unavailable due to maintenance.

SSW-MOV-MA-MV18B - Motor-operated valve 18B unavailable due to maintenance.

SSW-XHE-RE-SSWA - Human error: failure to restore SSW train A after maintenance.

SSW-XHE-RE-SSWB - Human error: failure to restore SSW train B after maintenance.

SSW-XHE-RE-SSWC - Human error: failure to restore SSW train C after maintenance.

SSW-XHE-RE-TAB2 - Failure to restore SSW train A after maintenance.

SSW-XHE-RE-TAB4 - Failure to restore SSW train B after maintenance.

SSW-XVM-PG-XV13 - Manual valve 13 fails due to plugging.

SSW-XVM-PG-XV23A - Manual valve 23A fails due to plugging.

SSW-XVM-PG-XV23B - Manual valve 23B fails due to plugging.

SSW-XVM-PG-XV54B - Manual valve 54B fails due to plugging.

SSW-XVM-PG-XV60 - Manual valve 60 fails due to plugging.

SSW-XVM-PG-V185A - Manual valve 185A fails due to plugging.

SSW-XVM-PG-V185B - Manual valve 185B fails due to plugging.

SSW-XVM-PG-V186A - Manual valve 186A fails due to plugging.

SSW-XVM-PG-V186B - Manual valve 186B fails due to plugging.

SSW-XVM-PG-V199A - Manual valve 199A fails due to plugging.

SSW-XVM-PG-V199B - Manual valve 199B fails due to plugging.

5.2 GRAND GULF ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: NUREG/CR-1150 ANALYSIS

The following presents the NUREG/CR-4550 accident sequences in which Standby Service Water (SSW) System events appear along with the contribution SSW makes to the total CDF for the given accident sequence.

Sequence TBSEQ16

This sequence is initiated by loss of offsite power (T1) followed by loss of all three diesel generators and failure of RCIC.

3.6E-06 Mean CDF	89% of the Total CDF
Basic Events:	
BETA-3SSW*SSW-MDP-FS-CM	1.56E-07
SSW-MDP-FS-MDP2C	4.60E-08
SSW-MOV-CC-MV11	4.60E-08
SSW-MOV-CC-MV1A	3.19E-08
SSW-MDP-FS-MDP1A	3.19E-08
SSW-MOV-CC-MV5A	3.19E-08
SSW-MOV-CC-MV5B	3.19E-08
SSW-MOV-CC-MV18B	3.19E-08
SSW-MDP-FS-MDP1B	3.19E-08
SSW-MOV-CC-MV1B	3.19E-08
SSW-MOV-CC-MV18A	3.19E-08
SSW-MDP-MA-MDP2C	2.48E-08
SSW-XHE-RE-TAB2	1.80E-08
SSW-XHE-RE-TAB4	1.80E-08
SSW-MDP-MA-MDP1A	1.68E-08
SSW-MDP-MA-MDP1B	1.67E-08
SSW-MDP-FR-MDP2C	6.27E-09
SSW-MOV-MA-MV11	4.98E-09
SSW-MDP-FR-MDP1A	4.33E-09
SSW-MDP-FR-MDP1B	4.33E-09
SSW-XHE RE-SSWC	2.72E-09
SSW-MOV-MA-MV1A	3.09E-09
SSW-MOV-MA-MV5A	3.09E-09
SSW-MOV-MA-MV5B	3.09E-09
SSW-MOV-MA-MV18A	3.09E-09
SSW-MOV-MA-MV1B	3.09E-09
SSW-MOV-MA-MV18B	3.09E-09
SSW-XHE-RE-SSWA	9.64E-10
SSW-XHE-RE-SSWB	9.64E-10
SSW-CKV-HW-CV12	4.23E-10
SSW-HTX-PG-HX1	5.92E-10
SSW-HTX-PG-HX01	5.92E-10
SSW-HTX-PG-HX4A	2.61E-10
SSW-HTX-PG-HX4B	2.61E-10
SSW-HTX-PG-HX1A	2.61E-10
SSW-HTX-PG-HX1B	2.61E-10
SSW-CKV-HW-CV8A	1.87E-10
SSW-CKV-HW-CV8B	1.87E-10

These basic events represent SWS cooling water faults that defeat the diesel generators which leads to station blackout.

CDF Contribution = 4.8E-07 which is 12% of the total CDF (4.05E-06).

Sequence TBSEQ21

This sequence is initiated by loss of offsite power (T1) followed by loss of all three diesel generators and failure of one SRV to reclose.

1.6E-07 Mean CDF	4% of the Total CDF
Basic Events:	
BETA-3SSW*SSW-MDP-FS-CM	6.23E-09
SSW-MDP-FS-MDP2C	1.84E-09
SSW-MOV-CC-MV11	1.83E-09
SSW-MOV-CC-MV1A	1.28E-09
SSW-MDP-FS-MDP1A	1.28E-09
SSW-MOV-CC-MV5A	1.28E-09
SSW-MOV-CC-MV5B	1.28E-09
SSW-MOV-CC-MV18B	1.28E-09
SSW-MDP-FS-MDP1B	1.28E-09
SSW-MOV-CC-MV1B	1.28E-09
SSW-MOV-CC-MV18A	1.28E-09
SSW-MDP-MA-MDP2C	9.93E-10
SSW-XHE-RE-TAB2	7.19E-10
SSW-XHE-RE-TAB4	7.19E-10
SSW-MDP-MA-MDP1A	6.73E-10
SSW-MDP-MA-MDP1B	6.58E-10
SSW-MDP-FR-MDP2C	2.51E-10
SSW-MOV-MA-MV11	1.99E-10
SSW-MDP-FR-MDP1A	1.73E-10
SSW-MDP-FR-MDP1B	1.73E-10
SSW-XHE-RE-SSWC	1.09E-10
SSW-MOV-MA-MV1A	1.23E-10
SSW-MOV-MA-MV5A	1.23E-10
SSW-MOV-MA-MV5B	1.23E-10
SSW-MOV-MA-MV18A	1.23E-10
SSW-MOV-MA-MV1B	1.23E-10
SSW-MOV-MA-MV18B	1.23E-10
SSW-XHE-RE-SSWA	3.86E-11
SSW-XHE-RE-SSWB	3.86E-11
SSW-CKV-HW-CV12	1.69E-11
SSW-HTX-PG-HX1	2.37E-11
SSW-HTX-PG-HX01	2.37E-11
SSW-HTX-PG-HX4A	1.05E-11
SSW-HTX-PG-HX4B	1.05E-11
SSW-HTX-PG-HX1A	1.05E-11
SSW-HTX-PG-HX1B	1.05E-11
SSW-CKV-HW-CV8A	7.46E-12
SSW-CKV-HW-CV8B	7.46E-12

These basic events represent SWS cooling water faults that defeat the diesel generators which leads to station blackout.

CDF Contribution = 1.8E-08 which is < 1% of the total CDF (4.05E-06).

Sequence TC74

This sequence is an ATWS, followed by a subsequent closure of the main steam line valves (Q).

1.1E-07 Mean CDF	3% of the Total CDF

Basic Events:

SSW-MDP-FS-MDP2C	9.84E-09
SSW-MOV-CC-MV11	9.84E-09
SSW-MDP-MA-MDP2C	6.56E-09
SSW-MDP-FR-MDP2C	2.36E-09
SSW-MOV-MA-MV11	2.62E-09
SSW-XHE-RE-SSWC	1.21E-09
SSW-HTX-PG-HX1C	4.59E-10

These basic events represent SWS cooling water faults that result in long term failure of the HPCS system due to loss of room cooling.

CDF Contribution = 3.2E-08 which is 1% of the toual CDF (4.05E-06).

Sequence TBSEQ13

This sequence is initiated by loss of offsite power (T1) followed by loss of all three diesel generators

6.6E-08 Mean CDF	2% of the Total CDF

Basic Events:

BETA-3SSW*SSW-MDP-FS-CM	2.58E-09
SSW-MDP-FS-MDP2C	1.18E-09
SSW-MOV-CC-MV11	1.18E-09
SSW-MOV-CC-MV1A	8.88E-10
SSW-MDP-FS-MDP1A	8.88E-10
SSW-MOV-CC-MV5A	8.88E-10
SSW-MOV-CC-MV5B	8.88E-10
SSW-MOV-CC-MV18B	8.88E-10
SSW-MDP-FS-MDP1B	8.88E-10
SSW-MOV-CC-MV1B	8.88E-10
SSW-MOV-CC-MV18A	8.88E-10
SSW-MDP-MA-MDP2C	6.37E-10
SSW-XHE-RE-TAB2	5.13E-10
SSW-XHE-RE-TAB4	5.17E-10
SSW-MDP-MA-MDP1A	4.57E-10
SSW-MDP-MA-MDP1B	4.57E-10
SSW-MDP-FR-MDP2C	2.53E-10
SSW-MOV-MA-MV11	1.69E-10
SSW-MDP-FR-MDP1A	1.86E-10
SSW-MDP-FR-MDP1B	1.86E-10
SSW-XHE-RE-SSWC	1.12E-10
SSW-MOV-MA-MV1A	1.04E-10

SSW-MOV-MA-MV5A	1.04E-10
SSW-MOV-MA-MV5B	1.04E-10
SSW-MOV-MA-MV18A	1.04E-10
SSW-MOV-MA-MV1B	1.04E-10
SSW-MOV-MA-MV18B	1.04E-10

These basic events represent SWS cooling water faults that defeat the diesel generators, which leads to station blackout.

CDF Contribution = 1.0E-08 which is <1% of the total CDF (4.05E-06).

Sequence TBSEQ17

This sequence is initiated by loss of offsite power (T1) followed by loss of all three diesel generators and two SRVs fail to reclose.

3.7E-03 Mean CDF	1% of the Total CDF

Basic Events:

BETA-3SSW*SSW-MDP-FS-CM	1.05E-09
SSW-MDP-FS-MDP2C	4.94E-10
SSW-MOV-CC-MV11	4.94E-10
SSW-MOV-CC-MV1A	3.73E-10
SSW-MDP-FS-MDP1A	3.73E-10
SSW-MOV-CC-MV5A	3.74E-10
SSW-MOV-CC-MV5B	3.73E-10
SSW-MOV-CC-MV18B	3.73E-10
SSW-MDP-FS-MDP1B	3.73E-10
SSW-MOV-CC-MV1B	3.72E-10
SSW-MOV-CC-MV18A	3.72E-10
SSW-MDP-MA-MDP2C	3.13E-10
SSW-XHE-RE-TAB2	2.19E-10
SSW-XHE-RE-TAB4	2.19E-10
SSW-MDP-MA-MDP1A	2.32E-10
SSW-MDP-MA-MDP1B	2.32E-10
SSW-MDP-FR-MDP2C	1.04E-10
SSW-MOV-MA-MV11	1.01E-10
SSW-MDP-FR-MDP1A	7.84E-11
SSW-MDP-FR-MDP1B	7.84E-11
SSW-XHE-RE-SSWC	5.06E-11
SSW-MOV-MA-MV1A	7.34E-11
SSW-MOV-MA-MV5A	7.34E-11
SSW-MOV-MA-MV5B	7.34E-11
SSW-MOV-MA-MV18A	7.34E-11
SSW-MOV-MA-MV1B	7.34E-11
SSW-MOV-MA-MV18B	7.34E-11
SSW-XHE-RE-SSWA	2.53E-11
SSW-XHE-RE-SSWB	2.53E-11

These basic events represent SWS cooling water faults that defeat the diesel generators, which leads to station blackout.

CDF Contribution = 7.3E-0[illegible] which is <1% of the total CDF (4.05E-06).

Sequence TBSEQ14

This sequence is initiated by loss of offsite power (T1) followed by loss of all three diesel generators and loss of all coolant injection.

4.4E-08 Mean CDF 1% of the Total CDF

Basic Events:

BETA-3SSW*SSW-MDP-FS-CM	1.92E-09
SSW-MDP-FS-MDP2C	8.66E-10
SSW-MOV-CC-MV11	8.66E-09
SSW-MOV-CC-MV1A	6.50E-10
SSW-MDP-FS-MDP1A	6.50E-10
SSW-MOV-CC-MV5A	6.50E-10
SSW-MOV-CC-MV5B	6.50E-10
SSW-MOV-CC-MV18B	6.50E-10
SSW-MDP-FS-MDP1B	5.50E-10
SSW-MOV-CC-MV1B	6.50E-10
SSW-MOV-CC-MV18A	6.50E-10
SSW-MDP-MA-MDP2C	3.76E-10
SSW-XHE-RE-TAB2	4.66E-10
SSW-XHE-RE-TAB4	3.79E-10
SSW-MDP-MA-MDP1A	3.35E-10
SSW-MDP-MA-MDP1B	3.35E-10
SSW-MDP-FR-MDP2C	1.85E-10
SSW-MOV-MA-MV11	1.24E-10
SSW-MDP-FR-MDP1A	1.36E-10
SSW-MDP-FR-MDP1B	1.36E-10
SSW-XHE-RE-SSWC	8.22E-11
SSW-MOV-MA-MV1A	7.62E-11
SSW-MOV-MA-MV5A	7.62E-11
SSW-MOV-MA-MV5B	7.62E-11
SSW-MOV-MA-MV18A	7.62E-11
SSW-MOV-MA-MV1B	7.62E-11
SSW-MOV-MA-MV18B	7.62E-11

These basic events represent SWS cooling water faults that defeat the diesel generators (i.e., loss of jacket water cooling), which leads to station blackout.

CDF Contribution = 1.3E-08 which is <1% of the total CDF (4.05E-06).

Sequence TSEQ56

This sequence is initiated by a loss of the PCS (T2). Offsite power is available and all high pressure coolant injection systems fail to inject.

1.3E-08 Mean CDF <1% of the Total CDF

Basic Events:

SSW-MDP-FS-MDP2C	4.22E-11
SSW-MOV-CC-MV11	4.03E-11
SSW-MOV-CC-MV5A	3.25E-11
SSW-MOV-CC-MV1A	3.25E-11
SSW-MDP-FS-MDP1A	3.25E-11
SSW-MDP-MA-MDP2C	2.68E-11
SSW-MDP-MA-MDP1A	2.17E-11
SSW-XHE-RE-TAB2	1.95E-11
SSW-XHE-RE-TAB1	1.08E-11
SSW-MOV-MA-MV5A	9.19E-12
SSW-MOV-MA-MV1A	9.19E-12
SSW-MOV-MA-MV11	9.01E-12
SSW-MDP-FR-MDP2C	7.79E-12
SSW-MDP-FR-MDP1A	7.95E-12
SSW-XHE-RE-SSWA	2.71E-12
SSW-XHE-RE-SSWC	4.01E-12
SSW-HTX-PG-HX1C	1.61E-12
SSW-HTX-PG-HX1A	1.16E-12
SSW-HTX-PG-HX6	1.09E-12

These basic events represent SSW faults that result in loss of HPCS and RCIC room cooling, i.e., loss of high pressure injection systems.

CDF Contribution = 3.1E-10 which is < 1% of the total CDF (4.05E-06).

6.0 ST. LUCIE: TAP A-45

6.1 ST. LUCIE: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Component Cooling Water (CCW) System and Intake Cooling Water (ICW) System) found to be major contributors to the total core damage frequency (CDF) at the St. Lucie nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
CCW-PUMP-CM	1.4E-06	2
ICW-PUMP-CM	3.5E-07	2
Total	1.8E-06	

Internal Events CDF	1.4E-05
External Events CDF	6.0E-05
Total	7.4E-05

ST. LUCIE Event Descriptions:

CCW-PUMP-CM - Common mode failure of component cooling water pumps.

ICW-PUMP-CM - Common mode failure of intake cooling water pumps.

6.2 St. LUCIE ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Component Cooling Water (CCW) and Intake Cooling Water (ICW) events appear along with the contribution SSW makes to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represents less than 50% of the total sequence frequency.

Sequence $S2MD_1D_2$

This sequence is initiated by a small LOCA (S_2) with subsequent failure of both high pressure and low pressure injection systems, HPIS (D_1) and LPIS (D_2) which leads to an early core melt.

1.9E-06 Mean CDF — 14% of the Total CDF

SSW Basic Events:

CCW-PUMP-CM	8.0E-07
ICW-PUMP-CM	2.0E-07

These basic events are failures of the ICW system, which fails CCW, and the CCW system which fails the high and low pressure injection systems, HPIS and LPIS, due to loss of pump cooling.

CDF Contribution = 1.0E-06 which is 7% of the total CDF (1.4E-05).

Sequence $T_3QD_1D_2$

This sequence is a transient in which PCS and offsite power are initially available. Following the transient, one SRV fails open (Q) and injection systems HPSI (D_1) and LPSI (D_2) fail to function.

1.25E-06 Mean CDF — 9% of the Total CDF

SWS Basic Events:

CCW-PUMP-CM	6.0E-07
ICW-PUMP-CM	1.5E-07

These basic events are failures of the ICW system, which fails CCW, and the CCW system which fails the high and low pressure injection systems, HPIS and LPIS, due to loss of pump cooling.

CDF Contribution = 7.5E-07 which is 5% of the total CDF (1.4E-05).

7.0 CALVERT CLIFFS: IREP

7.1 CALVERT CLIFFS: IREP SUMMARY OF RESULTS

The basic events for the Service Water System (SRWS), Salt Water System (SWS), and Component Cooling Water System (CCW) found to be major contributors to the total core damage frequency (CDF) at the Calvert Cliffs nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
SWS5170A-NCC-LF	1.77E-06	14
SWS5171A-NCC-LF	1.46E-06	11
SWS5173B-NCC-LF	9.63E-07	6
CCW0258X-XOC-LF	7.60E-07	1
CCW3826N-NCC-OE*SWS5206A-NCC-LF	6.30E-07	1
CCW3826N-NCC-OE*SWS5160A-NCC-LF	6.30E-07	1
CCW3826N-NCC-OE*CCW3823N-NTO-LF	6.30E-07	1
SWS5206A-NCC-LF*SWS5208B-NCC-LF	1.90E-07	1
SWS5206A-NCC-LF*SWS5163B-NCC-LF	1.90E-07	1
SWS5206A-NCC-LF*SWS5162B-NCC-LF	1.90E-07	1
SWS5206A-NCC-LF*CCW3826N-NCC-LF	1.90E-07	1
SWS5206A-NCC-LF*CCW3825N-NTO-LF	1.90E-07	1
SWS5160A-NCC-LF*SWS5208B-NCC-LF	1.90E-07	1
SWS5160A-NCC-LF*SWS5163B-NCC-LF	1.90E-07	1
SWS5160A-NCC-LF*SWS5162B-NCC-LF	1.90E-07	1
CCW3826N-NCC-LF*SWS5160A-NCC-LF	1.90E-07	1
CCW3825N-NTO-LF*SWS5160A-NCC-LF	1.90E-07	1
CCW3823N-NTO-LF*SWS5208B-NCC-LF	1.90E-07	1
CCW3823N-NTO-LF*SWS5163B-NCC-LF	1.90E-07	1
CCW3823N-NTO-LF*SWS5162B-NCC-LF	1.90E-07	1
CCW3823N-NTO-LF*CCW3826N-NCC-LF	1.90E-07	1
CCW3823N-NTO-LF*CCW3825N-NTO-LF	1.90E-07	1
SWS5173B-NCC-LF*SWS5171A-NCC-LF	1.90E-07	1
SWS5173B-NCC-LF*SWS5170A-NCC-LF	1.90E-07	1
SRW1587A-NCC-LF	1.06E-07	5
SRWAO11A-BOO-LF	1.70E-07	7
SWS5210A-NTC-CC	1.30E-07	4
SWS1105A-BOO-LF	1.70E-07	7
SWS5150A-NOC-CC	7.70E-08	3
SWS0196X-XOC-LF	5.00E-08	1
SWS5210A-NOC-CC	5.30E-08	1
CCW3826N-NCC OE*SWS5206A-NCC-CC*RA18	5.30E-08	1
CCW3826N-NCC-OE*SWS5160A-NCC-CC*RA18	5.30E-08	1
SWS5170A-NCC-CC*RA18	3.50E-08	1
SWS5171A-NCC-CC*RA18	3.50E-08	1
SWS5173B-NCC-CC*RA18	3.50E-08	1
SWS5174B-NOC-CC*RA18	3.50E-08	1
SWS5175B-NOC-CC*RA18	3.50E-08	1
SRW1588B-NCC-LF	2.90E-08	1
SWS1405B-BOO-LF	2.90E-08	1
SWS5153B-NOC-CC	2.40E-08	1
SWS5212B-NTC-CC	2.40E-08	1
SWSTD13-LF*CCW3826N-NCC-OE	2.30E-08	1
Total	1.17E-05	
Internal Events CDF	1.30E-04	

Calvert Cliffs Event Descriptions:

CCW0258X-XOC-LF - Local fault of CCW valve resulting in common mode failure of all LPSR and HPSR pump seal cooling and pump failure.

CCW3823N-NTO-LF - Local fault of bypass valve on CCW HTX #11 results in failure of heat removal, fails 1/2 CCW.

CCW3825N-NTO-LF - Local fault of CCW HTX #12 bypass valve results in failure to remove heat, fails 1/2 of CCW.

CCW3826N-NCC-lf - Local fault of outlet valve on CCW HTX #12 fails 1/2 of CCW.

CCW3826N-NCC-OE - Failure of the operator to open CCW HTX #12 outlet valve resulting in failure of CCW HTX #12 failing 1/2 of CCW.

RA18 - Probability of operator failing to manually open SWS pneumatic valves (p = 0.1).

SRWA011A-BOO-LF - Local fault of power breaker on SRW pump #11, fails DG #11 cooling and train A of AC power.

SRWA012B-BOO-LF - Local fault of SRW pump #12 power breaker, fails DG #12 cooling and train B of AC power.

SRW1587A-NCC-LF - Local fault of DG #11 cooling outlet valve, fails DG #11 and train A of AC power.

SRW1587A-111C-LF - Local fault of outlet valve from DG #11 coolers, fails DG #11 and Train A of AC power.

SRW1588B-NCC-LF - Local fault of inlet valve to DG #12 coolers, fails DG #12 and train B of AC power.

SWSTD13-LF - Short in one-second time delay salt water pump #13 results in failure of salt water pump #11, fails 1/2 CCW.

SWS0196X-XOC-LF - Local fault of SWS ESF and CCW HTX outlet valve failing heat removal from all ESF pump room coolers and both CCW HTXs. This fails all HPSR, LPSR, and CSSR pumps and both shutdown heat exchangers.

SWS1105A-BOO-LF - Local fault of power breaker on SWS pump #11, fails DG #11 cooling and train A of AC power.

SWS1405B-BOO-LF - Local fault of SWS pump #12 power breaker, fails DG #12 cooling and train B of AC power.

SWS5150A-NOC-CC - Control circuit fault of service water heat exchanger #11 inlet valve, fails DG #11 and train A of AC power.

SWS5153B-NOC-CC - Control circuit fault of service water heat exchanger outlet valve, fails DG #12 cooling and train B of AC power.

SWS5160A-NCC-CC - Control fault of salt water valve fails CCW HTX #11 cooling resulting in failure of 1/2 CCW.

SWS5160A-NCC-LF - Local fault of salt water valve fails CCW HTX #11 cooling resulting in failure of 1/2 CCW.

SWS5162B-NCC-LF - Failure of salt water valve fails cooling to CCW HTX #12 failing 1/2 of CCW.

Calvert Cliffs Event Descriptions (Continued):

SWS5153B-NCC-LF - Failure of salt water valve fails cooling to CCW HTX #12 failing 1/2 of CCW.

SWS5170A-NCC-CC - Control fault of ESF pump room cooler #11 inlet valve, fails HPSR pumps #11 and #12 and CSSR pump #11.

SWS5170A-NCC-LF - Failure of salt water valve results in failure of ESF pump room cooling and fails HPSR pump #11 and #12 and CSSR pump #11.

SWS5171A-NCC-CC - Control fault of ESF pump room cooler #11 outlet valve, fails HPSR pumps #11 and #12 and CSSR pump #11.

SWS5171A-NCC-LF - Failure of salt water valve results in failure of ESF pump room cooling and fails HPSR pump #11 and #12 and CSSR pump #11.

SWS5173B-NCC-CC - Control fault of ESF pump room cooler #12 inlet valve, fails HPSR pump #13 and CSSR pump #12.

SWS5173B-NCC-LF - Local fault of SWS valve, fails ESF pump room cooler #12 failing HPSR pump #13 and CSSR pump #12.

SWS5174B-NOC-CC - Control fault of ESF pump room cooler #12 outlet valve, fails HPSR pump #13 and CSSR pump #12.

SWS5175B-NOC-CC - Control fault of ESF pump room cooler #12 outlet valve, fails HPSR pump #13 and CSSR pump #12.

SWS5206A-NCC-CC - Control fault of salt water valve fails CCW HTX #11 cooling resulting in failure of 1/2 CCW.

SWS5206A-NCC-LF - Local fault of salt water valve fails CCW HTX #11 cooling resulting in failure of 1/2 CCW.

SWS5208B-NCC-LF - Failure of salt water valve fails cooling to CCW HTX #12 failing 1/2 of CCW.

SWS5210A-NTC-CC - Control circuit fault of service water heat exchanger #11 outlet valve, fails DG #11 and train A of AC power.

SWS5212B-NTC-CC - Control circuit fault of service water heat exchanger outlet valve, fails DG #12 cooling and train B of AC power.

7.2 CALVERT CLIFFS ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: IREP ANALYSIS

The following presents the IREP accident sequences in which Component Cooling Water (CCW), Service Water (SRWS), and Salt Water (SWS) events appear along with the contribution SSW makes to the total CDF for the given accident sequence.

Sequence S_3H

This sequence is initiated by a Small-small LOCA followed by loss of primary makeup (High Pressure Safety Recirculation system fails (H)) in the long term which results in the core uncovering and core melt.

1.5E-05 Mean CDF   11% of the Total CDF

Basic Events:

SWS5170A-NCC-LF	8.07E-07
SWS5171A-NCC-LF	8.07E-07
CCW0258X-XOC-LF	7.60E-07
CCW3826N-NCC-OE*SWS5206A-NCC-LF	6.30E-07
CCW3826N-NCC-OE*SWS5160A-NCC-LF	6.30E-07
CCW3826N-NCC-OE*CCW3823N-NTO-LF	6.30E-07
SWS4144A-VCC-LF	3.80E-07
SWS5206A-NCC-LF*SWS5208B-NCC-LF	1.90E-07
SWS5206A-NCC-LF*SWS5163B-NCC-LF	1.90E-07
SWS5206A-NCC-LF*SWS5162B-NCC-LF	1.90E-07
SWS5206A-NCC-LF*CCW3826N-NCC-LF	1.90E-07
SWS5206A-NCC-LF*CCW3825N-NTO-LF	1.90E-07
SWS5160A-NCC-LF*SWS5208B-NCC-LF	1.90E-07
SWS5160A-NCC-LF*SWS5163B-NCC-LF	1.90E-07
SWS5160A-NCC-LF*SWS5162B-NCC-LF	1.90E-07
CCW3826N-NCC-LF*SWS5160A-NCC-LF	1.90E-07
CCW3825N-NTO-LF*SWS5160A-NCC-LF	1.90E-07
CCW3823N-NTO-LF*SWS5208B-NCC-LF	1.90E-07
CCW3823N-NTO-LF*SWS5163B-NCC-LF	1.90E-07
CCW3823N-NTO-LF*SWS5162B-NCC-LF	1.90E-07
CCW3823N-NTO-LF*CCW3826N-NCC-LF	1.90E-07
CCW3823N-NTO-LF*CCW3825N-NTO-LF	1.90E-07
CCW3826N-NCC-OE*SWS5206A-NCC-CC*RA18	5.30E-08
CCW3826N-NCC-OE*SWS5160A-NCC-CC*RA18	5.30E-08
SWSTD13-LF*CCW3826N-NCC-OE	2.30E-08

These basic events represent SWS and CCW faults that result in the loss of pump seal cooling and room cooling for the HPSI/R pumps. Recovery action RA-18 is the failure of the operator to manually open SWS pneumatic valves (p = 0.1).

CDF Contribution = 7.6E-06 which is 6% of the total CDF (1.35E-04).

Sequence S_2FH

This sequence is initiated by a Small-small LOCA followed by loss of primary makeup (High Pressure Safety Recirculation system fails (H) and the Containment Spray system Recirculation (F)) in the long term which results in the core uncovering and core melt.

1.1E-05 Mean CDF   9[illegible] the Total CDF

Basic Events:

SWS5170A-NCC-LF	9.63E-07
SWS5171A-NCC-LF	6.49E-07
SWS5173B-NCC-LF	9.63E-07
SWS4144A-VCC-LF	3.90E-08
SWS5173B-NCC-LF*SWS5171A-NCC-LF	1.90E-07
SWS5173B-NCC-LF*SWS5170A-NCC-LF	1.90E-07
SWS0196X-XOC-LF	5.00E-08
SWS5170A-NCC-CC*RA-18	3.50E-08
SWS5171A-NCC-CC*RA-18	3.50E-08
SWS5173B-NCC-CC*RA-18	3.50E-08
SWS5174B-NOC-CC*RA-18	3.50E-08
SWS5175B-NOC-CC*RA-18	3.50E-08

These basic events represent SWS faults that result in the loss of ESF pump room coolers. This fails the HPSR and CSSR pumps. Recovery action RA-18 is the failure of the operator to manually open SWS pneumatic valves to an ESF room cooler, fails one room cooler (p = 0 [illegible]

CDF Contribution = 3.2E-06 which is 2% of the total CDF (1.3E-04).

Sequence T_1Q-D"CC'

This sequence is initiated by a loss of offsite power (T_1) followed by a transient induced LOCA (Q). HPSI (D"), CSSI (C') and CARCS (C) subsequently fail following the initiator which results in loss of primary system makeup uncovering the core.

5.3E-06 Mean CDF   4% of the Total CDF

Basic Events:

SRW1587A-NCC-LF	9.30E-08
SWS1105A-BOO-LF	9.30E-08
SRWA011A-BOO-LF	9.30E-08
SWS5210A-NTC-CC	7.70E-0[illegible]
SWS5210A-NOC-CC	5.30E-08
SRW1588B-NCC-LF	2.90E-08
SWS1405B-BOO-LF	2.90E-08
SWS5150A-NOC-CC	2.40E-08
SWS5153B-NOC-CC	2.40E-08
SWS5212B-NTC-CC	2.40E-08

These basic events represent SWS and SRW faults that result in the loss of diesel generator cooling and diesel generator room coolers. This fails the diesel generators which in turn fail the ESF systems.

CDF Contribution = 5.4E-07 which is <1% of the total CDF (1.3E-04).

Sequence T_1L

This sequence is initiated by a loss of offsite power (T_1) followed by failure of AFW (L).

4.9E-06 Mean CDF   4% of the Total CDF

Basic Events:

SWS1105A-BOO-LF	6.40E-08
SRWA011A-BOO-LF	6.40E-08
SWS5210A-NTC-CC	5.30E-08
SWS5150A-NOC-CC	5.30E-08

These basic events represent SWS and SRW faults that result in the loss of diesel generator #11 cooling. This fails diesel generator #11 which in turn fails AFW.
CDF Contribution = 2.3E-07 which is <1% of the total CDF (1.3E-04).

Sequence T_1LCC'

This sequence is initiated by a loss of offsite power (T_1) followed by failure of AFW (L), CSSI (C), and CARCS (C').

1.0E-06 Mean CDF   1% of the Total CDF

Basic Events:

SRW1587A-NCC-LF	1.33E-08
SWS1105A-BOO-LF	1.33E-08
SRWA011A-BOO-LF	1.33E-08

These basic events represent SWS and SRW faults that result in the loss of diesel generator #11 cooling. This fails diesel generator #11 which in turn fails 1/2 of all ESF systems and motor-driven AFW pump.

CDF Contribution = 4.0E-08 which is <1% of the total CDF (1.3E-04).

8.0 ANO-1: TAP-45

8.1 ANO-1: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Service Water System (SWS)) found to be major contributors to the total core damage frequency (CDF) at the ANO-1 nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
SWSV-02-03-CM	4.85E-06	4
SWSV-40-41-CM	3.34E-06	3
SWSV-40-51-CM	1.51E-06	1
SWSP-CM	7.59E-07	6
SWSV-06-07-CM	2.02E-07	2
SWS3824-VOC-LF	4.92E-08	2
SWSV-08-10-CM	4.55E-08	2
Total	1.08E-05	

Internal Events CDF	8.80E-05
External Events CDF	9.10E-05
Total	1.79E-04

ANO-1 Event Descriptions:

SWSP-CM - Local fault common mode failure between 2 PMD normally running and 1 PMD on standby.

SWSV-02-03-CM - Common mode failure of MOVs 02 and 03 - failure to open.

SWSV-06-07-CM - Common mode failure of MOVs 06 and 07 - failure to open.

SWSV-08-10-CM - Common mode failure of MOVs 08 and 10 - failure to open.

SWSV-40-41-CM - Common mode failure of MOVs 40 and 41 - failure to open.

SWSV-40-51-CM - Common mode failure of MOVs 40 and 51 - failure to open.

SWS3824-VOC-LF - Normally open valve 3824 fails closed.

8.2 ANO-1 ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Service Water System (SWS) events appear along with the contribution SWS makes to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represents less than 50% of the total sequence frequency.

Sequence $S_3MH_1H_2$

This sequence is initiated by a Small LOCA followed by loss of main feedwater (M) and primary makeup (High Pressure Recirculation system fails (H_1) and Low Pressure Recirculation system (H_2)) in the long term which results in the core uncovering and core melt.

2.34E-05 Mean CDF	27% of the Total CDF

Basic Events:

SWSV-40-41-CM	3.04E-06
SWSV-02-03-CM	3.04E-06

These basic events represent SWS faults that result in the loss of the low pressure pump room coolers and low pressure pump lube oil coolers.

CDF Contribution = 6.0E-06 which is 7% of the total CDF (8.8E-05).

Sequence S_3MED_2

This sequence is initiated by a Small LOCA followed by loss of main feedwater (M), failure of feed and bleed mode of HPSI (E), and failure of LPSI (D_2) which results in early core melt.

6.6E-06 Mean CDF	7% of the Total CDF

Basic Events:

SWSP-CM	1.9E-07

This basic event results in failure of both the HPSI and LPSI pumps due to loss of pump cooling.

CDF Contribution = 1.9E-07 which is <1% of the total CDF (8.8E-05).

Sequence S_3MXE

This sequence is initiated by a Small LOCA followed by loss of main feedwater (M), failure of feed and bleed mode of HPSI (E), and failure to depressurize (X) which results in early core melt.

2.33E-06 Mean CDF	3% of the Total CDF

Basic Events:

SWSP-CM	2.57E-09

This basic event results in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 2.57E-09 which is <1% of the total CDF (8.8E-05).

Sequence T_1MLE

This sequence is initiated by a loss-of-offsite power and followed by loss of main feedwater (M), failure of emergency feedwater (L), and failure of feed and bleed mode of HPSI (E), which results in core melt.

2.13E-05 Mean CDF	24% of the Total CDF

Basic Events:

SWSV-06-07-CM	1.93E-07

This basic event results in failure of the HPSI.

CDF Contribution = 1.93E-07 which is <1% of the total CDF (8.8E-05).

Sequence T_2MLE

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system followed by failure of the emergency feedwater system (L) and failure of feed and bleed mode of HPSI (E), which results in core melt.

2.38E-06 Mean CDF	3% of the Total CDF

Basic Events:

SWSP-CM	3.09E-07
SWS3824-VOC-LF	3.33E-08

These basic events result in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 6.4E-07 which is 1% of the total CDF (8.8E-05).

Sequence T_3MLE

This sequence is a transient with the power conversion system (PCS) initially available. The PCS subsequently fails (M) followed by loss of emergency feedwater system (L) and failure of feed and bleed mode of HPSI (E), which results in core melt.

1.14E-06 Mean CDF	1% of the Total CDF

Basic Events:

SWSP-CM	1.47E-07
SWS3824-VOC-LF	1.59E-08

This basic event results in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 1.6E-07 which is <1% of the total CDF (8.8E-05).

Sequence T_1MQLD_1

This sequence is initiated by a loss-of-offsite power and followed by loss of main feedwater (M), failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, failure of emergency feedwater (L), and failure of HPSI (D_1), which results in core melt.

7.85E-07 Mean CDF <1% of the Total CDF

Basic Events:

SWSV-06-07-CM 9.33E-09

This basic event results in failure of the HPSI.

CDF Contribution = 9.33E-09 which is <1% of the total CDF (8.8E-05).

Sequence $T_2MQH_1H'_2$

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both the high pressure recirculation system (H_1) and the low pressure recirculation system (H'_2) fail leading to core melt.

1.71E-06 Mean CDF 2% of the Total CDF

Basic Events:

SWSV-40-41-CM 2.13E-07
SWSV-02-03-CM 2.13E-07

These basic events represent SWS faults that result in the loss of the low pressure pump room coolers and low pressure pump lube oil coolers.

CDF Contribution = 4.2E-07 which is <1% of the total CDF (8.8E-05).

Sequence $T_2MQD_1D_2$

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

6.66E-07 Mean CDF <1% of the Total CDF

Basic Events:

SWSP-CM 1.40E-08

This basic event results in loss of the LPSI and HPSI pumps due to loss of cooling.

CDF Contribution = 1.8E-08 which is <1% of the total CDF (8.8E-05).

Sequence $T_3MQH_1H'_2$

This sequence is a transient with the power conversion system (PCS) initially available. The PCS subsequently fails (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both the high pressure recirculation system (H_1) and the low pressure recirculation system (H'_2) fail leading to core melt.

7.31E-07 Mean CDF	1% of the Total CDF

Basic Events:

SWSV-40-41-CM	9.12E-08
SWSV-02-03-CM	9.12E-08

These basic events represent SWS faults that result in the loss of the low pressure pump room coolers and low pressure pump lube oil coolers.

CDF Contribution = 1.8E-07 which is <1% of the total CDF (8.8E-05).

Sequence $T_3QH_1H'_2$

This sequence is a transient with the power conversion system (PCS) initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both the high pressure recirculation system (H_1) and the low pressure recirculation system (H'_2) fail leading to core melt.

1.21E-05 Mean CDF	14% of the Total CDF

Basic Events:

SWSV-40-41-CM	1.51E-06
SWSV-02-03-CM	1.51E-06

These basic events represent SWS faults that result in the loss of the low pressure pump room coolers and low pressure pump lube oil coolers.

CDF Contribution = 3.0E-06 which is 3% of the total CDF (8.8E-05).

Sequence $T_3QD_1D_2$

This sequence is a transient in which the power conversion system is initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

4.57E-06 Mean CDF 5% of the Total CDF

Basic Events:

SWSP-CM 9.6E-08

This basic event result in loss of the LPSI and HPSI pumps due to loss of cooling.

CDF Contribution = 9.6E-08 which is < 1% of the total CDF (8.8E-05).

Sequence T_4MLE

This sequence is initiated by a loss of an AC bus followed by failure of the power conversion system, failure of the emergency feedwater system (L) and failure of feed and bleed mode of HPSI (E), which results in core melt.

4.08E-06 Mean CDF 5% of the Total CDF

Basic Events:

SWSV-08-10-CM 3.05E-08

These basic events result in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 3.05E-08 which is < 1% of the total CDF (8.8E-05).

Sequence T_5MLE

This sequence is initiated by a loss of an DC bus followed by failure of the power conversion system, failure of the emergency feedwater system (L) and failure of feed and bleed mode of HPSI (E), which results in core melt.

2.46E-06 Mean CDF 3% of the Total CDF

Basic Events:

SWSV-08-10-CM 1.50E-08

These basic events result in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 1.50E-08 which is < 1% of the total CDF (8.8E-05).

9.0 POINT BEACH: TAP A-45

9.1 POINT BEACH: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Service Water System (SWS) and Component Cooling Water (CCW) System) found to be major contributors to the total core damage frequency (CDF) at the Point Beach nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
CCWXV30-XOC-UTM	1.19E-05	3
CCWMP-PMD-CM	6.30E-06	4
CCWXV30-XOC-LF	3.13E-06	3
CCWMDPA-PMD-LF*CCWMDPB-PMD-LF+ CCWMDPA-PMD-LF*CCWMDPB-PMD-UTM	1.86E-06	2
CCWHXA-HTX-FB	1.04E-06	3
SWSP-CM	2.15E-06	4
Total	2.64E-05	
Internal Events CDF	1.40E-04	
External Events CDF	1.70E-04	
Total	3.10E-04	

Point Beach Event Descriptions:

CCWHXA-HTX-FB -	Component Cooling Water heat exchanger fails due to flow blockage.
CCWMP-PMD-CM -	Common mode failure of both Component Cooling Water pumps to operate.
CCWMDPA-PMD-LF -	Normally running Component Cooling Water pump A fails to restart following LOSP.
CCWMDPB-PMD-LF -	Normally running Component Cooling Water pump B fails to restart following LOSP.
CCWMDPB-PMD-UTM -	Component Cooling Water pump B unavailable due to maintenance outage.
CCWXV30-XOC-LF -	Normally open Component Cooling Water manual valve 30, RHR pump coolers return valve, fails closed.
CCWXV30-XOC-UTM -	Component Cooling Water manual valve 30, RHR pump coolers return valve, unavailable due to maintenance.
SWSP-CM -	Common mode failure of all six Service Water pumps to operate.

9.2 POINT BEACH ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Service Water System (SWS) and Component Cooling Water (CCW) system events appear along with the contribution SSW and CCW makes to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represents less than 50% of the total sequence frequency.

Sequence $S_2MH'_1H'_2$

This sequence is initiated by a Small LOCA followed by main feedwater trip due from a safety injection signal (M) and primary makeup (High Pressure Recirculation system fails (H'_1) and Low Pressure Recirculation system (H'_2)) in the long term which results in the core uncovering and core melt.

5.96E-05 Mean CDF — 42% of the Total CDF

Basic Events:

CCWXV30-XOC-UTM	7.6E-06
CCWXV30-XOC-LF	2.0E-06

These basic events represent CCW faults that result in the loss of the low pressure pumps due to loss of pump cooling, which in turn fails the low pressure recirculation and high pressure recirculation modes of operation.

CDF Contribution = 9.6E-06 which is 7% of the total CDF (1.4E-04).

Sequence $S_2MD_1D_2$

This sequence is initiated by a Small LOCA followed by main feedwater trip due to a safety injection signal (M), failure of the high pressure injection system (D_1), and failure of the low pressure injection system (D_2) following successful deppressurization which results in early core melt.

8.98E-06 Mean CDF — 6% of the Total CDF

Basic Events:

CCWMP-PMD-CM	4.0E-06
CCW-HTX*ASSO XOC	3.8E-07
CCWMPA-PMD-LF*CCWMPB-PMD-LF+ CCWMPA-PMD-LF*CCWMDB-PMD-UTM	1.23E-06
SWSP-CM	6.0E-07

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection system.

CDF Contribution = 6.21E-06 which is 4% of the total CDF (1.4E-04).

Sequence S_2MXD_1

This sequence is initiated by a Small LOCA followed by main feedwater trip due to a safety injection signal (M), failure of the high pressure injection system (D_1), and failure to pressurize (X) where low pressure injection could be used which results in early core melt.

6.51E-07 Mean CDF <1% of the Total CDF

Basic Events:

CCW-PMD-CM 6.0E-08

This basic event results in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 6.0E-08 which is <1% of the total CDF (1.4E-04).

Sequence T_2MLE

This sequence is a loss of the feedwater system transient (T_2) caused by loss of the power conversion system (M) followed by failure of the auxiliary feedwater system (L) and failure of feed and bleed mode of HPSI (E), which results in core melt.

6.61E-06 Mean CDF 5% of the Total CDF

Basic Events:

SWSP-CM 1.21E-06

This basic event results in failure of the high pressure injection system and the AFW motor driven pumps due to loss of pump cooling.

CDF Contribution = 1.21E-06 which is 1% of the total CDF (1.4E-04).

Sequence $T_2MQH'_1H'_2$

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both the high pressure recirculation system (H'_1) and the low pressure recirculation system (H'_2) fail leading to core melt.

4.17E-06 Mean CDF 3% of the Total CDF

Basic Events:

CCWXV30-XOC-UTM	5.32E-07
CCWXV30-XOC-LF	1.4E-07

These basic events represent CCW faults that result in the loss of the low pressure pumps due to loss of pump cooling, which in turn fails the low pressure recirculation and high pressure recirculation modes of operation.

CDF Contribution = 6.72E-07 which is <1% of the total CDF (1.4E-04).

Sequence $T_2MQD_1D_2$

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

6.86E-07 Mean CDF <1% of the Total CDF

Basic Events:

CCWMP-PMD-CM	2.80E-07
SWSP-CM	4.20E-08
CCWHXA-HTX-FB*ASSOC XOC	8.26E-08

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection system.

CDF Contribution = 4.04E-07 which is <1% of the total CDF (1.4E-04).

Sequence $T_3QH'_1H'_2$

This sequence is a transient with the power conversion system (PCS) initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both the high pressure recirculation system (H'_1) and the low pressure recirculation system (H'_2) fail leading to core melt.

2.95E-05 Mean CDF 21% of the Total CDF

Basic Events:

CCWXV30-XOC-UTM	3.76E-06
CCWXV30-XOC-LF	9.90E-07

These basic events represent CCW faults that result in the loss of the low pressure pumps due to loss of pump cooling, which in turn fails the low pressure recirculation and high pressure recirculation modes of operation.

CDF Contribution = 4.75E-06 which is 3% of the total CDF (1.4E-04).

Sequence $T_3QD_1D_2$

This sequence is a transient in which the power conversion system is initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

4.80E-06 Mean CDF 3% of the Total CDF

Basic Events:

CCWMP-PMD-CM	1.96E-06
SWSP-CM	2.94E-07
CCWMPA-PMD-LF*CCWMPB-PMD-LF+	
CCWMPA-PMD-LF*CCWMPB-PMD-UTM	6.03E-07
CCWHXA-HTX-FB*ASSOS XOC	5.78E-07

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection system.

CDF Contribution = 3.44E-06 which is 2% of the total CDF (1.4E-04).

10.0 TURKEY POINT: TAP A-45

10.1 TURKEY POINT: TAP A-45 SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Service Water System (SWS) and Component Cooling Water (CCW) System) found to be major contributors to the total core damage frequency (CDF) at the Turkey Point nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
CCMDP-CM	1.13E-06	5
SWNV2201-NOO-LF	1.13E-06	5
SWSMP-CM	1.13E-06	5
Total	3.39E-06	
Internal Events CDF	7.10E-05	
External Events CDF	1.60E-04	
Total	2.31E-04	

Turkey Point Event Descriptions:

CCMDP-CM - Common mode failure of Component Cooling Water pumps to operate.

SWNV2201-NOO-LF - Normally open Service Water pneumatic valve 2201 fails to isolate non-essential systems.

SWSMP-CM - Common mode failure of all three Service Water pumps to operate.

10.2 TURKEY POINT ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: TAP A-45 ANALYSIS

The following presents the TAP A-45 accident sequences in which Service Water System (SWS) and Component Cooling Water (CCW) system events appear along with the contribution SSW and CCW make to the total CDF for the given accident sequence. Note that the dominant cutsets listed in the TAP A-45 report for each accident sequence typically represent less than 50% of the total sequence frequency.

Sequence $S_2MD_1D_2$

This sequence is initiated by a Small LOCA followed by main feedwater trip due to a safety injection signal (M), failure of the high pressure injection system (D_1), and failure of the low pressure injection system (D_2) following successful deppressurization which results in early core melt.

1.4E-05 Mean CDF	20% of the Total CDF
Basic Events:	
CCMDP-CM	6.0E-07
SWSMP-CM	6.0E-07
SWNV2201-NOO-LF	6.0E-07

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection pumps.

CDF Contribution = 1.8E-06 which is 2% of the total CDF (7.1E-05).

Sequence S_2MXD_1

This sequence is initiated by a Small LOCA followed by main feedwater trip due to a safety injection signal (M), failure of the high pressure injection system (D_1), and failure to pressurize (X) where low pressure injection could be used which results in early core melt.

8.42E-07 Mean CDF	1% of the Total CDF
Basic Events:	
CCMDP-CM	9.6E-09
SWSMP-CM	9.6E-09
SWNV2201-NOO-LF	9.6E-09

This basic event results in failure of the HPSI due to loss of pump cooling.

CDF Contribution = 2.88E-08 which is <.1% of the total CDF (7.1E-05).

Sequence $T_2MQD_1D_2$

This sequence is a loss of feedwater transient (T_2) caused by loss of the power conversion system (M) followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

1.23E-06 Mean CDF 2% of the Total CDF

Basic Events:

CCMDP-CM	6.3E-08
SWSMP-CM	6.3E-08
SWNV2201-NOO-LF	6.3E-08

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection system.

CDF Contribution = 1.894E-07 which is <1% of the total CDF (7.1E-05).

Sequence $T_3QD_1D_2$

This sequence is a transient in which the power conversion system is initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, and both HPSI (D_1) and LPSI (D_2) fail leading to core melt.

8.70E-06 Mean CDF 12% of the Total CDF

Basic Events:

CCMDP-CM	4.5E-07
SWSMP-CM	4.5E-07
SWNV2201-NOO-LF	4.5E-07

These basic events represent CCW and SWS faults that result in loss of pump cooling to the low pressure injection and high pressure injection system.

CDF Contribution = 1.35E-06 which is <1% of the total CDF (7.1E-05).

Sequence T_3QXD_1

This sequence is a transient in which the power conversion system is initially available, followed by failure of the pressurizer safety relief valves to reclose (Q) which results in a transient induced LOCA, failure of HPSI (D_1), and failure to depressurize (X) leading to core melt.

6.0E-08 Mean CDF <1% of the Total CDF

Basic Events:

CCMDP-CM	7.2E-09
SWSMP-CM	7.2E-09
SWNV2201-NOO-LF	7.2E-09

These basic events represent CCW and SWS faults that result in loss of pump cooling to the high pressure injection system.

CDF Contribution = 2.16E-08 which is <1% of the total CDF (1.4E-04).

11.0 SURRY: NUREG/CR-4550

11.1 SURRY UNIT 1: 1150 ANALYSIS SUMMARY OF RESULTS

The basic events for those cooling water systems (i.e., Service Water System (SWS)) found to be contributors to the total core damage frequency (CDF) at the Surry nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
SWS-CCF-FT-3ABCD	7.56E-09	3
SWS-XHE-FO-OPEN	7.56E-09	3
Total	1.51E-08	
Internal Events CDF	4.01E-05	
External Events CDF	1.30E-04	
Total	1.70E-04	

Surry, Unit 1 Event Descriptions:

SWS-CCF-FT-3ABCD - Common cause failure of SWS isolation MOVs 103A, B, C and D (SWS-MOV-FT * BETA-SWMOV).

SWS-XHE-FO-OPEN - Operator fails to open spray heat exchanger MOV.

11.2 SURRY, UNIT 1 ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: NUREG/CR 4550 ANALYSIS

The events listed above appear in the Surry "Total Core Damage Model" cutset listing and not in any specific accident cutset listing. Therefore no specific accident sequence is associated with the listed events.

12.0 SEQUOYAH: NUREG/CR-4550

12.1 SEQUOYAH, UNIT 1: 1150 ANALYSIS SUMMARY OF RESULTS

The basic events for those cooling water system (i.e., Service Water System (SWS) and Component Cooling Water (CCW) System) found to be major contributors to the total core damage frequency (CDF) at the Sequoyah nuclear power station are listed below along with the contribution each basic event makes to the total CDF and the number of cutsets in which the basic event appears. A description of each basic event is also included.

Internal Events:

Basic Event	Contribution to CDF	# Cutsets
CCW-MOV-CC-1153*RA8	5.28E-08	26
CCW-MOV-CC-1156*RA8	5.28E-08	26
CCW-MOV-CC-1153	2.48E-08	9
CCW-MOV-CC-1156	2.48E-08	9
CCW-MOV-CC-1153*CCW-MOV-CC-1156	1.80E-08	1
CCW-MOV-CC-1153*CCW-MOV-CC-1156*RA8	1.32E-08	4
CCW-XVM-RE-RHR1A	2.25E-09	3
CCW-XVM-RE-RHR1B	2.25E-09	3
CCW-XVM-RE-RHRX1A	1.12E-09	2
CCW-XVM-RE-RHRX1B	1.12E-09	2
SWS-STR-PG-A121H	8.19E-09	6
SWS-STR-PG-A221H	8.19E-09	6
SWS-STR-PG-B121H	8.19E-09	6
SWS-STR-PG-B221H	8.19E-09	6
SWS-XVM-PR-1603A	1.75E-09	3
SWS-XVM-PR-1603B	1.75E-09	3
SWS-XVM-PR-1606A	1.75E-09	3
SWS-XVM-PR-1606B	1.75E-09	3
SWS-XVM-PR-1613A	1.75E-09	3
SWS-XVM-PR-1613B	1.75E-09	3
Total	2.35E-07	
Internal Events CDF	5.70E-05	

Sequoyah, Unit 1, Event Descriptions:

CCW-MOV-CC-1153 -	Component Cooling Water flow control valve 1-153 fails to open.
CCW-MOV-CC-1156 -	Component Cooling Water flow control valve 1-156 fails to open.
CCW-XVM-RE-RHR1A -	Failure to restore valve to RHR seal water heat exchanger 1A-A.
CCW-XVM-RE-RHR1B -	Failure to restore valve to RHR seal water heat exchanger 1B-B.
CCW-XVM-RE-RHRX1A -	Failure to restore valve to RHR heat exchanger 1A-A.
CCW-XVM-RE-RHRX1B -	Failure to restore valve to RHR heat exchanger 1B-B.
RA8 -	Probability of operator failing to locally open the RHR CCW outlet valves ($p = 0.24$).
SWS-STR-PG-A121H -	SWS strainer A-1 plugged for 21 hours.
SWS-STR-PG-A221H -	SWS strainer A-2 plugged for 21 hours.
SWS-STR-PG-B121H -	SWS strainer B-1 plugged for 21 hours.
SWS-STR-PG-B221H -	SWS strainer B-2 plugged for 21 hours.
SWS-XVM-PR-1603A -	SWS manual valve 1603A plugged or mispositioned.
SWS-XVM-PR-1603B -	SWS manual valve 1603B plugged or mispositioned.
SWS-XVM-PR-1606A -	SWS manual valve 1606A plugged or mispositioned.
SWS-XVM-PR-1606B -	SWS manual valve 1606B plugged or mispositioned.
SWS-XVM-PR-1613A -	SWS manual valve 1613A plugged or mispositioned.
SWS-XVM-PR-1613B -	SWS manual valve 1613B plugged or mispositioned.

12.2 SEQUOYAH, UNIT 1 ACCIDENT SEQUENCES WITH SWS CONTRIBUTIONS: NUREG/CR 4550 ANALYSIS

The following presents the NUREG 4550 accident sequences in which Service Water System (SWS) and Component Cooling Water (CCW) system events appear along with the contribution SSW and CCW makes to the total CDF for the given accident sequence.

Sequence $S_3O_CH_2$

This sequence is initiated by a very Small LOCA followed by the operators inability to control containment sprays and subsequent failure of the high pressure injection system in the recirculation mode. Continued heat up and boil off of primary coolant leads to core uncovery.

1.4E-05 Mean CDF — 25% of the Total CDF

Basic Events:

CCW-MOV-CC-1156*RA8	4.27E-10
CCW-MOV-CC-1153*RA8	4.27E-10

These basic events result in failure of the CCW system to provide cooling to the RHR heat exchangers, failing LPR which fails HPR. Recovery action RA8 is the failure to locally open these valves (p = .24).

CDF Contribution = 8.54E-10 which is <1% of the total CDF (4.0E-05).

Sequence $S_3O_CH_1$

This sequence is initiated by a very Small LOCA followed by the operators inability to control containment sprays and subsequent failure of the low pressure recirculation system.

5.0E-06 Mean CDF — 8.8% of the Total CDF

Basic Events:

CCW-MOV-CC-1153*RA8	2.40E-08
CCW-MOV-CC-1156*RA8	2.40E-08
CCW-MOV-CC-1153*CCW-MOV-CC-1156*RA8	6.74E-09
CCW-XVM-RE-RHR1A	2.20E-09
CCW-XVM-RE-RHR1B	2.20E-09
CCW-XVM-RE-RHRX1A	1.12E-09
CCW-XVM-RE-RHRX1B	1.12E-09
SWS-XVM-PR-1603A	1.84E-09
SWS-XVM-PR-1603B	1.84E-09
SWS-XVM-PR-1606A	1.84E-09
SWS-XVM-PR-1606B	1.84E-09
SWS-XVM-PR-1613A	1.84E-09
SWS-XVM-PR-1613B	1.84E-09

These basic events result in failure of the CCW system to provide cooling to the RHR heat exchangers, failing LPR and failure of the SWS to provide cooling to the RHR room coolers. Recovery action RA8 is the failure to locally open the RHR CCW outlet valves (p = .24).

CDF Contribution = 7.24E-08 which is < 1% of the total CDF (4.0E-05).

Sequence S_1H_4

This sequence is initiated by a medium LOCA which is followed by successful operation of the high pressure injection system, but the low pressure system fails in either the miniflow mode during the injection phase or in the recirculation mode.

1.9E-06 Mean CDF 3.3% of the Total CDF

Basic Events:

CCW-MOV-CC-1153*RA8	6.60E-09
CCW-MOV-CC-1156*RA8	6.60E-09
CCW-MOV-CC-1153*CCW-MOV-CC-1156*RA8	2.16E-09
SWS-STR-PG-A121H	8.27E-09
SWS-STR-PG-A221H	8.27E-09
SWS-STR-PG-B121H	8.27E-09
SWS-STR-PG-B221H	8.37E-09

These basic events result in failure of the CCW system to provide cooling to the RHR heat exchangers, failing LPR and failure of the SWS to provide cooling to the RHR room coolers. Recovery action RA8 is the failure to locally open the RHR CCW outlet valves (p = .24).

CDF Contribution = 4.65E-08 which is < 1% of the total CDF (4.0E-05).

Sequence S_2H_3

This sequence is initiated by a small LOCA which is followed failure of the high pressure recirculation system due to failure of the low pressure recirculation system.

1.7E-06 Mean CDF 3.0% of the Total CDF

Basic Events:

CCW-MOV-CC-1153*RA8	7.72E-09
CCW-MOV-CC-1156*RA8	7.72E-09
CCW-MOV-CC-1153*CCW-MOV-CC 1156*RA8	2.16E-09

These basic events result in failure of the CCW system to provide cooling to the RHR heat exchangers, failing LPR which in turn fails HPR. Recovery action RA8 is the failure to locally open the RHR CCW outlet valves (p = .24).

CDF Contribution = 1.76E-08 which is < 1% of the total CDF (4.0E-05).

Sequence AH_1

This sequence is initiated by a large LOCA which is followed failure of the low pressure recirculation system.

9.97E-07 Mean CDF 2.0% of the Total CDF

Basic Events:

CCW-MOV-CC-1153	2.48E-08
CCW-MOV-CC-1156	2.48E-08
CCW-MOV-CC-1153*CCW-MOV-CC-1156	1.80E-08

These basic events result in failure of the CCW system to provide cooling to the RHR heat exchangers, failing LPR.

CDF Contribution = 6.75E-08 which is <1% of the total CDF (4.0E-05).

Sequence $S_3W_1H_3$

This sequence is initiated by a very small LOCA which is followed failure of the RHR system in the shutdown cooling mode and failure of low pressure recirculation.

6.34E-07 Mean CDF 1.1% of the Total CDF

Basic Events:

CCW-MOV-CC-1153*RA8	4.14E-09
CCW-MOV-CC-1156*RA8	4.14E-09
CCW-MOV-CC-1153*CCW-MOV-CC-1156*RA8	2.13E-09

These basic events results in failure of the CCW system to provide cooling to the RHR heat exchangers, failing RHR and LPR. Recovery action RA8 is the failure to locally open the RHR CCW outlet valves (p = .24).

CDF Contribution = 1.04E-08 which is <1% of the total CDF (4.0E-05).

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APPENDIX F

SCOPING STUDY BASE CASE

DOMINANT ACCIDENT SEQUENCE CUT SETS

Table of Contents

This Appendix presents the base case dominant accident sequence cut sets used in the pilot plant analysis. The base case cut sets are the result of updating the Peach Bottom NUREG/CR-4550 dominant accident sequence cut sets made available on IRRAS as discussed in Section 4.5 of the main report. These cut sets prov. ·d the bases for the dy of the service water modifications discussed in Section 4 of the main report and also the sensitivity study described in Section 4.7 of the main report. The values shown in the Prob./Freq. column of the tables are point estimates.

Table F.1

Accident Sequence T1-BNU11 Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family: PEACHBOT　　Event Tree: T1

Sequence: T1-BNU11　　Init. Event: IE-T1

Mincut Upper Bound 1.830E-006

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	4.7	4.7	8.6E-008	ACP-DGN-LP-CCF, BAT-DEP-3HR, BETA-4DGNS, DGCCFNR3HR, LOSPNR5HR
2	9.0	4.3	8.0E-008	ACP-DGN-LP-CCF, BETA-4DGNS, DGCCFNR12HR, INJ-FAILS, LOSPNR13HR
3	12.8	3.7	6.8E-008	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
4	16.5	3.7	6.8E-008	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
5	19.4	2.8	5.2E-008	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
6	22.2	2.8	5.2E-008	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
7	25.1	2.8	5.2E-008	ACP-DGN-LP-CCF, BAT-DEP-9HR, BETA-4DGNS, DGCCFNR9HR, LOSPNR12HR
8	27.8	2.6	4.9E-008	ACP-DGN-LP-CCF, BAT-DEP-5HR, BETA-4DGNS, DGCCFNR5HR, LOSPNR7HR
9	30.0	2.1	4.0E-008	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
10	32.2	2.1	4.0E-008	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
11	34.2	2.0	3.6E-008	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
12	35.8	1.6	2.9E-008	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
13	37.4	1.6	2.9E-008	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
14	39.0	1.6	2.9E-008	ACP-DGN-LP-CCF, BAT-DEP-7HR, BETA-4DGNS, DGCCFNR7HR, LOSPNR9HR
15	40.6	1.5	2.8E-008	BETA-3AOVS, ESW-AOV-CC-CCF, INJ-FAILS, LOSPNR13HR

16	42.1	1.5	2.7E-008	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
17	43.5	1.3	2.5E-008	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
18	44.9	1.3	2.5E-008	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
19	46.1	1.2	2.2E-008	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, LOSPNR5HR
20	47.4	1.2	2.2E-008	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, LOSPNR5HR
21	48.5	1.1	2.1E-008	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
22	49.7	1.1	2.0E-008	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
23	50.8	1.1	2.0E-008	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
24	51.8	1.0	1.8E-008	BETA-6AOVS, EHV-AOV-CC-CCF, INJ-FAILS, LOSPNR13HR
25	52.7	.9	1.7E-008	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR5HR
26	53.6	.8	1.6E-008	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR12HR
27	54.5	.8	1.5E-008	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
28	55.3	.8	1.5E-008	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, LOSPNR12HR
29	56.2	.8	1.5E-008	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, LOSPNR12HR
30	56.9	.7	1.3E-008	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, LOSPNR7HR
31	57.6	.7	1.3E-008	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, LOSPNR7HR
32	58.3	.6	1.1E-008	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR7HR
33	58.9	.6	1.1E-008	BAT-DEP-3HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR5HR
34	59.5	.6	1.0E-008	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
35	60.1	.5	1.0E-008	BAT-DEP-9HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR12HR
36	60.6	.5	9.9E-009	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR

37	61.2	.5	9.9E-009	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
38	61.7	.5	9.1E-009	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
39	62.2	.5	9.1E-009	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
40	62.6	.4	8.3E-009	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR9HR
41	63.1	.4	8.1E-009	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, LOSPNR9HR
42	63.5	.4	8.1E-009	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, LOSPNR9HR
43	63.9	.4	7.6E-009	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
44	64.3	.4	7.6E-009	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
45	64.8	.4	7.6E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR18HR
46	65.2	.4	7.6E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR18HR
47	65.6	.4	7.5E-009	BAT-DEP-5HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR7HR
48	66.0	.3	7.1E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
49	66.4	.3	7.1E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
50	66.7	.3	6.8E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
51	67.1	.3	6.8E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
52	67.5	.3	6.8E-009	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR
53	67.9	.3	6.8E-009	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR5HR
54	68.2	.3	6.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
55	68.5	.3	6.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
56	68.9	.3	5.8E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, LOSPNR9HR

57	69.2	.3	5.8E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, LOSPNR9HR
58	69.5	.3	5.4E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR9HR
59	69.8	.3	5.4E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR9HR
60	70.1	.3	5.4E-009	BAT-DEP-7HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR9HR
61	70.4	.2	5.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
62	70.6	.2	5.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
63	70.9	.2	5.2E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
64	71.2	.2	5.2E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
65	71.5	.2	5.1E-009	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
66	71.8	.2	5.1E-009	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
67	72.1	.2	5.1E-009	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
68	72.3	.2	5.1E-009	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
69	72.6	.2	5.0E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
70	72.9	.2	5.0E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
71	73.1	.2	4.8E-009	ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, INJ-FAILS, LOSPNR13HR
72	73.4	.2	4.8E-009	ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, INJ-FAILS, LOSPNR13HR
73	73.7	.2	4.6E-009	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
74	73.9	.2	4.6E-009	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR
75	74.2	.2	4.6E-009	ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, INJ-FAILS, LOSPNR13HR
76	74.4	.2	4.6E-009	ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, INJ-FAILS, LOSPNR13HR

77	74.7	.2	4.5E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
78	74.9	.2	4.5E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
79	75.2	.2	4.4E-009	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, LOSPNR17HR
80	75.4	.2	4.4E-009	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, LOSPNR17HR
81	75.6	.2	4.1E-009	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR17HR
82	75.9	.2	4.1E-009	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR17HR
83	76.1	.2	4.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
84	76.3	.2	4.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
85	76.5	.2	4.0E-009	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
86	76.7	.2	4.0E-009	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
87	77.0	.2	3.9E-009	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR7HR
88	77.2	.2	3.9E-009	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, LOSPNR5HR
89	77.4	.2	3.9E-009	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, LOSPNR5HR
90	77.6	.2	3.9E-009	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR
91	77.8	.2	3.9E-009	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
92	78.0	.2	3.9E-009	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
93	78.2	.2	3.8E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
94	78.5	.2	3.8E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
95	78.7	.2	3.7E-009	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR

96	78.9	.2	3.7E-009	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
97	79.0	.1	3.4E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
98	79.2	.1	3.4E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
99	79.4	.1	3.4E-009	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
100	79.6	.1	3.4E-009	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
101	79.8	.1	3.3E-009	ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, INJ-FAILS, LOSPNR13HR
102	80.0	.1	3.3E-009	ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, INJ-FAILS, LOSPNR13HR
103	80.2	.1	3.3E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, LOSPNR12HR
104	80.3	.1	3.3E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, LOSPNR12HR
105	80.5	.1	3.1E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR12HR
106	80.7	.1	3.1E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR12HR
107	80.9	.1	3.0E-009	ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, INJ-FAILS, LOSPNR13HR
108	81.0	.1	3.0E-009	ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, INJ-FAILS, LOSPNR13HR
109	81.2	.1	3.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
110	81.4	.1	3.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
111	81.5	.1	3.0E-009	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
112	81.7	.1	3.0E-009	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
113	81.8	.1	2.9E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
114	82.0	.1	2.9E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR

115	82.2	.1	2.9E-009	BAT-DEP-3HR, ESW-CK[illegible]-CB-[illegible]515[illegible], E[illegible]W-PTF RE-D[illegible]B, LOSPNR5HR
116	82.3	.1	2.9E-009	BAT-DEP-3H[illegible] ESW-[illegible]V-CB [illegible] ESW-PTF RE-DGC, LOSPNR5HR
117	82.5	.1	2.9E-009	ACP-DGN-FR-EDGB [illegible] DGHWNR9HR, ESW-PTF-RE-MDPB [illegible]S, LOSPNR17HR
118	82.7	.1	2.[illegible]-009	ACP-DGN-FR-ED[illegible] [illegible], DGHWNR9HR, ESW-PTF-RE-MDPA, ESW[illegible]HS, LOSPNR17HR
119	82.8	.1	2.8E-009	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR5HR
120	83.0	.1	2.8E-[illegible]09	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR5HR
121	83.1	.1	2.7[illegible]09	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR12HR
122	83.3	.1	2.7E-[illegible]09	BAT-DEP-[illegible]HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSP[illegible]R
123	83.4	.1	2.7E-009	ACP-[illegible]R-EDGB, DGHWNR12HR, ESW-MDP-F[illegible]-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
124	83.6	.1	2.7E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FR-M[illegible]A, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
125	83.7	.1	2.6E-00[illegible]	ACP-DGN-FR-EDGB, BAT-DEP-[illegible]HR, DGHWNR9HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
126	83.9	.1	2.6E-00[illegible]	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
127	84.0	.1	2.6E-009	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR12HR
128	84.2	.1	2.6E-009	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LO[illegible]PNR12HR
129	84.3	.1	2.4E-009	ACP-DGN-LP-EDGC, BAT-DEP-7HR, [illegible]7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EH[illegible], [illegible]SPNR9HR
130	84.4	.1	2.4E-00[illegible]	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
131	84.6	.1	2.4E-009	[illegible]CP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, LOSPNR12HR
132	84.7	.1	2.4E-00[illegible]	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, LOSPNR12HR
133	84.8	.1	2.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, [illegible]T-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR

134	84.9	.1	2.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
135	85.1	.1	2.2E-009	ACP-DGN-LP-EDGC, DGHWNR12HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
136	85.2	.1	2.2E-009	ACP-DGN-LP-EDGB, DGHWNR12HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
137	85.3	.1	2.2E-009	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
138	85.4	.1	2.2E-009	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
139	85.6	.1	2.2E-009	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, LOSPNR14HR
140	85.7	.1	2.2E-009	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, LOSPNR7HR
141	85.8	.1	2.2E-009	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, LOSPNR14HR
142	85.9	.1	2.2E-009	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, LOSPNR7HR
143	86.1	.1	2.2E-009	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
144	86.2	.1	2.2E-009	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
145	86.3	.1	2.1E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
146	86.4	.1	2.1E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
147	86.5	.1	2.1E-009	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR14HR
148	86.6	.1	2.1E-009	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR14HR
149	86.8	.1	2.0E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
150	86.9	.1	2.0E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
151	87.0	.1	2.0E-009	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR5HR
152	87.1	.1	2.0E-009	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR5HR

153	87.2	.1	2.0E-009	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR5HR
154	87.3	.1	2.0E-009	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
155	87.4	.1	2.0E-009	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
156	87.5	.1	2.0E-009	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR5HR
157	87.7	.1	1.9E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
158	87.8	.1	1.9E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
159	87.9	.1	1.9E-009	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR7HR
160	88.0	.1	1.9E-009	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR7HR
161	88.1	.1	1.9E-009	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR12HR
162	88.2	.1	1.9E-009	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR12HR
163	88.3	.1	1.9E-009	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR7HR
164	88.4	.1	1.9E-009	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR5HR
165	88.5	.1	1.9E-009	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR7HR
166	88.6	.1	1.9E-009	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR5HR
167	88.7	.1	1.7E-009	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR12HR
168	88.8	.1	1.7E-009	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR12HR
169	88.9	.1	1.7E-009	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
170	89.0	.1	1.7E-009	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR
171	89.1	.0	1.6E-009	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR

172	89.2	.0	1.6E-009	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
173	89.3	.0	1.5E-009	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
174	89.3	.0	1.5E-009	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
175	89.4	.0	1.5E-009	ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
176	89.5	.0	1.5E-009	ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
177	89.6	.0	1.5E-009	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
178	89.7	.0	1.5E-009	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
179	89.8	.0	1.5E-009	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, LOSPNR5HR
180	89.8	.0	1.5E-009	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, LOSPNR5HR
181	89.9	.0	1.4E-009	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
182	90.0	.0	1.4E-009	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
183	90.1	.0	1.4E-009	ESW-AOV-CC-0241C ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
184	90.2	.0	1.4E-009	ESW-AOV-CC-0241B, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
185	90.2	.0	1.4E-009	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR9HR
186	90.3	.0	1.4E-009	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR9HR
187	90.4	.0	1.4E-009	ACP-DGN-TE-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
188	90.5	.0	1.4E-009	ACP-DGN-TE-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
189	90.6	.0	1.3E-009	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR12HR
190	90.6	.0	1.3E-009	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR12HR

191	90.7	.0	1.3E-009	ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
192	90.8	.0	1.3E-009	ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
193	90.9	.0	1.3E-009	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR7HR
194	90.9	.0	1.3E-009	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR7HR
195	91.0	.0	1.3E-009	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
196	91.1	.0	1.3E-009	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
197	91.2	.0	1.3E-009	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR9HR
198	91.2	.0	1.3E-009	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR9HR
199	91.3	.0	1.3E-009	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, LOSPNR9HR
200	91.4	.0	1.3E-009	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, LOSPNR9HR
201	91.5	.0	1.3E-009	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR17HR
202	91.5	.0	1.3E-009	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR17HR
203	91.6	.0	1.3E-009	ACP-DGN-FR-EDGB, ACP-DGN-RE-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
204	91.7	.0	1.3E-009	ACP-DGN-FR-EDGC, ACP-DGN-RE-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
205	91.7	.0	1.2E-009	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR7HR
206	91.8	.0	1.2E-009	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR7HR
207	91.9	.0	1.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGC, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
208	91.9	.0	1.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGB, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
209	92.0	.0	1.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGD, DGHWNR12HR, INJ-FAILS, LOSPNR18HR

210	92.1	.0	1.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-RE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
211	92.1	.0	1.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-RE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
212	92.2	.0	1.1E-009	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR7HR
213	92.3	.0	1.1E-009	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
214	92.3	.0	1.1E-009	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR7HR
215	92.4	.0	1.1E-009	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
216	92.5	.0	1.1E-009	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR
217	92.5	.0	1.1E-009	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR5HR
218	92.6	.0	1.1E-009	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
219	92.7	.0	1.1E-009	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
220	92.7	.0	1.0E-009	ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, INJ-FAILS, LOSPNR18HR
221	92.8	.0	1.0E-009	ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, INJ-FAILS, LOSPNR18HR
222	92.8	.0	1.0E-009	ESW-AOV-CC-0241B, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
223	92.9	.0	1.0E-009	ESW-AOV-CC-0241C, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
224	92.9	.0	9.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
225	93.0	.0	9.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR
226	93.0	.0	9.9E-010	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR9HR
227	93.1	.0	9.9E-010	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR9HR
228	93.1	.0	9.7E-010	ESW-MDP-FR-MDPA, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR

229	93.2	.0	9.7E-010	ESW-MDP-FR-MDPB, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
230	93.3	.0	9.4E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR5HR
231	93.3	.0	9.4E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR5HR
232	93.4	.0	9.3E-010	ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
233	93.4	.0	9.3E-010	ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
234	93.5	.0	9.3E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGD, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
235	93.5	.0	9.3E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
236	93.6	.0	9.3E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
237	93.6	.0	9.2E-010	ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
238	93.7	.0	9.2E-010	ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
239	93.7	.0	9.2E-010	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, LOSPNR12HR
240	93.8	.0	9.2E-010	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, LOSPNR12HR
241	93.8	.0	9.0E-010	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR9HR
242	93.9	.0	9.0E-010	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR9HR
243	93.9	.0	8.9E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR5HR
244	94.0	.0	8.9E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR5HR
245	94.0	.0	8.8E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR12HR
246	94.1	.0	8.8E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR12HR
247	94.1	.0	8.7E-010	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, LOSPNR7HR

248	94.1	.0	8.7E-010	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, LOSPNR7HR
249	94.2	.0	8.5E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR
250	94.2	.0	8.5E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR
251	94.3	.0	8.3E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR12HR
252	94.3	.0	8.3E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR12HR
253	94.4	.0	8.2E-010	ACP-DGN-FR-EDGC, ACP-DGN-RE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
254	94.4	.0	8.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-RE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
255	94.5	.0	8.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
256	94.5	.0	8.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
257	94.6	.0	8.0E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
258	94.6	.0	8.0E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
259	94.6	.0	7.4E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
260	94.7	.0	7.4E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
261	94.7	.0	7.3E-010	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR9HR
262	94.8	.0	7.3E-010	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR9HR
263	94.8	.0	7.2E-010	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR
264	94.8	.0	7.2E-010	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
265	94.9	.0	7.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGD, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
266	94.9	.0	7.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR

267	95.0	.0	7.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
268	95.0	.0	6.8E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
269	95.0	.0	6.8E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
270	95.1	.0	6.8E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
271	95.1	.0	6.8E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
272	95.1	.0	6.8E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR14HR
273	95.2	.0	6.8E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR14HR
274	95.2	.0	6.8E-010	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR7HR
275	95.3	.0	6.8E-010	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR
276	95.3	.0	6.8E-010	ESW-MDP-FR-MDPA, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
277	95.3	.0	6.8E-010	ESW-MDP-FR-MDPB, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
278	95.4	.0	6.8E-010	ACP-DGN-FR-EDGC, ACP-DGN-RE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
279	95.4	.0	6.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-RE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
280	95.4	.0	6.6E-010	ACP-DGN-LP-EDGD, BETA-2SWPS, DGHWNR12HR, ESW-MDP-FS-CCF, INJ-FAILS, LOSPNR13HR
281	95.5	.0	6.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
282	95.5	.0	6.3E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR7HR
283	95.5	.0	6.3E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR7HR
284	95.6	.0	6.2E-010	ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
285	95.6	.0	6.2E-010	ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR

286	95.6	.0	6.2E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR
287	95.7	.0	6.2E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR
288	95.7	.0	5.9E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR7HR
289	95.7	.0	5.9E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR7HR
290	95.8	.0	5.9E-010	ACP-DGN-LP-EDGD, BAT-DEP-3HR, BETA-2SWPS, DGHWNR3HR, ESW-MDP-FS-CCF, LOSPNR5HR
291	95.8	.0	5.8E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
292	95.8	0	5.8E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
293	95.9	.0	5.7E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR17HR
294	95.9	.0	5.7E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR17HR
295	95.9	.0	5.6E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR
296	96.0	.0	5.6E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR
297	96.0	.0	5.6E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR
298	96.0	.0	5.6E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR
299	96.1	.0	5.4E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR9HR
300	96.1	.0	5.4E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR9HR
301	96.1	.0	5.4E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR17HR
302	96.1	.0	5.4E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR17HR
303	96.2	.0	5.3E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
304	96.2	.0	5.3E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR

305	96.2	.0	5.3E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
306	96.3	.0	5.3E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
307	96.3	.0	5.3E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGD, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
308	96.3	.0	5.2E-010	ACP-DGN-RE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, LOSPNR5HR
309	96.4	.0	5.2E-010	ACP-DGN-RE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, LOSPNR5HR
310	96.4	.0	5.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR9HR
311	96.4	.0	5.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR9HR
312	96.4	.0	5.2E-010	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, LOSPNR9HR
313	96.5	.0	5.2E-010	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, LOSPNR9HR
314	96.5	.0	5.1E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
315	96.5	.0	5.1E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
316	96.6	.0	5.1E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR9HR
317	96.6	.0	5.1E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR9HR
318	96.6	.0	4.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
319	96.6	.0	4.9E-010	ACP-DGN-RE-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
320	96.7	.0	4.9E-010	ACP-DGN-RE-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
321	96.7	.0	4.9E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
322	96.7	.0	4.9E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
323	96.7	.0	4.6E-010	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR

324	96.8	.0	4.6E-010	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
325	96.8	.0	4.6E-010	EHV-SRV-CC-RV2, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
326	96.8	.0	4.6E-010	ESW-AOV-CC-0241B, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
327	96.8	.0	4.6E-010	EHV-SRV-CC-RV3, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
328	96.9	.0	4.5E-010	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR5HR
329	96.9	.0	4.5E-010	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR
330	96.9	.0	4.5E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-AOV-MA-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
331	96.9	.0	4.5E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-AOV-MA-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
332	97.0	.0	4.5E-010	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR9HR
333	97.0	.0	4.5E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR9HR
334	97.0	.0	4.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-RE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
335	97.0	.0	4.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-RE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
336	97.1	.0	4.2E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR9HR
337	97.1	.0	4.2E-010	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR9HR
338	97.1	.0	4.2E-010	ACP-DGN-TE-EDGC, DGMANR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
339	97.1	.0	4.2E-010	ACP-DGN-TE-EDGB, DGMANR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
340	97.2	.0	4.1E-010	EHV-SRV-CC-RV2, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
341	97.2	.0	4.1E-010	EHV-SRV-CC-RV3, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
342	97.2	.0	4.1E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR

343	97.2	.0	4.1E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR
344	97.2	.0	4.0E-010	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
345	97.3	.0	4.0E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
346	97.3	.0	4.0E-010	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
347	97.3	.0	4.0E-010	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR
348	97.3	.0	4.0E-010	ACP-DGN-LP-EDGD, BAT-DEP-9HR, BETA-2SWPS, DGHWNR9HR, ESW-MDP-FS-CCF, LOSPNR12HR
349	97.4	.0	4.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR17HR
350	97.4	.0	4.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR17HR
351	97.4	.0	3.8E-010	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
352	97.4	.0	3.8E-010	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
353	97.4	.0	3.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
354	97.5	.0	3.7E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR
355	97.5	.0	3.7E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR
356	97.5	.0	3.7E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
357	97.5	.0	3.7E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
358	97.5	.0	3.7E-010	ESW-MDP-FR-MDPA, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
359	97.6	.0	3.6E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGD, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
360	97.6	.0	3.6E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
361	97.6	.0	3.6E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR

362	97.6	.0	3.5E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR5HR
363	97.6	.0	3.5E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR DGMANR3HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR5HR
364	97.7	.0	3.5E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
365	97.7	.0	3.5E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
366	97.7	.0	3.5E-010	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR[illegible]
367	97.7	.0	3.5E-010	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR12HR
368	97.7	.0	3.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-MA-0241B, ESW-XHE-FO-EHS, LOSPNR9HR
369	97.8	.0	3.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-MA-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
370	97.8	.0	3.4E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
371	97.8	.0	3.4E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
372	97.8	.0	3.4E-010	ACP-DGN-LP-EDGD, BAT-DEP-5HR, BETA-2SWPS, DGHWNR5HR, ESW-MDP-FS-CCF, LOSPNR7HR
373	97.8	.0	3.3E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR12HR
374	97.9	.0	3.3E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR12HR
375	97.9	.0	3.3E-010	ACP-DGN-MA-EDGB, DGMANR12HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
376	97.9	.0	3.3E-010	ACP-DGN-MA-EDGC, DGMANR12HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
377	97.9	.0	3.2E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
378	97.9	.0	3.2E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
379	97.9	.0	3.2E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
380	98.0	.0	3.2E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR

381	98.0	.0	3.1E-010	ACP-DGN-RE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, LOSPNR12HR
382	98.0	.0	3.1E-010	ACP-DGN-RE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, LOSPNR12HR
383	98.0	.0	3.1E-010	ESW-AOV-CC-0241C, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
384	98.0	.0	3.1E-010	ESW-AOV-CC-0241B, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
385	98.0	.0	3.0E-010	ESW-AOV-MA-0241C, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR
386	98.1	.0	3.0E-010	ESW-AOV-MA-0241B, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR
387	98.1	.0	3.0E 010	ACP-DGN-RE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, LOSPNR7HR
388	98.1	.0	3.0E-010	ACP-DGN-RE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, LOSPNR7HR
389	98.1	.0	2.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR12HR
390	98.1	.0	2.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR12HR
391	98.1	.0	2.9E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
392	98.2	.0	2.9E-010	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
393	98.2	.0	2.8E-010	ACP-DGN-TE-EDGC, DGMANR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
394	98.2	.0	2.8E-010	ACP-DGN-TE-EDGB, DGMANR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
395	98.2	.0	2.8E-010	BAT-DEP-3HR, EHV-SRV-CC-RV3, ESW-CKV-CB-C515B, LOSPNR5HR
396	98.2	.0	2.8E-010	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR14HR
397	98.2	.0	2.8E-010	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR14HR
398	98.3	.0	2.8E-010	BAT-DEP-3HR, EHV-SRV-CC-RV2, ESW-CKV-CB-C515A, LOSPNR5HR
399	98.3	.0	2.8E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR

400	98.3	.0	2.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
401	98.3	.0	2.7E-010	EHV-SRV-CC-RV2, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
402	98.3	.0	2.7E-010	EHV-SRV-CC-RV3, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
403	98.3	.0	2.7E-010	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR
404	98.3	.0	2.7E-010	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
405	98.4	.0	2.7E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
406	98.4	.0	2.7E-010	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
407	98.4	.0	2.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-MA-0241B, ESW-XHE-FO-EHS, LOSPNR17HR
408	98.4	.0	2.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-MA-0241C, ESW-XHE-FO-EHS, LOSPNR17HR
409	98.4	.0	2.6E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR14HR
410	98.4	.0	2.6E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR14HR
411	98.4	.0	2.6E-010	BAT-DEP-9HR, EHV-SRV-CC-RV3, ESW-CKV-CB-C515B, LOSPNR12HR
412	98.5	.0	2.6E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
413	98.5	.0	2.6E-010	BAT-DEP-9HR, EHV-SRV-CC-RV2, ESW-CKV-CB-C515A, LOSPNR12HR
414	98.5	.0	2.6E-010	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
415	98.5	.0	2.6E-010	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
416	98.5	.0	2.6E-010	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR7HR
417	98.5	.0	2.6E-010	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR
418	98.5	.0	2.5E-010	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR

419	98.6	.0	2.5E-010	BAT-DEP-3HR, EHV-SRV-CC-RV2, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR
420	98.6	.0	2.5E-010	BAT-DEP-3HR, EHV-SRV-CC-RV3, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR
421	98.6	.0	2.5E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
422	98.6	.0	2.5E-010	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
423	98.6	.0	2.5E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
424	98.6	.0	2.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGC, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
425	98.6	.0	2.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGD, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
426	98.7	.0	2.4E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGB, DGHWNR12HR, INJ-FAILS, LOSPNR18HR
427	98.7	.0	2.4E-010	BAT-DEP-9HR, EHV-SRV-CC-RV2, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
428	98.7	.0	2.4E-010	BAT-DEP-9HR, EHV-SRV-CC-RV3, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
429	98.7	.0	2.3E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
430	98.7	.0	2.3E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
431	98.7	.0	2.2E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
432	98.7	.0	2.2E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
433	98.7	.0	2.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR12HR
434	98.8	.0	2.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR12HR
435	98.8	.0	2.1E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
436	98.8	.0	2.1E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
437	98.8	.0	2.1E-010	ACP-DGN-LP-EDGD, BAT-DEP-7HR, BETA-2SWPS, DGHWNR7HR, ESW-MDP-FS-CCF, LOSPNR9HR

438	98.8	.0	2.0E-010	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
439	98.8	.0	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR14HR
440	98.8	.0	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR14HR
441	98.8	.0	2.0E-010	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR7HR
442	98.9	.0	2.0E-010	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR7HR
443	98.9	.0	1.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-MA-0241B, ESW-XHE-FO-EHS, LOSPNR12HR
444	98.9	.0	1.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-MA-0241C, ESW-XHE-FO-EHS, LOSPNR12HR
445	98.9	.0	1.9E-010	ACP-DGN-FR-EDGD, BETA-2SWPS, DGHWNR12HR, ESW-MDP-FS-CCF, INJ-FAILS, LOSPNR18HR
446	98.9	.0	1.9E-010	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
447	98.9	.0	1.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
448	98.9	.0	1.9E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR
449	98.9	.0	1.9E-010	BAT-DEP-5HR, EHV-SRV-CC-RV3, ESW-CKV-CB-C515B, LOSPNR7HR
450	98.9	.0	1.9E-010	BAT-DEP-5HR, EHV-SRV-CC-RV2, ESW-CKV-CB-C515A, LOSPNR7HR
451	98.9	.0	1.9E-010	BAT-DEP-3HR, ESW-AOV-MA-0241C, ESW-CKV-CB-C515B, LOSPNR5HR
452	99.0	.0	1.9E-010	BAT-DEP-3HR, ESW-AOV-MA-0241B, ESW-CKV-CB-C515A, LOSPNR5HR
453	99.0	.0	1.8E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
454	99.0	.0	1.8E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
455	99.0	.0	1.8E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
456	99.0	.0	1.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGD, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR

457	99.0	.0	1.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR
458	99.0	.0	1.8E-010	ACP-DGN-RE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, LOSPNR9HR
459	99.0	.0	1.8E-010	ACP-DGN-RE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, LOSPNR9HR
460	99.0	.0	1.7E-010	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
461	99.0	.0	1.7E-010	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
462	99.1	.0	1.7E-010	BAT-DEP-9HR, ESW-AOV-MA-0241B, ESW-CKV-CB-C515A, LOSPNR12HR
463	99.1	.0	1.7E-010	BAT-DEP-9HR, ESW-AOV-MA-0241C, ESW-CKV-CB-C515B, LOSPNR12HR
464	99.1	.0	1.7E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR9HR
465	99.1	.0	1.7E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR9HR
466	99.1	.0	1.7E-010	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR
467	99.1	.0	1.7E-010	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR
468	99.1	.0	1.7E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
469	99.1	.0	1.7E-010	BAT-DEP-3HR, EHV-SRV-CC-RV3, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR
470	99.1	.0	1.7E-010	BAT-DEP-5HR, EHV-SRV-CC-RV2, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR
471	99.1	.0	1.7E-010	BAT-DEP-5HR, EHV-SRV-CC-RV3, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR
472	99.1	.0	1.7E-010	BAT-DEP-3HR, EHV-SRV-CC-RV2, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR
473	99.2	.0	1.7E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
474	99.2	.0	1.6E-010	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
475	99.2	.0	1.6E-010	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR

476	99.2	.0	1.6E-010	BAT-DEP-9HR, EHV-SRV-CC-RV2, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
477	99.2	.0	1.6E-010	BAT-DEP-9HR, EHV-SRV-CC-RV3, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
478	99.2	.0	1.5E-010	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR
479	99.2	.0	1.5E-010	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
480	99.2	.0	1.5E-010	ACP-DGN-FR-EDGD, BAT-DEP-3HR, BETA-2SWPS, DGHWNR3HR, ESW-MDP-FS-CCF, LOSPNR9HR
481	99.2	.0	1.4E-010	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
482	99.2	.0	1.4E-010	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
483	99.2	.0	1.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
484	99.3	.0	1.4E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
485	99.3	.0	1.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGD, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR
486	99.3	.0	1.3E-010	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR5HR
487	99.3	.0	1.3E-010	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR5HR
488	99.3	.0	1.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-MA-0241B, ESW-XHE-FO-EHS, LOSPNR14HR
489	99.3	.0	1.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-MA-0241C, ESW-XHE-FO-EHS, LOSPNR14HR
490	99.3	.0	1.3E-010	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR
491	99.3	.0	1.3E-010	BAT-DEP-7HR, EHV-SRV-CC-RV3, ESW-CKV-CB-C515B, LOSPNR9HR
492	99.3	.0	1.3E-010	BAT-DEP-7HR, EHV-SRV-CC-RV2, ESW-CKV-CB-C515A, LOSPNR9HR
493	99.3	.0	1.3E-010	ACP-DGN-FR-EDGC, DGACTB, DGACTNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
494	99.3	.0	1.3E-010	ACP-DGN-FR-EDGB, DGACTC, DGACTNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR

495	99.3	.0	1.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR17HR
496	99.3	.0	1.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR17HR
497	99.3	.0	1.2E-010	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
498	99.4	.0	1.2E-010	ACP-DGN-TE-EDGB, DGMANR12HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
499	99.4	.0	1.2E-010	ACP-DGN-TE-EDGC, DGMANR12HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
500	99.4	.0	1.2E-010	BAT-DEP-5HR, ESW-AOV-MA-0241B, ESW-CKV-CB-C515A, LOSPNR7HR
501	99.4	.0	1.2E-010	BAT-DEP-5HR, ESW-AOV-MA-0241C, ESW-CKV-CB-C515B, LOSPNR7HR
502	99.4	.0	1.2E-010	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR9HR
503	99.4	.0	1.2E-010	BAT-DEP-7HR, EHV-SRV-CC-RV2, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
504	99.4	.0	1.2E-010	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR9HR
505	99.4	.0	1.2E-010	BAT-DEP-7HR, EHV-SRV-CC-RV3, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
506	99.4	.0	1.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, DGHWNR12HR, ESW-MDP-FS-MDPB, INJ-FAILS, LOSPNR18HR
507	99.4	.0	1.2E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, DGHWNR12HR, ESW-MDP-FS-MDPA, INJ-FAILS, LOSPNR18HR
508	99.4	.0	1.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MOV-CC-M0841, INJ-FAILS, LOSPNR18HR
509	99.4	.0	1.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-ECW, INJ-FAILS, LOSPNR18HR
510	99.4	.0	1.2E-010	BETA-2SWPS, ESW-CKV-CB-C515A, ESW-MDP-FS-CCF, INJ-FAILS, LOSPNR13HR
511	99.4	.0	1.2E-010	BETA-2SWPS, ESW-CKV-CB-C515B, ESW-MDP-FS-CCF, INJ-FAILS, LOSPNR13HR
512	99.4	.0	1.2E-010	BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MOV-CC-M0841, INJ-FAILS, LOSPNR13HR
513	99.5	.0	1.2E-010	BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MDP-FS-ECW, INJ-FAILS, LOSPNR13HR

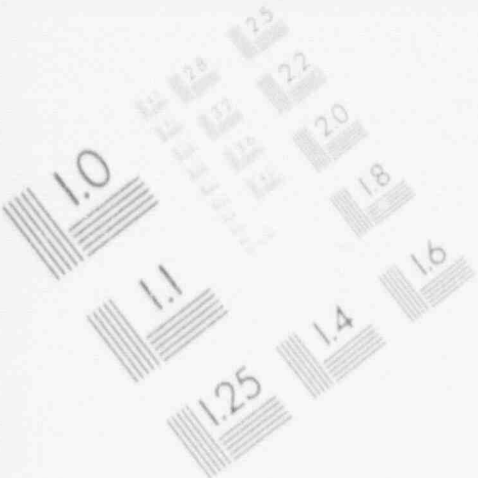
514	99.5	.0	1.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR5HR
515	99.5	.0	1.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR5HR
516	99.5	.0	1.1E-010	ACP-DGN-FR-EDGD, BAT-DEP-9HR, BETA-2SWPS, DGHWNR9HR, ESW-MDP-FS-CCF, LOSPNR17HR
517	99.5	.0	1.1E-010	BAT-DEP-5HR, EHV-SRV-CC-RV3, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR
518	99.5	.0	1.1E-010	BAT-DEP-5HR, EHV-SRV-CC-RV2, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR
519	99.5	.0	1.1E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
520	99.5	.0	1.1E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR
521	99.5	.0	1.0E-010	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR
522	99.5	.0	1.0E-010	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR
523	99.5	.0	1.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
524	99.5	.0	1.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGD, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
525	99.5	.0	1.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR
526	99.5	.0	1.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGACTB, DGACTNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
527	99.5	.0	1.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGACTC, DGACTNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR
528	99.5	.0	1.0E-010	ACP-DGN-MA-EDGD, BAT-DEP-3HR, BETA-2SWPS, DGMANR3HR, ESW-MDP-FS-CCF, LOSPNR5HR
529	99.6	.0	1.0E-010	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
530	99.6	.0	9.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR12HR
531	99.6	.0	9.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR12HR
532	99.6	.0	9.8E-011	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR

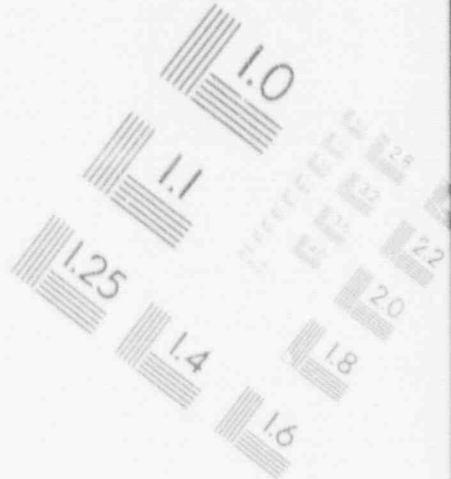
533	99.6	.0	9.8E-011	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
534	99.6	.0	9.6E-011	ACP-DGN-MA-EDGD, BETA-2SWPS, DGMANR12HR, ESW-MDP-FS-CCF, INJ-FAILS, LOSPNR13HR
535	99.6	.0	9.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, LOSPNR9HR
536	99.6	.0	9.3E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, LOSPNR9HR
537	99.6	.0	9.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MOV-CC-M0841, LOSPNR9HR
538	99.6	.0	9.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-ECW, LOSPNR9HR
539	99.6	.0	9.1E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505C, INJ-FAILS, LOSPNR18HR
540	99.6	.0	9.1E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505B, INJ-FAILS, LOSPNR18HR
541	99.6	.0	9.1E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV510, INJ-FAILS, LOSPNR18HR
542	99.6	.0	9.1E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV509, INJ-FAILS, LOSPNR18HR
543	99.6	.0	9.1E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507B, INJ-FAILS, LOSPNR18HR
544	99.6	.0	9.1E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507A, INJ-FAILS, LOSPNR18HR
545	99.6	.0	9.0E-011	BAT-DEP-7HR, ESW-AOV-MA-0241C, ESW-CKV-CB-C515B, LOSPNR9HR
546	99.6	.0	9.0E-011	BAT-DEP-7HR, ESW-AOV-MA-0241B, ESW-CKV-CB-C515A, LOSPNR9HR
547	99.6	.0	8.9E-011	ACP-DGN-FR-EDGB, DGHWNR18HR, DCP-BAT-LP-C3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
548	99.6	.0	8.6E-011	ACP-DGN-FR-EDGD, BAT-DEP-5HR, BETA-2SWPS, DGHWNR5HR, ESW-MDP-FS-CCF, LOSPNR12HR
549	99.7	.0	8.5E-011	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR
550	99.7	.0	8.5E-011	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR
551	99.7	.0	8.2E-011	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR12HR

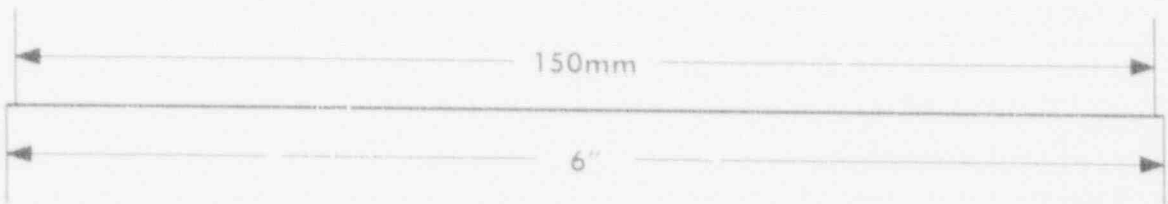
552	99.7	.0	8.2E-011	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR12HR
553	99.7	.0	8.1E-011	BAT-DEP-7HR, EHV-SRV-CC-RV3, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR
554	99.7	.0	8.1E-011	BAT-DEP-7HR, EHV-SRV-CC-RV2, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR
555	99.7	.0	8.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-MA-ECW, INJ-FAILS, LOSPNR18HR
556	99.7	.0	8.1E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, DGHWNR12HR, ESW-MDP-MA-MDPA, INJ-FAILS, LOSPNR18HR
557	99.7	.0	8.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, DGHWNR12HR, ESW-MDP-MA-MDPB, INJ-FAILS, LOSPNR18HR
558	99.7	.0	7.8E-011	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR7HR
559	99.7	.0	7.8E-011	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR7HR
560	99.7	.0	7.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGACTB, DGACTNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
561	99.7	.0	7.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGACTC, DGACTNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR
562	99.7	.0	7.3E-011	BAT-DEP-3HR, BETA-2SWPS, ESW-CKV-CB-C515A, ESW-MDP-FS-CCF, LOSPNR5HR
563	99.7	.0	7.3E-011	BAT-DEP-3HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MOV-CC-MO841, LOSPNR5HR
564	99.7	.0	7.3E-011	BAT-DEP-3HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MDP-FS-ECW, LOSPNR5HR
565	99.7	.0	7.3E-011	BAT-DEP-3HR, BETA-2SWPS, ESW-CKV-CB-C515B, ESW-MDP-FS-CCF, LOSPNR5HR
566	99.7	.0	7.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
567	99.7	.0	7.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGD, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
568	99.7	.0	7.2E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR
569	99.7	.0	7.2E-011	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR12HR
570	99.7	.0	7.2E-011	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR12HR

2

IMAGE EVALUATION TEST TARGET (MT-3)







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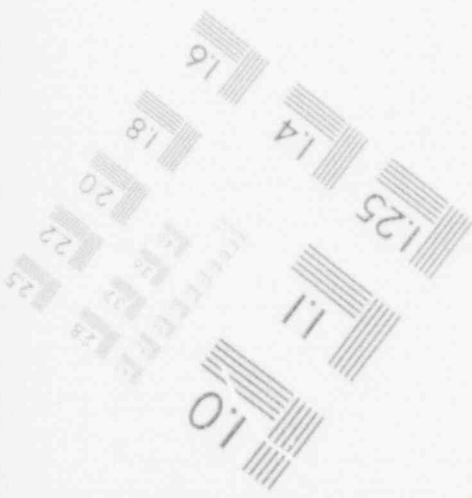
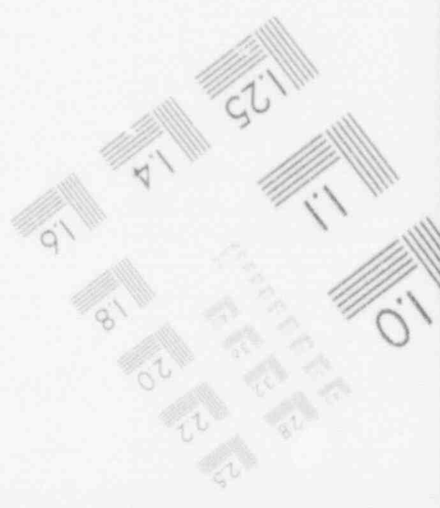
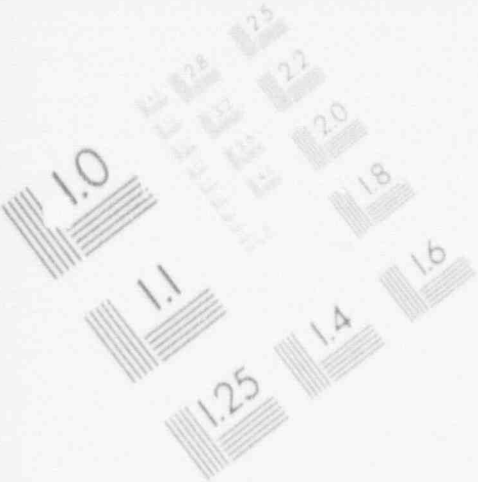
6"

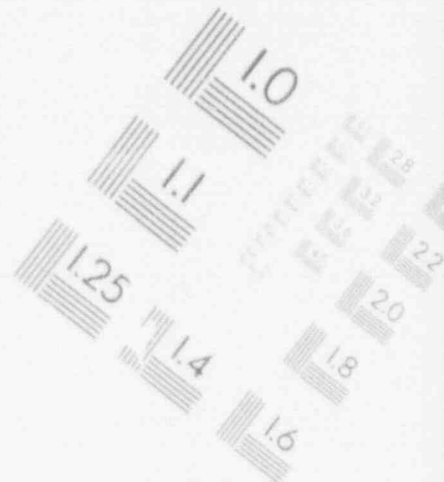


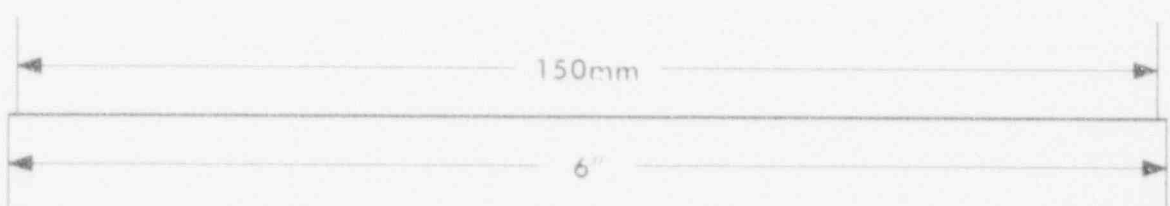


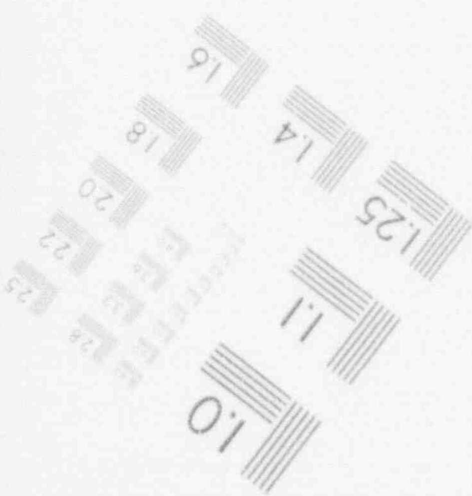
2

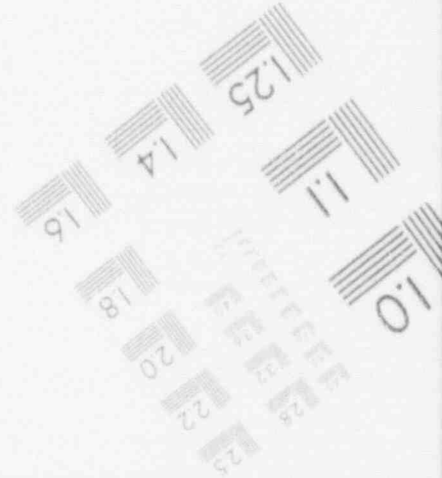
IMAGE EVALUATION TEST TARGET (MT-3)











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(716) 265-1600

2

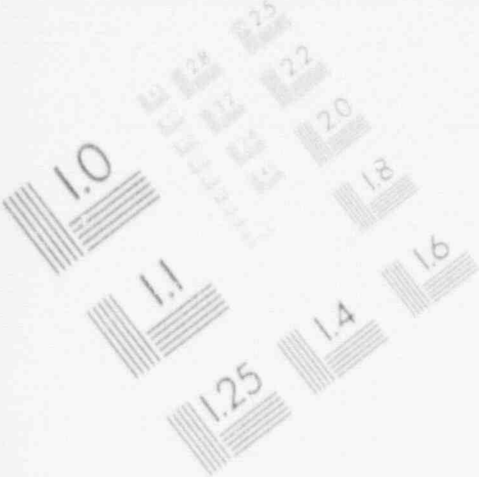
IMAGE EVALUATION TEST TARGET (M1-3)

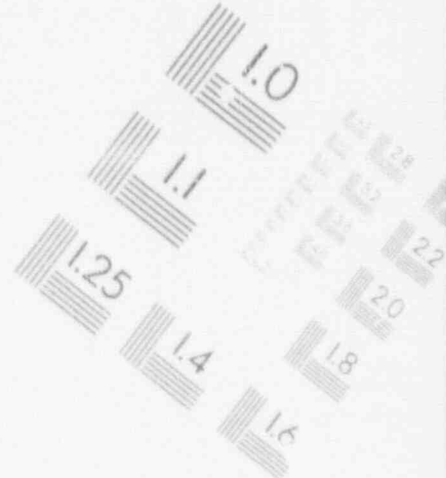
150mm

6"

2

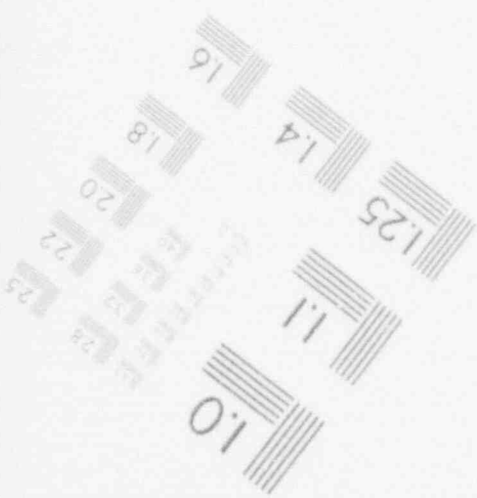
IMAGE EVALUATION TEST TARGET (MT-3)

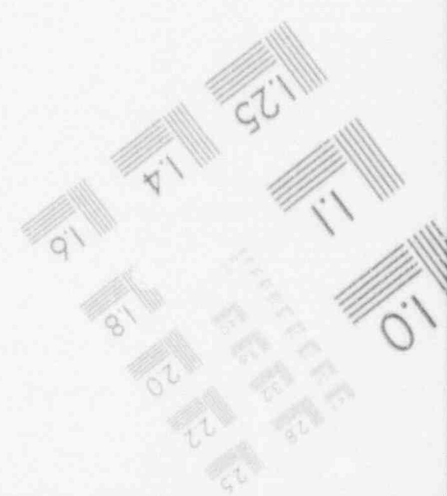




150mm

6"





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571	99.7	.0	7.1E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, LOSPNR17HR
572	99.7	.0	7.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MOV-CC-M0841, LOSPNR17HR
573	99.8	.0	7.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-ECW, LOSPNR17HR
574	99.8	.0	7.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, LOSPNR17HR
575	99.8	.0	7.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR9HR, DCP-BAT-LP-C3, ESW-XHE-FO-EHS, LOSPNR9HR
576	99.8	.0	6.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505C, LOSPNR9HR
577	99.8	.0	6.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507A, LOSPNR9HR
578	99.8	.0	6.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV509, LOSPNR9HR
579	99.8	.0	6.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV510, LOSPNR9HR
580	99.8	.0	6.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507B, LOSPNR9HR
581	99.8	.0	6.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505B, LOSPNR9HR
582	99.8	.0	6.9E-011	BAT-DEP-9HR, BETA-2SWPS, ESW-CKV-CB-C515B, ESW-MDP-FS-CCF, LOSPNR12HR
583	99.8	.0	6.9E-011	BAT-DEP-9HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MDP-FS-ECW, LOSPNR12HR
584	99.8	.0	6.9E-011	BAT-DEP-9HR, BETA-2SWPS, ESW-CKV-CB-C515A, ESW-MDP-FS-CCF, LOSPNR12HR
585	99.8	.0	6.9E-011	BAT-DEP-9HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MOV-CC-M0841, LOSPNR12HR
586	99.8	.0	6.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGACTC, DGACTNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
587	99.8	.0	6.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGACTB, DGACTNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR
588	99.8	.0	6.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR14HR
589	99.8	.0	6.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR14HR

590	99.8	.0	6.8E-011	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR7HR
591	99.8	.0	6.8E-011	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR7HR
592	99.8	.0	6.2E-011	ACP-DGN-MA-EDGD, BAT-DEP-9HR, BETA-2SWPS, DGMANR9HR, ESW-MDP-FS-CCF, LOSPNR12HR
593	99.8	.0	6.2E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DCHWNR17HR, DCP-BAT-LP-C3, ESW-XHE-FO-EHS, LOSPNR17HR
594	99.8	.0	6.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPB, LOSPNR9HR
595	99.8	.0	6.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-ECW, LOSPNR9HR
596	99.8	.0	6.2E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPA, LOSPNR9HR
597	99.8	.0	5.9E-011	ACP-DGN-MA-EDGD, BAT-DEP-5HR, BETA-2SWPS, DGMANR5HR, ESW-MDP-FS-CCF, LOSPNR7HR
598	99.8	.0	5.9E-011	ACP-DGN-FR-EDGD, BAT-DEP-7HR, BETA-2SWPS, DGHWNR7HR, ESW-MDP-FS-CCF, LOSPNR14HR
599	99.8	.0	5.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGACTB, DGACTNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
600	99.9	.0	5.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGACTC, DGACTNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR
601	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507B, LOSPNR17HR
602	99.9	.0	5.3E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV510, LOSPNR17HR
603	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505C, LOSPNR17HR
604	99.9	.0	5.3E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505B, LOSPNR17HR
605	99.9	.0	5.3E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507A, LOSPNR17HR
606	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV509, LOSPNR17HR
607	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, LOSPNR12HR
608	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MOV-CC-M0841, LOSPNR12HR

609	99.9	.0	5.3E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, LOSPNR12HR
610	99.9	.0	5.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-ECW, LOSPNR12HR
611	99.9	.0	4.9E-011	BAT-DEP-5HR, BETA-2SWPS, ESW-CKV-CB-C515B, ESW-MDP-FS-CCF, LOSPNR7HR
612	99.9	.0	4.9E-011	BAT-DEP-5HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MDP-FS-ECW, LOSPNR7HR
613	99.9	.0	4.9E-011	BAT-DEP-5HR, BETA-2SWPS, ESW-CKV-CB-C515A, ESW-MDP-FS-CCF, LOSPNR7HR
614	99.9	.0	4.9E-011	BAT-DEP-5HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MOV-CC-M0841, LOSPNR7HR
615	99.9	.0	4.7E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPB, LOSPNR17HR
616	99.9	.0	4.7E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-ECW, LOSPNR17HR
617	99.9	.0	4.7E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPA, LOSPNR17HR
618	99.9	.0	4.7E-011	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR9HR
619	99.9	.0	4.7E-011	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR9HR
620	99.9	.0	4.6E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DCHWNR12HR, DCP-BAT-LP-C3, ESW-XHE-FO-EHS, LOSPNR12HR
621	99.9	.0	4.0E-011	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-HW-C515B, ESW-XHE-FO-EHS, LOSPNR9HR
622	99.9	.0	4.0E-011	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-HW-C515A, ESW-XHE-FO-EHS, LOSPNR9HR
623	99.9	.0	3.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV510, LOSPNR12HR
624	99.9	.0	3.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507B, LOSPNR12HR
625	99.9	.0	3.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505B, LOSPNR12HR
626	99.9	.0	3.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507A, LOSPNR12HR
627	99.9	.0	3.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV509, LOSPNR12HR

628	99.9	.0	3.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505C, LOSPNR12HR
629	99.9	.0	3.6E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, LOSPNR14HR
630	99.9	.0	3.6E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-ECW, LOSPNR14HR
631	99.9	.0	3.6E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, LOSPNR14HR
632	99.9	.0	3.6E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MOV-CC-M0841, LOSPNR14HR
633	99.9	.0	3.5E-011	ACP-DGN-MA-EDGD, BAT-DEP-7HR, BETA-2SWPS, DGMANR7HR, ESW-MDP-FS-CCF, LOSPNR9HR
634	99.9	.0	3.5E-011	BAT-DEP-7HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MOV-CC-M0841, LOSPNR9HR
635	99.9	.0	3.5E-011	BAT-DEP-7HR, BETA-2SWPS, ESW-CKV-CB-C515B, ESW-MDP-FS-CCF, LOSPNR9HR
636	99.9	.0	3.5E-011	BAT-DEP-7HR, BETA-2SWPS, ESW-MDP-FS-CCF, ESW-MDP-FS-ECW, LOSPNR9HR
637	99.9	.0	3.5E-011	BAT-DEP-7HR, BETA-2SWPS, ESW-CKV-CB-C515A, ESW-MDP-FS-CCF, LOSPNR9HR
638	99.9	.0	3.5E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPA, LOSPNR12HR
639	99.9	.0	3.5E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-ECW, LOSPNR12HR
640	99.9	.0	3.5E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPB, LOSPNR12HR
641	99.9	.0	3.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DCHWNR14HR, DCP-BAT-LP-C3, ESW-XHE-FO-EHS, LOSPNR14HR
642	99.9	.0	2.7E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507A, LOSPNR14HR
643	100.0	.0	2.7E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV510, LOSPNR14HR
644	100.0	.0	2.7E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-XV509, LOSPNR14HR
645	100.0	.0	2.7E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-X507B, LOSPNR14HR
646	100.0	.0	2.7E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505B, LOSPNR14HR

647	100.0	.0	2.7E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, ESW-XVM-PG-D505C, LOSPNR14HR
648	100.0	.0	2.4E-011	ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPA, LOSPNR14HR
649	100.0	.0	2.4E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-ECW, LOSPNR14HR
650	100.0	.0	2.4E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPB, LOSPNR14HR

Table F.2

Accident Sequence T1-BU11NU21 Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family: PEACHBOT Event Tree: T1

Sequence: T1-BU11NU21 Init. Event: IE-T1

Mincut Upper Bound 1.365E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	3.1	3.1	4.3E-009	ACP-DGN-LP-CCF, BAT-DEP-3HR, BETA-4DGNS, DGCCFNR3HR, HCI-TDP-FR-20S37, LOSPNR5HR
2	6.0	2.9	4.0E-009	ACP-DGN-LP-CCF, BETA-4DGNS, DGCCFNR12HR, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
3	8.6	2.5	3.4E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
4	11.1	2.5	3.4E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
5	13.0	1.9	2.6E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
6	14.9	1.9	2.6E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
7	16.8	1.9	2.6E-009	ACP-DGN-LP-CCF, BAT-DEP-9HR, BETA-4DGNS, DGCCFNR9HR, HCI-TDP-FR-20S37, LOSPNR12HR
8	18.7	1.9	2.5E-009	ACP-DGN-LP-CCF, BAT-DEP-3HR, BETA-4DGNS, DGCCFNR3HR, HCI-TDP-FS-20S37, LOSPNR5HR
9	20.5	1.8	2.4E-009	ACP-DGN-LP-CCF, BAT-DEP-5HR, BETA-4DGNS, DGCCFNR5HR, HCI-TDP-FR-20S37, LOSPNR7HR
10	22.3	1.7	2.4E-009	ACP-DGN-LP-CCF, BETA-4DGNS, DGCCFNR12HR, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
11	23.8	1.5	2.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
12	25.3	1.5	2.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR

13	26.7	1.4	2.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
14	28.2	1.4	2.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
15	29.6	1.3	1.8E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
16	30.7	1.1	1.5E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
17	31.9	1.1	1.5E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
18	33.0	1.1	1.5E-009	ACP-DGN-LP-CCF, BAT-DEP-9HR, BETA-4DGNS, DGCCFNR9HR, HCI-TDP-FS-20S37, LOSPNR12HR
19	34.1	1.0	1.4E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
20	35.2	1.0	1.4E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
21	36.3	1.0	1.4E-009	ACP-DGN-LP-CCF, BAT-DEP-5HR, BETA-4DGNS, DGCCFNR5HR, HCI-TDP-FS-20S37, LOSPNR7HR
22	37.3	1.0	1.4E-009	ACP-DGN-LP-CCF, BAT-DEP-7HR, BETA-4DGNS, DGCCFNR7HR, HCI-TDP-FR-20S37, LOSPNR9HR
23	38.4	1.0	1.4E-009	BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
24	39.4	1.0	1.3E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
25	40.3	.9	1.2E-009	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
26	41.3	.9	1.2E-009	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR

27	42.1	.8	1.2E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
28	43.0	.8	1.2E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
29	43.9	.8	1.1E-009	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR5HR
30	44.7	.8	1.1E-009	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR5HR
31	45.5	.8	1.1E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
32	46.3	.7	1.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
33	47.0	.7	1.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
34	47.8	.7	1.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
35	48.5	.6	9.2E-010	BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
36	49.1	.6	8.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
37	49.8	.6	8.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
38	50.4	.6	8.8E-010	ACP-DGN-LP-CCF, BAT-DEP-7HR, BETA-4DGNS, DGCCFNR7HR, HCI-TDP-FS-20S37, LOSPNR9HR
39	51.1	.6	8.6E-010	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR5HR
40	51.7	.6	8.6E-010	ACP-DGN-LP-CCF, BAT-DEP-3HR, BETA-4DGNS, DGCCFNR3HR, HCI-TDP-MA-20S37, LOSPNR5HR
41	52.3	.6	8.4E-010	BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR

42	52.9	.6	8.3E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
43	53.5	.6	8.1E-010	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR12HR
44	54.1	.5	8.0E-010	ACP-DGN-LP-CCF, BETA-4DGNS, DGCCFNR12HR, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
45	54.7	.5	7.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
46	55.2	.5	7.7E-010	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR12HR
47	55.8	.5	7.7E-010	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B HCI-TDP-FR-20S37, LOSPNR12HR
48	56.4	.5	7.6E-010	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
49	56.9	.5	7.6E-010	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
50	57.4	.5	6.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR18HR
51	57.9	.5	6.8E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR18HR
52	58.4	.5	6.8E-010	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR5HR
53	58.9	.5	6.8E-010	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR5HR
54	59.4	.4	6.6E-010	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR7HR
55	59.9	.4	6.6E-010	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR7HR
56	60.4	.4	6.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
57	60.8	.4	6.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR

58	61.3	.4	6.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
59	61.7	.4	5.7E-010	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR7HR
60	62.1	.4	5.6E-010	BAT-DEP-3HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR5HR
61	62.5	.4	5.5E-010	BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
62	62.9	.4	5.4E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
63	63.3	.3	5.3E-010	BAT-DEP-9HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR12HR
64	63.7	.3	5.2E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
65	64.1	.3	5.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
66	64.5	.3	5.2E-010	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR5HR
67	64.8	.3	5.2E-010	ACP-DGN-LP-CCF, BAT-DEP-9HR, BETA-4DGNS, DGCCFNR9HR, HCI-TDP-MA-20S37, LOSPNR12HR
68	65.2	.3	4.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
69	65.6	.3	4.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
70	65.9	.3	4.9E-010	ACP-DGN-LP-CCF, BAT-DEP-5HR, BETA-4DGNS, DGCCFNR5HR, HCI-TDP-MA-20S37, LOSPNR7HR
71	66.3	.3	4.8E-010	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR12HR
72	66.6	.3	4.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR

73	67.0	.3	4.6E-010	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR12HR
74	67.3	.3	4.6E-010	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR12HR
75	67.7	.3	4.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
76	68.0	.3	4.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
77	68.3	.3	4.1E-010	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR9HR
78	68.6	.3	4.0E-010	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR9HR
79	68.9	.3	4.0E-010	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR9HR
80	69.2	.2	4.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR17HR
81	69.5	.2	4.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR17HR
82	69.8	.2	3.9E-010	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR7HR
83	70.1	.2	3.9E-010	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR7HR
84	70.3	.2	3.8E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
85	70.6	.2	3.8E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
86	70.9	.2	3.7E-010	BAT-DEP-5HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR7HR
87	71.2	.2	3.6E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR18HR
88	71.4	.2	3.5E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR

89	71.7	.2	3.5E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
90	71.9	.2	3.4E-010	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR7HR
91	72.2	.2	3.4E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
92	72.5	.2	3.4E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
93	72.7	.2	3.4E-010	BAT-DEP-3HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR5HR
94	72.9	.2	3.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
95	73.2	.2	3.2E-010	BAT-DEP-9HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR12HR
96	73.4	.2	3.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
97	73.6	.2	3.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
98	73.9	.2	2.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
99	74.1	.2	2.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
100	74.3	.2	2.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
101	74.5	.2	2.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
102	74.7	.2	2.9E-010	ACP-DGN-LP-CCF, BAT-DEP-7HR, BETA-4DGNS, DGCCFNR7HR, HCI-TDP-MA-20S37, LOSPNR9HR

103	74.9	.2	2.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR9HR
104	75.1	.2	2.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR9HR
105	75.4	.2	2.8E-010	BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
106	75.6	.2	2.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
107	75.8	.2	2.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
108	76.0	.2	2.7E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
109	76.2	.2	2.7E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
110	76.4	.2	2.7E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
111	76.6	.2	2.7E-010	BAT-DEP-7HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FR-20S37, LOSPNR9HR
112	76.8	.1	2.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
113	76.9	.1	2.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
114	77.1	.1	2.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
115	77.3	.1	2.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
116	77.5	.1	2.5E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR

117	77.7	.1	2.5E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
118	77.9	.1	2.5E-010	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR9HR
119	78.0	.1	2.4E-010	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR9HR
120	78.2	.1	2.4E-010	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR9HR
121	78.4	.1	2.4E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
122	78.6	.1	2.4E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
123	78.8	.1	2.4E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
124	78.9	.1	2.4E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
125	79.1	.1	2.3E-010	ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
126	79.3	.1	2.3E-010	ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
127	79.4	.1	2.2E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
128	79.6	.1	2.2E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
129	79.8	.1	2.2E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
130	80.0	.1	2.2E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
131	80.1	.1	2.2E-010	BAT-DEP-5HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR7HR
132	80.3	.1	2.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR17HR

133	80.4	.1	2.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR17HR
134	80.6	.1	2.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR5HR
135	80.8	.1	2.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR5HR
136	80.9	.1	2.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR5HR
137	81.1	.1	2.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR5HR
138	81.2	.1	2.1E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
139	81.4	.1	2.1E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
140	81.6	.1	2.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR17HR
141	81.7	.1	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
142	81.9	.1	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
143	82.0	.1	2.0E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
144	82.2	.1	2.0E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
145	82.3	.1	2.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR14HR

146	82.5	.1	2.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR14HR
147	82.6	.1	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
148	82.8	.1	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
149	82.9	.1	1.9E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR5HR
150	83.0	.1	1.9E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR5HR
151	83.2	.1	1.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR5HR
152	83.3	.1	1.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR5HR
153	83.5	.1	1.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
154	83.6	.1	1.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
155	83.7	.1	1.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
156	83.9	.1	1.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
157	84.0	.1	1.8E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
158	84.2	.1	1.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
159	84.3	.1	1.8E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR

160	84.4	.1	1.8E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
161	84.6	.1	1.8E-010	BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
162	84.7	.1	1.7E-010	ACP DGN-FR-EDGC, ACP-DGN-MA-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
163	84.8	.1	1.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
164	85.0	.1	1.7E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
165	85.1	.1	1.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
166	85.2	.1	1.7E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
167	85.3	.1	1.7E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
168	85.5	.1	1.7E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, HCI TDP-FS-20S37, LOSPNR9HR
169	85.6	.1	1.7E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR9HR
170	85.7	.1	1.7E-010	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR5HR
171	85.8	.1	1.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
172	86.0	.1	1.7E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
173	86.1	.1	1.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR12HR
174	86.2	.1	1.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR12HR

175	86.3	.1	1.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
176	86.5	.1	1.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
177	86.6	.1	1.6E-010	BAT-DEP-7HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-FS-20S37, LOSPNR9HR
178	86.7	.1	1.6E-010	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR12HR
179	86.8	.1	1.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
180	86.9	.1	1.5E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
181	87.0	.1	1.5E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
182	87.2	.1	1.5E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
183	87.3	.1	1.5E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
184	87.4	.1	1.5E-010	ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
185	87.5	.1	1.5E-010	ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
186	87.6	.1	1.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
187	87.7	.1	1.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
188	87.8	.1	1.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR

189	87.9	.1	1.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
190	88.0	.1	1.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
191	88.2	.1	1.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
192	88.3	.1	1.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
193	88.4	.1	1.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
194	88.5	.1	1.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
195	88.6	.1	1.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
196	88.7	.1	1.4E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FR-20S37, LOSPNR5HR
197	88.8	.1	1.4E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FR-20S37, LOSPNR5HR
198	88.9	.1	1.3E-010	ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
199	89.0	.1	1.3E-010	ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
200	89.1	.1	1.3E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
201	89.2	.1	1.3E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR13HR
202	89.3	.1	1.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
203	89.4	.1	1.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR

204	89.5	.1	1.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR17HR
205	89.6	.1	1.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR17HR
206	89.7	.1	1.3E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FR-20S37, LOSPNR12HR
207	89.8	.1	1.3E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FR-20S37, LOSPNR12HR
208	89.9	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR7HR
209	90.0	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR7HR
210	90.1	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR7HR
211	90.2	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR7HR
212	90.2	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
213	90.3	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
214	90.4	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, HCI-TDP-MA-20S37, LOSPNR5HR
215	90.5	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, HCI-TDP-MA-20S37, LOSPNR5HR
216	90.6	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
217	90.7	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
218	90.8	.0	1.2E-010	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR12HR

219	90.9	.0	1.2E-010	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR12HR
220	91.0	.0	1.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR5HR
221	91.0	.0	1.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR5HR
222	91.1	.0	1.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
223	91.2	.0	1.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
224	91.3	.0	1.1E-010	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR7HR
225	91.4	.0	1.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
226	91.5	.0	1.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
227	91.6	.0	1.1E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
228	91.6	.0	1.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
229	91.7	.0	1.1E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
230	91.8	.0	1.1E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR18HR
231	91.9	.0	1.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR7HR
232	92.0	.0	1.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR14HR
233	92.1	.0	1.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR7HR

234	92.1	.0	1.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR14HR
235	92.2	.0	1.1E-010	BAT-DEP-3HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR5HR
236	92.3	.0	1.1E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
237	92.4	.0	1.1E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR13HR
238	92.5	.0	1.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV19, INJ-FAILS, LOSPNR18HR
239	92.5	.0	1.1E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV14, INJ-FAILS, LOSPNR18HR
240	92.6	.0	1.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR14HR
241	92.7	.0	1.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR7HR
242	92.8	.0	1.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR7HR
243	92.9	.0	1.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
244	92.9	.0	1.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
245	93.0	.0	1.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
246	93.1	.0	1.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
247	93.2	.0	1.0E-010	BAT-DEP-9HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR12HR

248	93.3	.0	1.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
249	93.3	.0	1.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
250	93.4	.0	1.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
251	93.5	.0	1.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
252	93.6	.0	1.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR[illegible] ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR[illegible]
253	93.6	.0	1.0E-010	ACP-DGN-[illegible]R-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
254	93.7	.0	9.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR12HR
255	93.8	.0	9.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
256	93.9	.0	9.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
257	93.9	.0	9.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR12HR
258	94.0	.0	9.8E-011	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
259	94.1	.0	9.8E-011	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
260	94.1	.0	9.4E-011	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, HCI-TDP-FR-20S37, LOSPNR5HR
261	94.2	.0	9.4E-011	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FR-20S37, LOSPNR7HR

262	94.3	.0	9.4E-011	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FR-20S37, LOSPNR7HR
263	94.4	.0	9.4E-011	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, HCI-TDP-FR-20S37, LOSPNR5HR
264	94.4	.0	9.3E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
265	94.5	.0	9.3E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
266	94.6	.0	8.9E-011	ACP-DGN-FR-EDGC, DCHWNR18HR, DCP-BAT-LP-B2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR
267	94.6	.0	8.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
268	94.7	.0	8.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
269	94.7	.0	8.8E-011	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, HCI-TDP-FR-20S37, LOSPNR12HR
270	94.8	.0	8.8E-011	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, HCI-TDP-FR-20S37, LOSPNR12HR
271	94.9	.0	8.7E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
272	94.9	.0	8.7E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
273	95.0	.0	8.5E-011	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FS-20S37, LOSPNR5HR
274	95.1	.0	8.5E-011	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FS-20S37, LOSPNR5HR
275	95.1	.0	8.4E-011	BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV14, INJ-FAILS, LOSPNR13HR
276	95.2	.0	8.4E-011	BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV19, INJ-FAILS, LOSPNR13HR
277	95.3	.0	8.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV19, LOSPNR9HR

278	95.3	.0	8.3E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV14, LOSPNR9HR
279	95.4	.0	8.3E-011	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR9HR
280	95.4	.0	8.2E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, HCI-TDP-MA-20S37, LOSPNR12HR
281	95.5	.0	8.2E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, HCI-TDP-MA-20S37, LOSPNR12HR
282	95.6	.0	8.2E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
283	95.6	.0	8.2E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
284	95.7	.0	8.0E-011	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FS-20S37, LOSPNR12HR
285	95.7	.0	8.0E-011	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FS-20S37, LOSPNR12HR
286	95.8	.0	7.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
287	95.8	.0	7.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR9HR
288	95.9	.0	7.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
289	96.0	.0	7.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
290	96.0	.0	7.6E-011	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR5HR
291	96.1	.0	7.6E-011	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR5HR
292	96.1	.0	7.5E-011	BAT-DEP-5HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR7HR

293	96.2	.0	7.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
294	96.2	.0	7.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
295	96.3	.0	7.2E-011	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR12HR
296	96.3	.0	7.2E-011	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR12HR
297	96.4	.0	7.1E-011	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
298	96.5	.0	7.1E-011	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
299	96.5	.0	7.0E-011	ACP-DGN-TE-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
300	96.6	.0	7.0E-011	ACP-DGN-TE-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, INJ-FAILS, LOSPNR13HR
301	96.6	.0	7.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, HCI-TDP-MA-20S37, LOSPNR7HR
302	96.7	.0	7.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, HCI-TDP-MA-20S37, LOSPNR7HR
303	96.7	.0	7.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR9HR, DCP-BAT-LP-32, ESW-XHE-FO-EHS, LOSPNR9HR
304	96.8	.0	6.8E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR
305	96.8	.0	6.8E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR18HR
306	96.9	.0	6.8E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, INJ-FAILS, LOSPNR18HR
307	96.9	.0	6.8E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, INJ-FAILS, LOSPNR18HR

308	97.0	.0	6.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
309	97.0	.0	6.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
310	97.1	.0	6.8E-011	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR7HR
311	97.1	.0	6.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR14HR
312	97.2	.0	6.8E-011	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR7HR
313	97.2	.0	6.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR14HR
314	97.3	.0	6.8E-011	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR9HR
315	97.3	.0	6.8E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FR-20S37, LOSPNR9HR
316	97.4	.0	6.8E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FR-20S37, LOSPNR9HR
317	97.4	.0	6.8E-011	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR9HR
318	97.5	.0	6.6E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
319	97.5	.0	6.6E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR17HR
320	97.6	.0	6.5E-011	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
321	97.6	.0	6.5E-011	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
322	97.7	.0	6.5E-011	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR

323	97.7	.0	6.5E-011	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
324	97.7	.0	6.4E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV19, LOSPNR17HR
325	97.8	.0	6.4E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV14, LOSPNR17HR
326	97.8	.0	6.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
327	97.9	.0	6.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
328	97.9	.0	6.3E-011	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, HCI-TDP-FR-20S37, LOSPNR7HR
329	98.0	.0	6.3E-011	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, HCI-TDP-FR-20S37, LOSPNR7HR
330	98.0	.0	6.2E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
331	98.1	.0	6.2E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
332	98.1	.0	6.2E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR17HR, DCP-BAT-LP-B2, ESW-XHE-FO-EHS, LOSPNR17HR
333	98.2	.0	6.1E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
334	98.2	.0	6.1E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
335	98.3	.0	5.8E-011	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
336	98.3	.0	5.8E-011	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR

337	98.3	.0	5.6E-011	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FS-20S37, LOSPNR7HR
338	98.4	.0	5.6E-011	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FS-20S37, LOSPNR7HR
339	98.4	.0	5.4E-011	BAT-DEP-7HR, BETA-6AOVS, EHV-AOV-CC-CCF, HCI-TDP-MA-20S37, LOSPNR9HR
340	98.5	.0	5.2E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
341	98.5	.0	5.2E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
342	98.5	.0	5.2E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR9HR
343	98.6	.0	5.2E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR9HR
344	98.6	.0	5.2E-011	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV14, LOSPNR5HR
345	98.6	.0	5.2E-011	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV19, LOSPNR5HR
346	98.7	.0	4.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
347	98.7	.0	4.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR12HR
348	98.8	.0	4.8E-011	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV14, LOSPNR12HR
349	98.8	.0	4.8E-011	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV19, LOSPNR12HR
350	98.8	.0	4.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
351	98.9	.0	4.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR

352	98.9	.0	4.7E-011	ACP-DGN-FR-EDCB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV14, LOSPNR12HR
353	98.9	.0	4.7E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV19, LOSPNR12HR
354	99.0	.0	4.6E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DCHWNR12HR, DCP-BAT-LP-B2, ESW-XHE-FO-EHS, LOSPNR12HR
355	99.0	.0	4.6E-011	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR12HR
356	99.0	.0	4.6E-011	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR12HR
357	99.1	.0	4.5E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, HCI-TDP-FR-20S37, LOSPNR9HR
358	99.1	.0	4.5E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, HCI-TDP-FR-20S37, LOSPNR9HR
359	99.1	.0	4.3E-011	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR7HR
360	99.2	.0	4.3E-011	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR7HR
361	99.2	.0	4.3E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, HCI-TDP-MA-20S37, LOSPNR9HR
362	99.2	.0	4.3E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, HCI-TDP-MA-20S37, LOSPNR9HR
363	99.3	.0	4.0E-011	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, HCI-TDP-FS-20S37, LOSPNR9HR
364	99.3	.0	4.0E-011	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, HCI-TDP-FS-20S37, LOSPNR9HR
365	99.3	.0	4.0E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, HCI-TDP-FS-20S37, LOSPNR9HR
366	99.3	.0	4.0E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, HCI-TDP-FS-20S37, LOSPNR9HR
367	99.4	.0	4.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR17HR
368	99.4	.0	4.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR17HR

369	99.4	.0	4.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
370	99.5	.0	4.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR17HR
371	99.5	.0	3.9E-011	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
372	99.5	.0	3.9E-011	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
373	99.5	.0	3.5E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
374	99.6	.0	3.5E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
375	99.6	.0	3.4E-011	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV14, LOSPNR7HR
376	99.6	.0	3.4E-011	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV19, LOSPNR7HR
377	99.7	.0	3.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
378	99.7	.0	3.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FR-20S37, LOSPNR14HR
379	99.7	.0	3.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV19, LOSPNR14HR
380	99.7	.0	3.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, HCI-MOV-CC-MV14, LOSPNR14HR
381	99.7	.0	3.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DCHWNR14HR, DCP-BAT-LP-B2, ESW-XHE-FO-EHS, LOSPNR14HR
382	99.8	.0	2.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR

383	99.8	.0	2.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
384	99.8	.0	2.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR12HR
385	99.8	.0	2.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR12HR
386	99.9	.0	2.6E-011	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, HCI-TDP-FR-20S37, LOSPNR9HR
387	99.9	.0	2.6E-011	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, HCI-TDP-FR-20S37, LOSPNR9HR
388	99.9	.0	2.5E-011	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV19, LOSPNR9HR
389	99.9	.0	2.5E-011	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, HCI-MOV-CC-MV14, LOSPNR9HR
390	99.9	.0	2.4E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
391	99.9	.0	2.4E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
392	100.0	.0	2.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
393	100.0	.0	2.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, HCI-TDP-FS-20S37, LOSPNR14HR
394	100.0	.0	2.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR14HR
395	100.0	.0	2.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, HCI-TDP-MA-20S37, LOSPNR14HR

Table F.3

Accident Sequence T1-P1BNU11 Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT   Event Tree: T1
Sequence: T1-P1BNU11   Init. Event IE-T1
Mincut Upper Bound 1.625E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	5.0	5.0	8.2E-009	ACP-DGN-LP-CCF, BAT-DEP-3HR, BETA-4DGNS, DGCCFNR3HR, LOSPNR5HR, P1
2	9.8	4.7	7.6E-009	ACP-DGN-LP-CCF, BETA-4DGNS, DGCCFNR12HR, INJ-FAILS, LOSPNR13HR, P1
3	13.8	4.0	6.5E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
4	17.9	4.0	6.5E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
5	21.0	3.0	5.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
6	24.1	3.0	5.0E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
7	27.1	3.0	4.9E-009	ACP-DGN-LP-CCF, BAT-DEP-9HR, BETA-4DGNS, DGCCFNR9HR, LOSPNR12HR, P1
8	30.0	2.9	4.7E-009	ACP-DGN-LP-CCF, BAT-DEP-5HR, BETA-4DGNS, DGCCFNR5HR, LOSPNR7HR, P1
9	32.4	2.3	3.8E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
10	34.8	2.3	3.8E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
11	36.9	2.1	3.5E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
12	38.7	1.7	2.8E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
13	40.5	1.7	2.8E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
14	42.2	1.7	2.8E-009	ACP-DGN-LP-CCF, BAT-DEP-7HR, BETA-4DGNS, DGCCFNR7HR, LOSPNR9HR, P1
15	43.[illegible]	1.6	2.7E-009	BETA-3AOVS, ESW-AOV-CC-CCF, INJ-FAILS, LOSPNR13HR, P1

16	45.5	1.6	2.6E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
17	47.0	1.5	2.4E-009	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR, P1
18	48.5	1.5	2.4E-009	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR, P1
19	49.9	1.3	2.1E-009	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, LOSPNR5HR, P1
20	51.2	1.3	2.1E-009	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, LOSPNR5HR, P1
21	52.5	1.2	2.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
22	53.7	1.2	1.9E-009	ACP-DGN-FR-EDGC, ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
23	54.9	1.2	1.9E-009	ACP-DGN-FR-EDGB, ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
24	56.0	1.0	1.7E-009	BETA-6AOVS, EHV-AOV-CC-CCF, INJ-FAILS, LOSPNR13HR, P1
25	57.0	1.0	1.6E-009	BAT-DEP-3HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR5HR, P1
26	58.0	.9	1.5E-009	BAT-DEP-9HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR12HR, P1
27	58.9	.9	1.5E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
28	59.8	.9	1.4E-009	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, LOSPNR12HR, P1
29	60.7	.9	1.4E-009	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, LOSPNR12HR, P1
30	61.5	.7	1.2E-009	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, LOSPNR7HR, P1
31	62.3	.7	1.2E-009	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, LOSPNR7HR, P1
32	63.0	.6	1.1E-009	BAT-DEP-5HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR7HR, P1
33	63.7	.6	1.0E-009	BAT-DEP-3HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR5HR, P1
34	64.3	.6	1.0E-009	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1

35	64.9	.6	1.0E-009	BAT-DEP-9HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR12HR, P1
36	65.5	.5	9.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
37	66.1	.5	9.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, DGMANR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
38	66.7	.5	8.7E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
39	67.2	.5	8.7E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
40	67.7	.4	7.9E-010	BAT-DEP-7HR, BETA-3AOVS, ESW-AOV-CC-CCF, LOSPNR9HR, P1
41	68.2	.4	7.8E-010	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, LOSPNR9HR, P1
42	68.7	.4	7.8E-010	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, LOSPNR9HR, P1
43	69.1	.4	7.3E-010	ACP-DGN-LP-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
44	69.6	.4	7.3E-010	ACP-DGN-LP-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
45	70.0	.4	7.3E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR18HR, P1
46	70.5	.4	7.3E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR18HR, P1
47	70.9	.4	7.2E-010	BAT-DEP-5HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR7HR, P1
48	71.3	.4	6.8E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
49	71.8	.4	6.8E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
50	72.2	.4	6.5E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
51	72.6	.4	6.5E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
52	73.0	.4	6.5E-010	ACP-DGN-LP-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR, P1
53	73.4	.4	6.5E-010	ACP-DGN-LP-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR5HR, P1

54	73.7	.3	5.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
55	74.1	.3	5.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
56	74.4	.3	5.5E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515B, LOSPNR9HR, P1
57	74.8	.3	5.5E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-CKV-CB-C515A, LOSPNR9HR, P1
58	75.1	.3	5.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR9HR, P1
59	75.4	.3	5.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
60	75.8	.3	5.2E-010	BAT-DEP-7HR, BETA-6AOVS, EHV-AOV-CC-CCF, LOSPNR9HR, P1
61	76.1	.3	5.0E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
62	76.4	.3	5.0E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, DGHWNR12HR, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
63	76.7	.3	5.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
64	77.0	.3	5.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
65	77.3	.3	4.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
66	77.6	.3	4.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
67	77.9	.3	4.8E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
68	78.2	.3	4.8E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
69	78.5	.2	4.6E-010	ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, INJ-FAILS, LOSPNR13HR, P1
70	78.8	.2	4.6E-010	ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, INJ-FAILS, LOSPNR13HR, P1
71	79.0	.2	4.4E-010	ACP-DGN-LP-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR, P1
72	79.3	.2	4.4E-010	ACP-DGN-LP-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR, P1

73	79.6	.2	4.4E-010	ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, INJ-FAILS, LOSPNR13HR, P1
74	79.9	.2	4.4E-010	ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, INJ-FAILS, LOSPNR13HR, P1
75	80.1	.2	4.3E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
76	80.4	.2	4.3E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
77	80.7	.2	4.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515A, LOSPNR17HR, P1
78	80.9	.2	4.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-CKV-CB-C515B, LOSPNR17HR, P1
79	81.2	.2	4.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR17HR, P1
80	81.4	.2	4.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
81	81.6	.2	3.8E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
82	81.9	.2	3.8E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-XHE-FO-EHS, LOSPNR9HR, P1
83	82.1	.2	3.8E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR, P1
84	82.4	.2	3.8E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
85	82.6	.2	3.8E-010	ACP-DGN-LP-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR, P1
86	82.8	.2	3.8E-010	ACP-DGN-LP-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR7HR, P1
87	83.1	.2	3.8E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, LOSPNR5HR, P1
88	83.3	.2	3.8E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, LOSPNR5HR, P1
89	83.5	.2	3.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
90	83.8	.2	3.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
91	84.0	.2	3.5E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR, P1

92	84.2	.2	3.5E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR, P1
93	84.4	.2	3.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
94	84.6	.2	3.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
95	84.8	.2	3.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
96	85.0	.2	3.2E-010	ACP-DGN-FR-EDGC, ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
97	85.2	.2	3.2E-010	ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, INJ-FAILS, LOSPNR13HR, P1
98	85.4	.2	3.2E-010	ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, INJ-FAILS, LOSPNR13HR, P1
99	85.6	.2	3.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515A, LOSPNR12HR, P1
100	85.8	.2	3.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-CKV-CB-C515B, LOSPNR12HR, P1
101	86.0	.1	2.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DG3, ESW-XHE-FO-EHS, LOSPNR12HR, P1
102	86.2	.1	2.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR12HR, P1
103	86.3	.1	2.9E-010	ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, INJ-FAILS, LOSPNR13HR, P1
104	86.5	.1	2.9E-010	ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, INJ-FAILS, LOSPNR13HR, P1
105	86.7	.1	2.9E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
106	86.9	.1	2.9E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-XHE-FO-EHS, LOSPNR17HR, P1
107	87.1	.1	2.8E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
108	87.2	.1	2.8E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
109	87.4	.1	2.8E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR5HR, P1
110	87.6	.1	2.8E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR5HR, P1

111	87.8	.1	2.8E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
112	87.9	.1	2.8E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR P1
113	88.1	.1	2.7E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FS-[illegible]A, LOSPNR5HR, P1
114	88.3	.1	2.7E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR5HR, P1
115	88.4	.1	2.6E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR12HR, P1
116	88.6	.1	2.6E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR12HR, P1
117	88.8	.1	2.6E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
118	.9	.1	2.6E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
119	89.1	.1	2.5E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR, P1
120	89.2	.1	2.5E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
121	89.4	.1	2.5E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR12HR, P1
122	89.6	.1	2.5E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR12HR, P1
123	89.7	.1	2.3E-010	ACP-DGN-LP-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR, P1
124	[illegible]	.1	2.3E-010	ACP-DGN-LP-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR, P1
125	90.0	.1	2.3E-010	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, LOSPNR12HR, P1
126	90.1	.1	2.3E-010	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, LOSPNR12HR, P1
127	90.3	.1	2.2E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
128	90.4	.1	2.2E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-XHE-FO-EHS, LOSPNR12HR, P1
129	90.5	.1	2.1E-010	ACP-DGN-FR-EDGB, DGHWNR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1

130	90.7	.1	2.1E-010	ACP-DGN-FR-EDGC, DGHWNR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
131	90.8	.1	2.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, LOSPNR7HR, P1
132	90.9	.1	2.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, LOSPNR7HR, P1
133	91.1	.1	2.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515B, LOSPNR14HR, P1
134	91.2	.1	2.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-CKV-CB-C515A, LOSPNR14HR, P1
135	91.3	.1	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
136	91.5	.1	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
137	91.6	.1	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGB, ESW-XHE-FO-EHS, LOSPNR14HR, P1
138	91.7	.1	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-DGC, ESW-XHE-FO-EHS, LOSPNR14HR, P1
139	91.8	.1	2.0E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
140	92.0	.1	2.0E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
141	92.1	.1	1.9E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR5HR, P1
142	92.2	.1	1.9E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR5HR, P1
143	92.3	.1	1.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1
144	92.5	.1	1.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
145	92.6	.1	1.9E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
146	92.7	.1	1.9E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
147	92.8	.1	1.9E-010	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR7HR, P1
148	92.9	.1	1.9E-010	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR7HR, P1

149	93.0	.1	1.8E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR12HR, P1
150	93.2	.1	1.8E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR12HR, P1
151	93.3	.1	1.8E-010	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR5HR, P1
152	93.4	.1	1.8E-010	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR5HR, P1
153	93.5	.1	1.8E-010	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR7HR, P1
154	93.6	.1	1.8E-010	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR7HR, P1
155	93.7	.1	1.7E-010	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR12HR, P1
156	93.8	.1	1.7E-010	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR12HR, P1
157	93.9	.1	1.6E-010	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR, P1
158	94.0	.1	1.6E-010	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR, P1
159	94.1	.0	1.5E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR, P1
160	94.2	.0	1.5E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
161	94.3	.0	1.5E-010	ACP-DGN-FR-EDGC, ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
162	94.4	.0	1.5E-010	ACP-DGN-FR-EDGB, ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-XHE-FO-EHS, LOSPNR14HR, P1
163	94.5	.0	1.4E-010	ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR, P1
164	94.6	.0	1.4E-010	ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR, P1
165	94.7	.0	1.4E-010	ACP-DGN-TE-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515B, LOSPNR5HR, P1
166	94.8	.0	1.4E-010	ACP-DGN-TE-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-CKV-CB-C515A, LOSPNR5HR, P1
167	94.8	.0	1.4E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1

168	94.9	.0	1.4E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-PTF-RE-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
169	95.0	.0	1.3E-010	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-PTF-RE-DGC, LOSPNR9HR, P1
170	95.1	.0	1.3E-010	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-PTF-RE-DGB, LOSPNR9HR, P1
171	95.2	.0	1.3E-010	ACP-DGN-TE-EDGB, DGMANR12HR, ESW-CKV-CB-C515A, INJ-FAILS, LOSPNR13HR, P1
172	95.3	.0	1.3E-010	ACP-DGN-TE-EDGC, DGMANR12HR, ESW-CKV-CB-C515B, INJ-FAILS, LOSPNR13HR, P1
173	95.3	.0	1.3E-010	ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
174	95.4	.0	1.3E-010	ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
175	95.5	.0	1.3E-010	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR7HR, P1
176	95.6	.0	1.3E-010	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR7HR, P1
177	95.7	.0	1.3E-010	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1
178	95.8	.0	1.3E-010	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
179	95.8	.0	1.3E-010	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, LOSPNR9HR, P1
180	95.9	.0	1.3E-010	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FS-MDPB, LOSPNR9HR, P1
181	96.0	.0	1.3E-010	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, LOSPNR9HR, P1
182	96.1	.0	1.3E-010	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FS-MDPA, LOSPNR9HR, P1
183	96.2	.0	1.2E-010	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR17HR, P1
184	96.2	.0	1.2E-010	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR17HR, P1
185	96.3	.0	1.2E-010	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR7HR, P1
186	96.4	.0	1.2E-010	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR7HR, P1

187	96.5	.0	1.1E-010	ACP-DGN-MA-EDGB, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR5HR, P1
188	96.5	.0	1.1E-010	ACP-DGN-MA-EDGC, BAT-DEP-3HR, DGMANR3HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR5HR, P1
189	96.6	.0	1.1E-010	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
190	96.7	.0	1.1E-010	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
191	96.7	.0	1.0E-010	ACP-DGN-MA-EDGB, DGMANR12HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
192	96.8	.0	1.0E-010	ACP-DGN-MA-EDGC, DGMANR12HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
193	96.9	.0	9.9E-011	ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, INJ-FAILS, LOSPNR18HR, P1
194	96.9	.0	9.9E-011	ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, INJ-FAILS, LOSPNR18HR, P1
195	97.0	.0	9.5E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR, P1
196	97.0	.0	9.5E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR, P1
197	97.1	.0	9.5E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-PTF-RE-MDPB, LOSPNR9HR, P1
198	97.2	.0	9.5E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-PTF-RE-MDPA, LOSPNR9HR, P1
199	97.2	.0	9.1E-011	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR5HR, P1
200	97.3	.0	9.1E-011	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR5HR, P1
201	97.3	.0	8.9E-011	ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
202	97.4	.0	8.9E-011	ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
203	97.4	.0	8.8E-011	ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
204	97.5	.0	8.8E-011	ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR13HR, P1
205	97.5	.0	8.8E-011	ACP-DGN-TE-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515A, LOSPNR12HR, P1

206	97.6	.0	8.8E-011	ACP-DGN-TE-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-CKV-CB-C515B, LOSPNR12HR, P1
207	97.6	.0	8.7E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-MA-MDPA, LOSPNR9HR, P1
208	97.7	.0	8.7E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-MA-MDPB, LOSPNR9HR, P1
209	97.8	.0	8.5E-011	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR12HR, P1
210	97.8	.0	8.5E-011	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR12HR, P1
211	97.9	.0	8.3E-011	ACP-DGN-TE-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515B, LOSPNR7HR, P1
212	97.9	.0	8.3E-011	ACP-DGN-TE-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-CKV-CB-C515A, LOSPNR7HR, P1
213	98.0	.0	8.1E-011	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR, P1
214	98.0	.0	8.1E-011	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR, P1
215	98.1	.0	7.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1
216	98.1	.0	7.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-MDP-FR-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
217	98.2	.0	7.6E-011	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
218	98.2	.0	7.6E-011	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
219	98.2	.0	6.9E-011	ACP-DGN-MA-EDGB, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR12HR, P1
220	98.3	.0	6.9E-011	ACP-DGN-MA-EDGC, BAT-DEP-9HR, DGMANR9HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR12HR, P1
221	98.3	.0	6.5E-011	ACP-DGN-FR-EDGC, DGHWNR12HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
222	98.4	.0	6.5E-011	ACP-DGN-FR-EDGB, DGHWNR12HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
223	98.4	.0	6.5E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR14HR, P1
224	98.4	.0	6.5E-011	ACP-DGN-MA-EDGC, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR7HR, P1

225	98.5	.0	6.5E-011	ACP-DGN-MA-EDGB, BAT-DEP-5HR, DGMANR5HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR7HR, P1
226	98.5	.0	6.5E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR14HR, P1
227	98.6	.0	6.2E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, DGHWNR12HR, INJ-FAILS, LOSPNR18HR, P1
228	98.6	.0	6.0E-011	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR7HR, P1
229	98.6	.0	6.0E-011	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR7HR, P1
230	98.7	.0	5.9E-011	ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
231	98.7	.0	5.9E-011	ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, INJ-FAILS, LOSPNR18HR, P1
232	98.7	.0	5.5E-011	BAT-DEP-9HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR17HR, P1
233	98.8	.0	5.5E-011	BAT-DEP-9HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR17HR, P1
234	98.8	.0	5.4E-011	BAT-DEP-3HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR5HR, P1
235	98.9	.0	5.4E-011	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR, P1
236	98.9	.0	5.4E-011	BAT-DEP-3HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR5HR, P1
237	98.9	.0	5.4E-011	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR, P1
238	98.9	.0	5.2E-011	BAT-DEP-3HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR9HR, P1
239	99.0	.0	5.2E-011	BAT-DEP-3HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR9HR, P1
240	99.0	.0	5.1E-011	BAT-DEP-9HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
241	99.0	.0	5.1E-011	BAT-DEP-9HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
242	99.1	.0	5.0E-011	ACP-DGN-FR-EDGC, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR9HR, P1
243	99.1	.0	5.0E-011	ACP-DGN-FR-EDGB, BAT-DEP-3HR, DGHWNR3HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR9HR, P1

244	99.1	.0	5.0E-011	ACP-DGN-TE-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515A, LOSPNR9HR, P1
245	99.2	.0	5.0E-011	ACP-DGN-TE-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-CKV-CB-C515B, LOSPNR9HR, P1
246	99.2	.0	4.9E-011	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR, P1
247	99.2	.0	4.9E-011	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
248	99.3	.0	4.7E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-3HR, DGHWNR3HR, LOSPNR9HR, P1
249	99.3	.0	4.7E-011	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
250	99.3	.0	4.7E-011	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
251	99.3	.0	4.3E-011	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-CKV-CB-C515A, LOSPNR9HR, P1
252	99.4	.0	4.3E-011	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-CKV-CB-C515B, LOSPNR9HR, P1
253	99.4	.0	3.9E-011	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
254	99.4	.0	3.9E-011	ACP-DGN-MA-EDGC, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241B, ESW-XHE-FO-EHS, LOSPNR9HR, P1
255	99.4	.0	3.9E-011	ACP-DGN-MA-EDGB, BAT-DEP-7HR, DGMANR7HR, ESW-AOV-CC-0241C, ESW-XHE-FO-EHS, LOSPNR9HR, P1
256	99.5	.0	3.9E-011	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
257	99.5	.0	3.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR17HR, P1
258	99.5	.0	3.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-9HR, DGHWNR9HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR17HR, P1
259	99.5	.0	3.6E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-9HR, DGHWNR9HR, LOSPNR17HR, P1
260	99.6	.0	3.6E-011	BAT-DEP-5HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR7HR, P1
261	99.6	.0	3.6E-011	BAT-DEP-5HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR7HR, P1
262	99.6	.0	3.4E-011	BAT-DEP-5HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR12HR, P1

263	99.6	.0	3.4E-011	BAT-DEP-5HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR12HR, P1
264	99.6	.0	3.3E-011	BAT-DEP-9HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR17HR, P1
265	99.7	.0	3.3E-011	BAT-DEP-9HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR17HR, P1
266	99.7	.0	3.1E-011	BAT-DEP-3HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
267	99.7	.0	3.1E-011	BAT-DEP-3HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
268	99.7	.0	3.0E-011	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
269	99.7	.0	3.0E-011	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
270	99.8	.0	2.8E-011	ACP-DGN-FR-EDGB, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR12HR, P1
271	99.8	.0	2.8E-011	ACP-DGN-FR-EDGC, BAT-DEP-5HR, DGHWNR5HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR12HR, P1
272	99.8	.0	2.7E-011	BAT-DEP-7HR, ESW-CKV-CB-C515B, ESW-MDP-FR-MDPB, LOSPNR14HR, P1
273	99.8	.0	2.7E-011	BAT-DEP-7HR, ESW-CKV-CB-C515A, ESW-MDP-FR-MDPA, LOSPNR14HR, P1
274	99.8	.0	2.7E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-5HR, DGHWNR5HR, LOSPNR12HR, P1
275	99.8	.0	2.6E-011	BAT-DEP-7HR, ESW-AOV-CC-0241C, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR9HR, P1
276	99.9	.0	2.6E-011	BAT-DEP-7HR, ESW-AOV-CC-0241B, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR9HR, P1
277	99.9	.0	2.4E-011	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-MDP-FS-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
278	99.9	.0	2.4E-011	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-MDP-FS-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1
279	99.9	.0	2.0E-011	BAT-DEP-5HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR12HR, P1
280	99.9	.0	2.0E-011	BAT-DEP-5HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR12HR, P1
281	99.9	.0	1.9E-011	ACP-DGN-FR-EDGB, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV3, ESW-XHE-FO-EHS, LOSPNR14HR, P1

282	99.9	.0	1.9E-011	ACP-DGN-FR-EDGC, BAT-DEP-7HR, DGHWNR7HR, EHV-SRV-CC-RV2, ESW-XHE-FO-EHS, LOSPNR14HR, P1
283	99.9	.0	1.8E-011	ACP-DGN-FR-EDGB, ACP-DGN-FR-EDGC, ACP-DGN-FR-EDGD, BAT-DEP-7HR, DGHWNR7HR, LOSPNR14HR, P1
284	100.0	.0	1.6E-011	BAT-DEP-7HR, ESW-MDP-FR-MDPB, ESW-MDP-MA-MDPA, ESW-XHE-FO-EHS, LOSPNR14HR, P1
285	100.0	.0	1.6E-011	BAT-DEP-7HR, ESW-MDP-FR-MDPA, ESW-MDP-MA-MDPB, ESW-XHE-FO-EHS, LOSPNR14HR, P1

Table F.4 Accident Sequence T1-BU11U21 Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT   Event Tree: T1
Sequence: T1-BU11U21   Init. Event: IE-T1
Mincut Upper Bound 1.777E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	1.7E-007	BETA-5BAT, DCP-BAT-LF-CCF, NR

Table F.5 Accident Sequence T1-C-SLC Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT   Event Tree: T1
Sequence: T1-C-SLC   Init. Event: IE-T1
Mincut Upper Bound 4.418E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	57.0	57.0	2.5E-008	NR, RPSM, SLC-XHE-RE-DIVER
2	92.8	35.7	1.5E-008	NR, RPSM, SLC-XHE-FO-SLC
3	98.8	6.0	2.6E-009	NR, RPSM, SLC-SYS-TE-SLC
4	100.0	1.1	4.9E-010	BETA-2SIPUMPS, NR, RPSM, SLC-MDP-FS-CCF

Table F.6 Accident Sequence T1-P1BU11U21 Cut Sets

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T1
Sequence: T1-P1BU11U21 Init. Event: IE-T1
Mincut Upper Bound 1.706E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	1.7E-008	BETA-5BAT, DCP-BAT-LF-CCF, NR, P1

Table F.7 Accident Sequence T1-P2V234NU11B-1

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T1
Sequence: T1-P2V234NU11B-1 Init. Event: IE-T1
Mincut Upper Bound 5.530E-009

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	71.4	71.4	3.9E-009	ESF-XHE-FO-HSWIN, ESW-CKV-HW-CV513, NR, P2
2	100.0	28.5	1.5E-009	ESF-XHE-FO-HSWIN, ESW-XVM-PG-XV502, NR, P2

Table F.8 Accident Sequence T1-P2V234NU11B-2

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T1
Sequence: T1-P2V234NU11B-2 Init. Event: IE-T1
Mincut Upper Bound 8.437E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	99.6	99.6	8.4E-008	ESF-XHE-MC-PRES, NR, P2
2	99.8	.1	1.5E-010	ESF-ASP-FC-PL52C, ESF-ASP-FC-PL52D, NR, P2
3	100.0	.1	1.5E-010	ESF-ASP-FC-PL52A, ESF-ASP-FC-PL52B, NR, P2

Table F.10 Accident Sequence S1-V234NU11

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: S1
Sequence: S1-V2V3V4NU11 Init. Event: IE-S1
Mincut Upper Bound 1.602E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	99.6	99.6	1.6E-007	ESF-XHE-MC-PRES, NR
2	99.8	.1	3.0E-010	ESF-ASP-FC-PL52C, ESF-ASP-FC-PL52D, NR
3	100.0	.1	3.0E-010	ESF-ASP-FC-PL52A, ESF-ASP-FC-PL52B, NR

Table F.11 Accident Sequence A-V2V3

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: A
Sequence: A-V2V3 Init. Event: IE-A
Mincut Upper Bound 5.340E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	99.6	99.6	5.3E-008	ESF-XHE-MC-PRES, NR
2	99.8	.1	1.0E-010	ESF-ASP-FC-PL52C, ESF-ASP-FC-PL52D, NR
3	100.0	.1	1.0E-010	ESF-ASP-FC-PL52A, ESF-ASP-FC-PL52B, NR

Table F.12 Accident Sequence T3A-C-SLC

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3A
Sequence: T3A-C-SLC Init. Event: IE-T3A
Mincut Upper Bound 1.406E-006

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	56.7	56.7	7.9E-007	NR, RPSM, SLC-XHE-RE-DIVER
2	92.2	35.5	5.0E-007	NR, RPSM, SLC-XHE-FO-SLC
3	98.3	6.0	8.5E-008	NR, RPSM, SLC-SYS-TE-SLC
4	99.4	1.1	1.5E-008	BETA-2SIPUMPS, NR, RPSM, SLC-MDP-FS-CCF
5	99.6	.1	2.5E-009	NR, RPSM, SLC-CKV-HW-CV17
6	99.8	.1	2.5E-009	NR, RPSM, SLC-CKV-HW-CV16
7	99.8	.0	1.0E-009	NR, RPSM, SLC-XVM-PG-XV11
8	99.9	.0	1.0E-009	NR, RPSM, SLC-XVM-PG-XV18
9	100.0	.0	1.0E-009	NR, RPSM, SLC-XVM-PG-XV15

Table F.13 Accident Sequence T3A-CU11X

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3A
Sequence. T3A-CU11X Init. Event: IE-T3A
Mincut Upper Bound 2.621E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	57.2	57.2	1.5E-007	ESF-XHE-FO-DATWS, HCI-TDP-FS-20S37, NR, RPSM
2	76.3	19.0	5.0E-008	ESF-XHE-FO-DATWS, HCI-TDP-MA-20S37, NR, RPSM
3	85.8	9.5	2.5E-008	ESF-XHE-FO-DATWS, HCI-TDP-FO-20S37, NR, RPSM
4	91.5	5.7	1.5E-008	ESF-XHE-FO-DATWS, HCI-MOV-CC-MV19, NR, RPSM
5	97.2	5.7	1.5E-008	ESF-XHE-FO-DATWS, HCI-MOV-CC-MV14, NR, RPSM
6	97.6	.3	1.0E-009	ESF-XHE-FO-DATWS, HCI-MOV-MA-MV17, NR, RPSM
7	98.0	.3	1.0E-009	ESF-XHE-FO-DATWS, HCI-MOV-MA-MV57, NR, RPSM
8	98.4	.3	1.0E-009	ESF-XHE-FO-DATWS, HCI-MOV-MA-PCV50, NR, RPSM
9	98.8	.3	1.0E-009	ESF-XHE-FO-DATWS, HCI-MOV-MA-MV20, NR, RPSM
10	99.2	.3	1.0E-009	ESF-XHE-FO-DATWS, HCI-MOV-MA-MV14, NR, RPSM
11	99.4	.2	6.2E-010	ESF-XHE-FO-DATWS, HCI-ICC-HW-FC108, NR, RPSM
12	99.6	.1	5.0E-010	ESF-XHE-FO-DATWS, HCI-CKV-HW-CV65, NR, RPSM
13	99.8	.1	5.0E-010	ESF-XHE-FO-DATWS, HCI-CKV-HW-CV32, NR, RPSM
14	100.0	.1	5.0E-010	ESF-XHE-FO-DATWS, HCI-TCV-HW-TCV18, NR, RPSM

Table F.14 Accident Sequence T3A-P2V234NU11

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3A
Sequence: T3A-P2V234NU11 Init. Event: IE-T3A
Mincut Upper Bound 2.660E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	2.6E-008	ESF-XHE-MC-PRES, NR, P2, Q

Table F.15 Accident Sequence T2-C-SLC

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T2
Sequence: T2-C-SLC Init. Event: IE-T2
Mincut Upper Bound 2.796E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	57.0	57.0	1.6E-008	NR, RPSM, SLC-XHE-RE-DIVER
2	92.8	35.7	1.0E-008	NR, RPSM, SLC-XHE-FO-SLC
3	98.8	6.0	1.7E-009	NR, RPSM, SLC-SYS-TE-SLC
4	100.0	1.1	3.1E-010	BETA-2SIPUMPS, NR, RPSM, SLC-MDP-FS-CCF

Table F.16 Accident Sequence T2-P2V234NU11

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family: PEACHBOT Event Tree: T2

Sequence: T2-P2V234NU11 Init. Event: IE-T2

Mincut Upper Bound 5.320E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	5.3E-008	ESF-XHE-MC-PRES, NR, P2

Table F.17 Accident Sequence T3B-C-SLC

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family: PEACHBOT Event Tree: T3B

Sequence: T3B-C-SLC Init. Event: IE-T3B

Mincut Upper Bound 3.355E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	57.0	57.0	1.9E-008	NR, RPSM, SLC-XHE-[illegible]-DIVER
2	92.8	35.7	1.2E-008	NR, RPSM, SLC-XHE-FO-SLC
3	98.9	6.0	2.0E-009	NR, RPSM, SLC-SYS-TE-SLC
4	100.0	1.1	3.7E-010	BETA-2SIPUMPS, NR, RPSM, SLC-MDP-FS-CCF

Table F.18 Accident Sequence T3B-P2V234NU11-1

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3B
Sequence: T3B-P2V234NU11-1 Init. Event: IE-T3B
Mincut Upper Bound 6.384E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	6.3E-008	ESF-XHE-MC-PRES, NR, P2

Table F.19 Accident Sequence T3B-P2V234NU11-2

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3B
Sequence: T3B-P2V234NU11-2 Init. Event: IE-T3B
Mincut Upper Bound 3.000E-010

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	3.0E-010	ESF-XHE-FO-HSWIN, ESW-CKV-HW-CV513, NR, NSW-SYS-FO-NSW-1, P2

Table F.20 Accident Sequence T3C-C-SLC

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3C
Sequence: T3C-C-SLC Init. Event: IE-T3C
Mincut Upper Bound 1.066E-007

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	56.8	56.8	6.0E-008	NR, RPSM, SLC-XHE-RE-DIVER
2	92.5	35.6	3.8E-008	NR, RPSM, SLC-XHE-FO-SLC
3	98.5	6.0	6.4E-009	NR, RPSM, SLC-SYS-TE-SLC
4	99.6	1.1	1.2E-009	BETA-2SIPUMPS, NR, RPSM, SLC-MDP-FS-CCF
5	99.8	.1	1.9E-010	NR, RPSM, SLC-CKV-HW-CV16
6	100.0	.1	1.9E-010	NR, RPSM, SLC-CKV-HW-CV17

Table F.21 Accident Sequence T3C-CU11X

SEQUENCE CUT SETS (QUANTIFICATION) REPORT
Family: PEACHBOT Event Tree: T3C
Sequence: T3C-CU11X Init. Event: IE-T3C
Mincut Upper Bound 1.938E-008

Cut No.	Accum % Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	58.8	58.8	1.1E-008	ESF-XHE-FO-DATWS, HCI-TDP-FS-20S37, NR, RPSM
2	78.4	19.6	3.8E-009	ESF-XHE-FO-DATWS, HCI-TDP-MA-20S37, NR, RPSM
3	88.2	9.8	1.9E-009	ESF-XHE-FO-DATWS, HCI-TDP-FO-20S37, NR, RPSM
4	94.1	5.8	1.1E-009	ESF-XHE-FO-DATWS, HCI-MOV-CC-MV19, NR, RPSM
5	100.0	5.8	1.1E-009	ESF-XHE-FO-DATWS, HCI-MOV-CC-MV14, NR, RPSM

APPENDIX G

RISK CALCULATIONS

The risk calculation is essentially a mapping of an accident sequence or plant damage state (PDS) to a consequence. This includes the accident phenomenology, source term, containment failure, release of radioactive material, propagation to the affected population and the affects on the public of that release (consequence). In this study that mapping is simply a conversion factor for each affected PDS that was calculated from the NUREG/CR-4551 back end analysis (Table D.1)[1].

These factors could be determined more accurately by rerunning parts of the back end analysis, since the weighting of various outcomes from any plant damage state change when the frequency of the PDS changes. Our estimate is that the factor used is within ±2 times the number if rerun, and not rerunning saves resources. Only PDS-5 is of interest. Its value is 2.23E+06. If one compares the corresponding Cooper PDS from the TAP A-45 analysis which used WASH-1400 as a basis, the value is 5.26E+05 (Table D.2), which is a factor of 4 different given a different plant and location.

Table D.2 Cooper TAP A-45 PDS to Consequence Mapping

Cooper TAP A-45		Release Category	WASH 1400 = Upper Estimate	Producr
Accident Sequence Type 1	α = 1.0E-02	C-1	4.3E05	4.30E03
	β = 7.0E-02	C-2	6.2E05	4.34E04
- LOCA & Loss of Inj./ SBO	γ = 1.8E-01	C-2	6.2E05	1.12E05
	γ = 7.3E-01	C-3	5.0E05	3.65E05
	δ = 1.0E-02	C-4	9.2E04	9.20E[illegible]
	ϵ = 1.0			5.26E05

[1]NUREG/CR-4551, Vol. 4, page 2.16(A), 5.38(B), and 5.8(D).

Table D.1 Peach Bottom NUREG/CR-4550 PRA Consequences

PDS	Mean Internal CDF Sample Size 200	Mean Internal CDF Sample Size 1000	Population Dose 50 Miles Consequence	Population Dose 50 Miles (FCMR) %	RISK Population Dose 50 Miles
1 LOCA	1.5E-07	2.6E-07	1.32E+05	2.5	1.98E-01
2 Fast Trans.	1.8E-07	2.2E-07	8.78E+05	2.0	1.58E-01
3 Fast Trans.	2.6E-09	6.1E-09	1.52E+06	0.05	3.95E-03
4 Fast SBO	2.0E-07	2.1E-07	7.90E+05	2.0	1.58E-01
5 Slow SBO	1.9E-06	1.9E-06	2.23E+06	53.7	4.24E-00
6 Fast ATWS	3.5E-07	3.0E-07	5.43E+05	2.4	1.90E-01
7 ATWS CV	9.9E-08	1.1E-07	1.84E+06	2.3	1.82E-01
8 ATWS CV	1.4E-06	1.5E-06	1.91E+06	33.9	2.68E-00
9 ATWS CV	4.7E-08	4.4E-08	1.85E+06	1.1	8.09E-02
Totals	4.3E-06 (A)	4.5E-06	(C ÷ A)	99.95 (B)	7.9 → (D) (C = B * D)

The following calculations give the ΔCDF and ΔRisk for all alternatives.

Base Case: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.

T1-BNU11	1.83E-06		
T1-P1BNU11	1.62E-07		
T1-BU11NU21	1.36E-07		
PDS - 5 = SUM	2.13E-06	* 2.23E06	= 4.75

Alternative 1: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.
T1-BNU11	1.41E-06		
T1-P1BNU11	1.24E-07		
T1-BU11NU21	1.12E-07		
PDS - 5 = SUM	1.65E-06	* 2.23E06	= 3.68

ΔCDF = (2.13E-06) - (1.65E-06) = 4.80E-07

ΔRisk = 4.75 - 3.68 = 1.07

Alternative 2: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.
T1-BNU11	1.33E-06		
T1-P1BNU11	1.17E-07		
T1-BU11NU21	1.07E-07		
PDS - 5 = SUM	1.55E-06	* 2.23E06	= 3.46

ΔCDF = (2.13E-06) - (1.55E-06) = 5.80E-07

ΔRisk = 4.75 - 3.46 = 1.29

Alternative 3: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.
T1-BNU11	5.01E-07		
T1-P1BNU11	4.60E-08		
T1-BU11NU21	4.04E-08		
PDS - 5 = SUM	5.87E-07	* 2.23E06	= 1.31

ΔCDF = (2.13E-06) - (5.87E-07) = 1.54E-06

ΔRisk = 4.75 - 1.31 = 3.44

Alternative 4: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.

T1-BNU11	5.70E-07		
T1-P1BNU11	5.24E-08		
T1-BU11NU21	4.51E-08		
PDS - 5 = SUM	6.68E-07	* 2.23E06	= 1.49

ΔCDF = (2.13E-06) - (6.68E-07) = 1.46E-06

ΔRisk = 4.75 - 1.49 = 3.26

Alternative 5: Risk Calculation

Accident Sequence	Core Damage Frequency	Population Dose 50 Miles Consequence	Risk Person - REM/R yr.
T1-BNU11	9.21E-07		
T1-P1BNU11	8.10E-08		
T1-BU11NU21	6.79E-08		
PDS - 5 = SUM	1.07E-06	* 2.23E06	= 2.39

ΔCDF = (2.13E-06) - (1.07E-06) = 1.06E-06

ΔRisk = 4.75 - 2.39 = 2.36

While only the cut sets in each of the three contributing accident sequences in PDS 5 that relate to service water should change, the ΔRisk should be the same for the total as if only the service water related cut sets were considered since the non-service water cut set's contribution should not change.

APPENDIX H

PILOT PLANT MODIFICATION

COST ESTIMATES

The method used is to examine comparable modifications from TAP A-45 to those being proposed for the pilot plant and any other pertinent information to determine an estimate of total one time cost, operational and maintenance cost/year, and replacement power cost. We will assume the replacement power cost will be zero in that all work that needs to be done with the plant shutdown will be done during normal outages. Table H.1 presents those TAP A-45 modifications that are relevant to the pilot plant modifications. Most are similar in requirements and should provide reasonable estimates. Neither Turkey Point nor St. Lucie had any modifications that related to the pilot plant. The numbers and letters e.g., 803-C represent the modification number used by the architect engineer in TAP A-45 and the applicable "appendix" of Appendix J. Since the TAP A-45 studies were based on January 1985 dollars we will use a factor for January 1992 dollars based on the consumer price index (CPI) although we realize construction costs may have gone up more or less than this amount. This is shown in Table H.2.

The following estimates include the basic characteristics of the pilot plant modification, the characteristics of the comparable modification, costs of the comparable modification, and major differences between them. The conclusion of each modification cost estimate gives the rational for using the comparable modification costs and any other information used to estimate the modification costs to be used in the value/impact analysis.

Table H.1
Relevant TAP A-45 Modification Cost Estimates.

	Pilot Plant Modifications	Quad Cities	Cooper	Point Beach	ANO-1
1.	3rd ESW Train pump-cv-mv	ECW Train 803-C		RHR Pump 816-L	DHR Pump 804-C
2.	Auto-Actuation Logic	Auto-Transfer 304-D	Auto-Act. 506-F		
3.	Operator training, procedures - no credit taken for this potential modification so no cost estimates were made.				
4.	Add additional pump discharge check valve (2 each)		Isolation MOV 805-E	Parallel MV 803-C	Parallel AOV 805-D
5.	Increase Test Frequency of ESW Discharge check valves				
6.	Check valve in series with AOVs (4 each)		Isolation MOV 805-E	Parallel MV 803-C	Parallel AOV 805-D
7.	Swing EDG, self cooled with battery	EDG 301-A	EDG 301-A	TD Gen. 815-K	TD Gen. 303-B

Table H.2.
Inflation Between 1/85 and 1/92.

Year	Percent Inflation[1]	Multiplier
1985	3.6	1.036 *
1986	1.9	1.019 *
1987	3.6	1.036 *
1988	4.1	1.041 *
1989	4.8	1.048 *
1990	5.4	1.054 *
1991	~5.5	1.055 =1.327 factor for 1/92 dollars

[1]These values come from the consumer price index percentages given in the 1992 World Almanac.

PILOT PLANT MODIFICATION NO. 1

Addition of a Third ESW Pump

- 100% Flow Capacity 8000 gpm
- Separate Suction Line to Water Source
- One Manual Valve and One Check Valve in Pump Train
- Power From Diesel Generator D - Different Than Two Existing ESW Pumps
- Same Actuation as Existing Pumps
- Extra Building Space Required

Related TAP A-45 Modification - Quad Cities 1/1985 Dollars

- Add Cooling Water Pump for Diesel Generators - Mod. 803, App. C
- Flow Capacity 900 gpm
- Located in Existing Building
- Two Manual Valves, Two Motor Operated Valves, and Two Check Valves
- Control, Power, and Actuation Costed

Generic Costs From Quad Cities Alt. 2, p. J-36, 37:

Direct	2613 K
Indirect (2613/3097) * 1941	= 1638 K
Contingency and Owner's Costs (2613/3097) * 1764	= 1488 K
Total One Time Cost of Modification	$5739 K
Operations and Maintenance Costs Per Year	6 K

Major Differences:

- Pump Capacity 8000 gpm Verses 900 gpm
- Number of Valves 2 Verses 6
- Building Space/Construction Uncertain

Estimated Costs Based on Comparison With Quad Cities Mod. 803 in 1/1992 Dollars

Total One Time Cost 5739 * 1.327	= 7616 K
Operations and Maintenance Costs Per Year 6 * 1.327	= 8 K

Related TAP A-45 Modification - Point Beach 1/1985 Dollars

- Add RHR Pump - Mod. 816, App. L
- Flow Capacity 1560 gpm
- Located in Existing Building
- Two Manual Valves
- Control, Power, and Actuation Costed

Generic Costs From Point Beach Alt. 3, p. J-46, 47

Direct	1161 K
Indirect (1161/12487) * 8375	= 779 K
Contingency and Owner's Cost (1161/12487) * 7300	= 679 K
Total One Time Cost of Modification	$2619 K
Operations and Maintenance Costs Per Year (1161/12487) * 235	= 22 K

Major Differences:

- Pump Capacity 8000 gpm Versus 1560 gpm
- Building Space/Construction Uncertain

Estimated Costs Based on Comparison With Point Beach Mod. 816 in 1/1992 Dollars

Total One Time Cost 2619 * 1.327	= 3475 K
Operations and Maintenance Costs Per Year 22 * 1.327	= 29 K

Related TAP A-45 Modification - ANO-1

- Addition of a Third DHR Pump - Mod. 804, App. C
- Flow Capacity 2500 gpm
- Located in Existing Building
- Four Manual Valves
- Control, Power, and Actuation Costed

Generic Costs From ANO-1 Alt. 1, p. J-30, 31:

Direct	2665 K
Indirect (2665/6747) * 5221	= 2062 K
Total One Time Cost of Modification	$4727 K
Operations and Maintenance Costs Per Year (2665/6747) * 114	= 45 K

Major Differences:

- Pump Capacity 8000 gpm Versus 2500 gpm
- Number of Valves 2 Versus 4
- Building Space/Construction Uncertain

Estimated Costs Based on Comparison With ANO-1 Mod. 804 in 1/1992 Dollars

• Total One Time Cost 4727 * 1.327	= 6273 K
• Operations and Maintenance Costs Per Year 45 * 1.327	= 60 K

In summary, the average of three estimates ($7.6M, $3.5M, and $6.3M) is $5.8M. This is low because the ESW pump to be estimated here is a much larger pump, the piping lengths should be longer and there may need to be modifications to the service water building and intake structures. NUREG/CR-5526 uses a data base of three estimates ($12.5M, $37.5M, and $7.0M) averaging to $19M for a swing service water pump as a per unit cost. Clearly such a modification cost will be in the $5M to $20M range. Considering the accuracy of our estimates without any detailed examination and evaluation of the plant, our engineering judgement of the estimated one time cost for this modification is $12.4M. We believe this is within a factor of two of a more accurate estimate and should not affect the results significantly.

Similarly, the O & M costs ($8 K, $29 K, and $60 K) need to be combined. The average value of $32 K will be used.

PILOT PLANT MODIFICATION NO. 2

Addition of a Standby Auto Actuation Logic for the ECW Pump

- Change Pump Control Logic
- No New Sensors or Power Supplies Required

Related TAP A-45 Modification - Quad Cities 1/1985 Dollars

- Add Automatic Transfer ECCS DC Control Logic to Active DC Bus if Original Bus Fails - Mod. 304, App. D

  Three terminal boxes and two junction boxes
  Automatic Transfer Switches, Conduit and Cable

  Generic Costs From Quad Cities Alt. 1, p. J-30, 31

Direct	224 K
Indirect (224/6568) * 5502	= 188 K
Contingency and Owner's Costs (224/6568) * 4225	= 144 K
Total One Time Cost of Modification	$556 K
Operations and Maintenance Cost Per Year (224/6568) * 137	= 5 K

  Major Differences:

  - Less Logic Circuitry
  - Much More Electrical Equipment

  Estimated Costs Based on Comparison With Quad Cities Mod. 304 in 1/1992 Dollars

  - Total One Time Cost 556 * 1.327 = 738 K
  - Operations and Maintenance Costs Per Year 5 * 1.327 = 7 K

Related TAP A-45 Modification - Cooper 1/1985 Dollars

- Automatic Closure of Reactor Building Service Water Isolation Valve MOV-37 - Mod. 506 App. F
- Modify Control Circuit for MOV to Add Close Signal on Receipt of an Accident Signal
- Install Necessary Conduit and Cable

  Generic Costs From Cooper Alt. 1, p. J-30, 31

Direct	91 K
Indirect (91/10267) * 8264	= 73 K
Contingency and Owner's Costs Per Year (91/10267) * 6485	= 57 K
Total One Time Cost of Modification	$221 K
Operations and Maintenance Costs Per Year (91/10267) * 171	= 2 K

  Major Differences:

  - Control Circuits Verses Logic Circuits
  - Much More Cable and Conduit

  Estimated Costs Based on Comparison With Mod. 506 in 1/1992 Dollars

  Total One Time Cost 221 * 1.327 = 293 K

Operations and Maintenance Costs Per Year 2* 1.327 = 3 K

The relatively comparable TAP A-45 modifications are considerably more involved than the proposed modification for the pilot plant. The two one time costs are $738 K and $253 K. Our engineering judgement is that this modification would cost less than the Cooper modification. The estimates are $150 K for one time costs and $5 K for operations and maintenance costs.

PILOT PLANT MODIFICATION NO. 4

Addition of a Second Pump Discharge Check Valve

- Add Two Check Valves to ESW Pump Discharge Lines for Improved Back-Leakage Isolation

Related TAP A-45 Modification - Cooper 1/1985 Dollars

- Redundant RBCCW Isolation Valve - Mod. 805, App. E
- Single Motor Operated Valve to Isolate Non-Essential Loads
- Junction Box, Conduit, Cable, and Controls

Generic Costs From Cooper - Alt. 1, p. J-30, 31

Direct	197 K
Indirect (197/10267) * 8264	= 159 K
Contingency and Owner's Costs Per Year (197/10267) * 6485	= 124 K
Total One Time Cost of Modification	$480 K
Operations and Maintenance Costs Per Year (197/10267) * 171	= 3 K

Major Differences:

- Two Check Valves Versus One Motor Operated Valve
- Much More Installation Work

Estimated Costs Based on Comparison With Mod. 805 in 1/1992 Dollars

Total One Time Cost 480 * 1.327	= 637 K
Operations and Maintenance Costs Per Year 3 * 1.327	= 4 K

Related TAP A-45 Modification - Point Beach 1/1985 Dollars

- Redundant RHR Pump Cooler Outlet Valves - Mod. 803, App. C
- Parallel Manual Valves in Two RHR Pump Oil Cooler CCW 2" Return Lines

Generic Costs From Point Beach Alt. 1, p. J-33, 34

Direct	16 K
Indirect (16/4419) * 2752	= 10 K
Contingency and Owner's Costs Per Year (16/4419) * 2510	= 9 K
Total One Time Cost of Modification	$35 K
Operations and Maintenance Costs Per Year (16/4416) * 13	≈ 0 K

Major Differences:

- Much Larger Pipe Size
- Check Valve Verses Manual Valve

Estimated Costs Based On Comparison with Mod. 803 in 1/1992 Dollars

• Total One Time Cost 35 * 1.327	= 46 K
• Operations and Maintenance Costs Per Year 0 * 1.327	0 K

Related TAP A-45 Modification - ANO-1 1/1985 Dollars

- Addition of Redundant BWST Supply Valves - Mod. 805, App. D
- Parallel Air Operated Valve in Each of Two Suction Lines

Generic Costs From ANO-1 Alt. 1, p. J-30, 31

Direct	1345 K
Indirect (1345/6747) * 5221	= 1041 K
Contingency and Owner's Costs Per Year (1345/6747) * 4189	= 835 K
Total One Time Cost of Modification	$3221 K
Operations and Maintenance Costs Per Year (1345/6747) * 114	= 23 K

Major Differences:

- Two Air Operated Valves and One Manual Valve Versus Two Check Valves
- Smaller Pipe Size

Estimated Costs Based on Comparison With Mod. 805 in 1/1992 Dollars

Total One Time Cost 3221 * 1.327	= 4274 K
Operations and Maintenance Costs Per Year 23 * 1.327	= 31 K

The total one time costs for the three roughly comparable TAP A-45 modifications are given in Table H-3. A rough scaling for the number of valves is given showing similar costs for the two motor operated valves versus the two manual valves which indicates the pipe size is a significant factor as well as the type of valve. The Point Beach $92 K estimate is driven by the pipe size. The ANO-1 modification would logically appear to be low due to the pipe size and the Cooper modification high due to the cost of motor operated valves versus manual valves. Our engineering judgement is that a realistic cost is $1200 K. The corresponding operations and maintenance cost estimate is $10 K.

Table H-3
Mod. 4 Comparison Mod Cost Estimates.

Peach Bottom	Cooper	Point Beach	ANO-1
2 Check Valves Large Pipe	1 MOV Large Pipe	1 Manual Valve Small Pipe	2 AOVs and 1 Manual Valve Medium Pipe
	637 K	46 K	4274 K
Rough Scaling	2 MOVs	2 Manual Valves Small Pipe	2 Manual Valves (1) Medium Pipe
	1274 K	92 K	1221 K

(1) Assuming AOV to Manual Valve Cost Ratio is 3 i.e., [4274 + (2 * 3 + 1)] * 2.

PILOT PLANT MODIFICATION NO. 5

Increase System Functional Testing Frequency for ESW Pump Discharge Check Valves

- Increase Test Frequency From Quarterly to Monthly

The operations and maintenance yearly costs for modifications 4 and 6 respectively are \$10 K and \$20 K which is essentially \$5 K per check valve per year. Assuming most of this cost is incurred in testing, increasing the test frequency from quarterly to monthly would increase the operations and maintenance costs from \$5 K to \$15 K per check valve for a total of \$30 K. By comparison, NUREG/CR-5526 (p. 157) gives a value of \$1 K per leak test of isolation valves resulting in \$1 K/valve test * 2 valves * 12 tests/year = \$24 K per year. The one time cost of implementing this change in procedure is estimated to be \$5 K (reference NUREG/CR-5526 p. 157).

PILOT PLANT MODIFICATION NO. 6

Addition of a Check Valve in Series to the Diesel Generator Air Operated Valves

- Add four Series Check Valves in the Diesel Generator Jacket Cooling Lines

This proposed modification is similar to modification 4 except that four check valves are required instead of two. Our engineering judgement is that the cost of a motor operated valve versus a manual valve outweighs the cost of the large versus medium pipe size resulting in an estimate of \$1800 K for modification 6. The corresponding estimated O & M costs are \$20 K.

PILOT PLANT MODIFICATION NO. 7

Addition of a Swing, Self-Cooled, Diesel Generator

- Self Contained Lube Oil System
- No External Power Required for Self Cooling Water System or Lube Oil System
- Includes Dedicated Batteries
- 2600 KW

Related TAP A-45 Modification - Quad Cities 1/1985 Dollars

- Addition of a Fourth Diesel Generator - Mod. 301, App. A
- Dedicated Cooling Water System
- New Building
- Includes Dedicated Batteries
- 2500 KW

Generic Costs From Quad Cities Alt. 1, p. J-30, 31

Direct	6344 K
Indirect (6344/6568) * 5502	= 5314 K
Contingency and Owner's Costs Per Year (6344/6568) * 4225	= 4081 K
Total One Time Cost of Modification	$15,739 K
Operations and Maintenance Costs Per Year (6344/6568) * 137	= 132 K

Major Differences:

- Assume Equal to the Basic Mod. 7 Requirements

Estimated Costs Based on Comparison With Mod. 301 in 1/1992 Dollars

Total One Time Cost 15,739 * 1.327	= 20,886 K
Operations and Maintenance Costs Per Year 132 * 1.327	= 175 K

Related TAP A-45 Modification - Cooper 1/1985 Dollars

- Addition of a Third Diesel Generator - Mod. 301, App. A
- Dedicated Cooling Water System
- New Building
- Includes Dedicated Batteries
- 4000 KW

Generic Costs From Cooper Alt. 1, p. J-30, 31

Direct	8960 K
Indirect (8960/10267) * 8264	= 7212 K
Contingency and Owner's Costs Per Year (8960/10267) * 6485	= 5659 K
Total One Time Cost of Modification	$21,831 K
Operations and Maintenance Costs Per Year (8960/10267) * 171	= 149 K

Major Differences:

- Assume Equal to the Basic Mod. 7 Requirements
- Larger Capacity 4000 KW verses 2600 KW

Estimated Costs Based on Comparison with Mod. 301 in 1/1992 Dollars

Total One Time Cost 21,831 * 1.327	= 28,970 K
Operations and Maintenance Costs Per Year 149 * 1.327	= 198 K

Related TAP A-45 Modification - Point Beach 1/1985 Dollars

- Turbine Driven Generator - Mod. 815, App. K
- Enclosed in Existing Space
- Lube Oil and Jacket Cooling Unknown - Probably Self Sufficient
- 500 KW

Generic Costs From Point Beach Alt. 2, p. J-39, 40

Direct	2178 K
Indirect (2178/8074) * 5289	= 1427 K
Contingency and Owner's Costs Per Year (2178/8074) * 5289	= 1261 K
Total One Time Cost of Modification	$4866 K
Operations and Maintenance Costs Per Year (2178/8074) * 51	= 14 K

Major Differences:

- Turbine Versus Diesel Driven
- 500 KW Versus 2600 KW
- No New Building

Estimated Costs Based on Comparison With Mod. 515 in 1/1992 Dollars

Total One Time Cost 4866 * 1.327	= 6457 K
Operations and Maintenance Costs Per Year 14 * 1.327	= 19 K

Related TAP A-45 Modification - ANO-1 1/1985 Dollars

- Addition of a Turbine Driven Generator for Emergency Loads Mod. 303, App. B
- Enclosed in Existing Space
- Lube Oil and Jacket Cooling Unknown - Probably Self Sufficient
- 500 KW

Generic Costs From ANO-1 Alt. 1, p. J-30, 31

Direct	1855 K
Indirect (1855/6747) * 5221	= 1435 K
Contingency and Owner's Costs Per Year (1855/6747) * 4189	= 1152 K
Total One Time Cost of Modification	$4442 K
Operations and Maintenance Costs Per Year (1855/6747) * 114	= 31 K

Major Differences:

- Turbine Versus Diesel Driven
- 500 KW versus 2600 KW
- No New Building

Estimated Costs Based on Comparison With Mod. 303 in 1/1992 Dollars

Total One Time Cost 4442 * 1.327 = 5895 K
Operations and Maintenance Costs Per Year 31 * 1.327 = 41 K

The results of the four comparable modifications costs estimated for the pilot plant modification No. 7 are very consistent based on capacity and requirements. Clearly the most representative estimate is that from Quad Cities; $20.9M one time cost of the modification and $175 K operations and maintenance cost per year.

The costs for the seven modifications are given in Table H.4. These numbers will be used in the value/impact analysis.

Table H.4

Summary of Pilot Plant Best Estimate

	Mod. 1	Mod. 2	Mod.3	Mod. 4	Mod. 5	Mod. 6	Mod. 7
Total One Time Cost	$12.4M	$150K	NA	$1200K	$5K	$1800K	$20.9M
Operation and Maintenance Cost Per Year	$32K	$5K	NA	$10K	$30K	$20K	$175K
Replacement Power Cost	$0	$0	$0	$0	$0	$0	$0

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11. ABSTRACT (200 words or less)

The contribution of essential service water (ESW) system failure to core damage frequency has long been a concern of the NRC. The objective of this study is to assess the safety significance of the loss of ESW systems in LWRs relative to core damage frequency (CDF) and perform a limited value/impact analysis of potential modifications to solve ESW vulnerabilities using a prototypical (pilot) plant. Previous studies indicate that service water systems contribute from <1% to 65% of the total internal CDF. For the pilot plant analyzed, common ESW vulnerabilities are failure of standby service water pumps to start, backflow through check valves for cross-tied pumps, and failure of normally closed isolation valves in diesel generator cooling loops to open on demand. For the potential modifications evaluated for the pilot plant, the results showed that they could reduce the CDF by as much as 33 percent. However, the dollars per person REM measures resulting from various groups of these modifications significantly exceeded the current criteria of $1000. The results, since they only apply to the pilot plant, are not typical of all BWRs. Due to the importance of service water to CDF and the plant specific nature of ESW systems there could be plants for which there would be cost effective modifications. Additional analysis would be required to identify them.

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