UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
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ARLINGTON, TEXAS 76011-4125

July 15, 2010

EA-10-084

David J. Bannister, Vice President
and Chief Nuclear Officer
Omaha Public Power District
9610 Power Lane
Blair, NE 68008

SUBJECT: FORT CALHOUN STATION - NRC FOLLOWUP INSPECTION - INSPECTION REPORT 05000285/2010007; PRELIMINARY SUBSTANTIAL FINDING

Dear Mr. Bannister:

The U.S. Nuclear Regulatory Commission (NRC) completed an inspection at the Fort Calhoun Station. The enclosed inspection report documents the inspection findings, which were discussed, with Mr. J. Reinhart Site Vice President, and other members of your staff on June 21, 2010.

The attached report documents the results of the inspection, which reviewed an unresolved item from the 2009 Component Design Basis Inspection at the Fort Calhoun Station (URI 05000285/2009006-03). The inspection examined activities conducted under your license as they relate to safety and compliance with the NRC's rules and regulations with respect to external flooding.

This report discusses preliminary results of the inspection including a finding, which involves a failure to establish and maintain procedures to protect the intake structure and auxiliary building during external flooding events. The inspectors determined that the protection strategy discussed in station operating procedures, if implemented, would be insufficient to protect vital station facilities to an external flood level of 1014 feet mean sea level, as described in the Fort Calhoun Station Updated Safety Analysis Report and station procedures. This finding was assessed based on the best available information, including influential assumptions, using the applicable significance determination process. The preliminary significance (Yellow) was based on the extrapolated external flood frequencies established by the Fort Calhoun Station Individual Plant Examination for External Events and credit given for use of a portable gas powered pump system. Additional details of the primary assumptions associated with the preliminary significance determination process are documented in Attachment 2 of the enclosure.

The finding is also an apparent violation of NRC requirements and is being considered for escalated enforcement action in accordance with the NRC Enforcement Policy. The current Enforcement Policy is included on the NRC's Web site at http://adamswebsearch2.nrc.gov/idmws/doccontent.dll?library=PU_ADAMS^PBNTAD01&ID=092450167

Before we make a final decision on this matter, we are providing you an opportunity (1) to present to the NRC your perspectives on the facts and assumptions, used by the NRC to arrive at the finding and its significance, at a Regulatory Conference or (2) submit your position on the finding to the NRC in writing. If you request a Regulatory Conference, it should be held within 30 days of the receipt of this letter and we encourage you to submit supporting documentation at least one week prior to the conference in an effort to make the conference more efficient and effective. If a Regulatory Conference is held, it will be open for public observation. If you decide to submit only a written response, such submittal should be sent to the NRC within 30 days of the receipt of this letter.

In accordance with NRC Inspection Manual Chapter 0609, we intend to complete our evaluation using the best available information and issue our final determination of safety significance within 90 calendar days of the date of this letter. The significance determination process encourages an open dialogue between the NRC staff and the licensee. However, the dialogue should not impact the timeliness of the staff's final determination.

Since the NRC has not made a final determination in this matter, a Notice of Violation is not being issued for these inspection findings at this time. In addition, please be advised that the number and characterization of apparent violations described in the enclosed inspection report may change as a result of further NRC review.

If you have additional questions about NRC rules and processes, please contact Mr. Thomas Farnholtz at (817) 860-8243.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Roy J. Caniano

Roy J. Caniano, Director
Division of Reactor Safety

Docket: 50-285
License: DPR-40

Enclosure:
NRC Inspection Report 05000285/20010007
w/Attachments: Attachment 1: Supplemental Information
Attachment 2: Phase 3 Analysis
Attachment 3: SPAR-H Worksheets
Attachment 4: Flooding Frequency Sensitivity
Attachment 5: Significance Determination Processes Combinations
Attachment 6: Additional Fault Trees

cc w/Enclosure:
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U.S. NUCLEAR REGULATORY COMMISSION

REGION IV

Docket:	50-285
License:	DPR-40
Report Nos.:	05000285/2010007
Licensee:	Omaha Public Power District
Facility:	Fort Calhoun Station
Location:	9610 Power Lane Blair, NE 68008
Dates:	February 9, 2010 (Onsite) April 13, 2010 (Onsite) January 1, 2010 – June 14, 2010 (In-Office)
Lead Inspector:	G. George, Reactor Inspector, Engineering Branch 1
Inspectors:	J. Kirkland, Senior Resident Inspector, Fort Calhoun Station M. Williams, Reactor Inspector, Plant Support Branch 2
Others:	G. Replogle, Senior Reactor Analyst, Division of Reactor Safety D. Loveless, Senior Reactor Analyst, Division of Reactor Safety
Approved By:	Thomas Farnholtz, Branch Chief, Engineering Branch 1

SUMMARY OF FINDINGS

IR 05000285/2010007; 01/01/2010 – 06/21/2010; Fort Calhoun Station: Inspection Procedure 92701, Followup.

The report covers a 6-month period of followup inspection by regional based inspectors from the NRC Region IV office. One apparent violation of NRC requirements with potential substantial (Yellow) safety significance was identified. The significance of most findings is indicated by their color (Green, White, Yellow, or Red) using Inspection Manual Chapter 0609, "Significance Determination Process." Findings for which the significance determination process does not apply may be Green or be assigned a severity level after NRC management review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

A. NRC-Identified Findings and Self-Revealing Findings

Cornerstone: Mitigating Systems

- Yellow. The inspectors identified an apparent violation of Technical Specification 5.8.1.a, "Procedures," for failure to establish and maintain procedures that protect the intake structure and auxiliary building during external flooding events. The inspectors determined that the procedural guidance of GM-RR-AE-1002, "Flood Control Preparedness for Sandbagging," was inadequate because stacking and draping sandbags at a height of four feet over the top of floodgates would be insufficient to protect the vital facilities to 1014 feet mean sea level, as described in the Updated Safety Analysis Report and station procedures. The licensee has entered this condition into their corrective action program as Condition Report 2010-2387. As result of this violation, the licensee has implemented a corrective action plan to correct identified deficiencies and ensure site readiness.

  This performance deficiency is more than minor because it adversely affected the Mitigating Systems Cornerstone attribute of external events and affected the cornerstone objective of ensuring the availability and reliability of systems that respond to initiating events to prevent undesirable consequences. The inspectors determined the finding resulted in the degradation of equipment and functions specifically designed to mitigate a flooding initiating event. In addition, an external flood event would degrade two or more trains of a multi-train safety system. Therefore, the finding was potentially risk significant to flood initiators and a Phase 3 analysis was required. The preliminary change in core damage frequency was calculated to be 3.1E-5/year indicating that the finding was of substantial safety significance (Yellow). The finding was determined to have a crosscutting aspect in the area of problem identification and resolution, corrective action program, for failure to take appropriate corrective actions to address safety issues and adverse trends in a timely manner, commensurate with their safety significance and complexity. Specifically, from 2003 to 2008, the licensee failed to initiate appropriate corrective actions to ensure regulatory compliance of the external flooding design basis was maintained. [P.1(d)] (Section 4OA5.1)

REPORT DETAILS

4OA5 Other Activities

.1 IP 92701, "Followup": URI 05000285/2009006-03, "Failure to Update Flood Protection for Safety Related Buildings"

a. Inspection Scope

As documented in NRC Inspection Report 2009006, the NRC inspectors identified an unresolved item concerning external flood protection for plant areas considered vital to allow the reactor to achieve cold shutdown. The unresolved item concerned: (1) the ability of the licensee to protect the Fort Calhoun Station auxiliary building, intake structure, and turbine building basement from external floods up to flood elevation 1013 feet mean sea level* (MSL) as stated in the Updated Safety Analysis Report (USAR) and station procedures; and, (2) upon receiving new flooding information in November 2003, if the licensee was required to update the USAR.

Because further inspection was necessary, the issue was considered an unresolved item pending further NRC Region IV review. The NRC Region IV review was to determine:

1. If the failure to meet the self-imposed standard of flood protection up to 1013 feet MSL* is a performance deficiency in accordance with NRC Manual Chapter 0612.

2. If a violation of NRC requirements is associated with the performance deficiency because the licensee did not update the external flood design basis when new information was received in November 2003.

   *Note: During this inspection, the inspectors determined that the Fort Calhoun Station original USAR described protection of the facility up to 1014 feet MSL.

This unresolved item was identified as URI 05000285/2009006-03, "Failure to Update Flood Protection for Safety Related Buildings." Based on followup inspections conducted at the Fort Calhoun Station and the NRC Region IV office, the inspectors determined that no further inspection is necessary. Therefore, URI 05000285/2009006-03 will be closed. Findings are documented in the following section.

b. Findings

Failure to Maintain External Flood Procedures

Introduction. The inspectors identified a Yellow, apparent violation of Technical Specification 5.8.1.a, "Procedures," for failure to establish and maintain procedures that protect the intake structure and auxiliary building during external flood events. Specifically, stacking and draping sandbags on floodgates is not a sufficient configuration to protect the auxiliary building and intake structure to an external flood height of 1014 feet MSL as stated in station operating procedures and the USAR.

Description. The inspectors determined design basis flood elevations at the Fort Calhoun Station by reviewing USAR Chapter 2.7, "Hydrology," USAR Chapter 9.8, "Raw Water System," and Technical Specification 2.16, "River Level."

USAR Section 2.7.1.2 states, in part:

> "The design flood elevation of 1,006 feet based on a 0.1 percent probability flood is considered conservative. Without special provisions, the plant can accommodate flood levels of up to 1,007 [feet mean sea level]. Steel flood gates are permanently mounted above and adjacent to openings in structures containing equipment required for a safe and orderly plant shutdown. In the event of high water levels, these flood gates can be installed to provide protection to a level of 1,009.5 [feet mean sea level]. In the Intake Structure, protection to 1009.5 [feet] MSL is accomplished with flood gates and sandbagging. The plant can be protected by sandbags, temporary earth levees and other methods to allow a safe shutdown with a flood elevation of 1,013 [feet mean sea level]."

USAR Section 9.8.6 states, in part:

> "Protection for the raw water pumps and their drives against floods is provided at three elevations as indicated on Figure 9.8-1. The pumps are permanently protected against any water level up to elevation 1007.5 feet MSL by the Class I concrete substructure of the intake building. Protection is provided to elevation 1009.5 [feet MSL] by sandbags around the traveling screen areas and by gasketed steel closures at exterior doorway openings in the intake structure reinforced concrete perimeter walls. Protection to elevation 1014.5 feet [MSL] is provided by additional sandbags around the traveling screen areas, and by supplementing the intake structure perimeter walls with sandbags. The water level inside the intake cells can be controlled by positioning the exterior sluice gates to restrict the inflow into the cells."

Technical Specification 2.16, "Basis," dated November 1, 2007, states:

> "The maximum Missouri River level of 1009 feet MSL is the level at which the installed flood gates will protect the plant. Any increase in river level will require sand bagging to repel the water to a maximum flood level of 1014 feet [MSL] or greater."

When the licensee determines it is necessary to protect the plant at elevated flood levels, the licensee implements Section I of procedure AOP-1, "Acts of Nature." AOP-1 is a procedure required by Technical Specification 5.8.1.a and NRC Regulatory Guide 1.33, Appendix A, Section 6.w. AOP-1 directs the licensee to implement applicable sections of procedures PE-RR-AE-1001, "Floodgate Installation and Removal," and GM-RR-AE-1002, "Flood Control Preparedness for Sandbagging," when river levels reach specified heights of 1002, 1004, 1007, and 1009 feet MSL.

GM-RR-AE-1002, step 7.4 states:

> "The primary focus for flood protection should be directed to those facilities which are considered vital with respect to nuclear safety and credited with flood protection in the Individual Plant Examination of External Events Flooding evaluation, Reference 2.3. These facilities shall be protected at the sacrifice of the other facilities if site conditions warrant. The vital facilities are: Auxiliary Building, Intake Structure, and Turbine Building Basement."

Reference 2.3 of procedure GM-RR-AE-1002 is the Individual Plant Examination of External Events for Fort Calhoun Station, Section 5.2, "External Flooding," Table 5.2.3. This table credited flood protection by sandbagging up to 1010.8 ft MSL for the turbine building and up to 1013.5 feet MSL for the auxiliary building and intake structure. Table 5.2.3, "Impact of Periodic Flood due to Rain and Snow," comments that "severe core damage results if either intake or auxiliary building sandbagging fails." The turbine building, which does not contain safety related equipment necessary for safe shutdown, was assumed lost at floods greater than 1010.8 feet MSL.

Attachment 9.5 of procedure GM-RR-AE-1002 contains specific instructions that plant operators would use to protect from flood crest above 1009 feet mean sea level. The attachment notes that sandbags would be tied and draped over the top of floodgates to supplement the protection capability to the projected flood crest. Specifically, the attachment stated, "Place additional sandbags on top of the floodgates to raise the protection against the expected crest of the flood." Additionally, Attachment 9.8 of GM-RR-AE-1002 stated the intake structure and auxiliary building could be protected to 1014.5 feet MSL with floodgates and sandbags.

The inspectors requested a demonstration of flood protection for vital facilities against flood levels above the probable maximum flood level of 1009 feet MSL. As a result of this demonstration, the inspectors determined that the procedural guidance of GM-RR-AE-1002 was inadequate because stacking and draping sandbags at a height of five feet over the top of floodgates would be insufficient to protect the vital facilities to 1014 feet MSL, as described in the USAR and station procedures. The sandbagging activity would be insufficient because the ½-inch cross section on the top of the floodgates was too small to support a stacked sandbag configuration that would retain five feet of moving water. Therefore, the inspectors determined that a failure of the sandbags would cause potential damage to the auxiliary building, intake structure, and turbine building and their equipment at external flood levels above 1009.5 feet MSL.

The inspectors also identified plant personnel would need to take additional action to prevent flooding through the traveling screen discharge trench in the intake structure or the intake structure would be potentially lost at a flood level of 1008 feet MSL. Furthermore, the inspectors determined that any actions taken per AOP-1 could be difficult because of the risk to personnel safety when flood waters are within the protected area.

While reviewing the Fort Calhoun Station design basis, the inspectors discovered the licensee missed several opportunities to implement appropriate corrective actions when new external flood information was available. The failure to implement appropriate corrective actions directly contributed to the licensee's failure to identify inadequacies in their external flood procedures and strategy.

As documented in Condition Report 2002-1296, the licensee obtained external flood information from the Federal Emergency Management Administration and an Army Corps of Engineers letter to Omaha Public Power District (OPPD), dated January 14, 1993. The information estimated projected flood elevations to be three feet greater than the flood elevations described in the original USAR. The corrective actions were to evaluate the information to determine if the design basis and procedures would need to be updated. The licensee determined that the design basis would remain the same; however, a USAR change would reflect that an evaluation of the new information's impact on the design basis was completed. A USAR change was submitted to the NRC in January 2008, but no change to operating procedures was initiated.

During the evaluation associated with Condition Report 2002-1296, the licensee identified that more recent external flood information was available from the Army Corps of Engineers. In July 2003, the licensee identified that external flood frequencies and associated Missouri River levels evaluated in the 2003 draft version of Army Corps of Engineers report, "Upper Mississippi River System Flow Frequency Study (final version January 2004)," had increased since last evaluated the Army Corps of Engineers letter to OPPD, dated January 14, 1993. This condition was entered into the corrective action program as Condition Report 2003-2664.

The licensee's corrective action tasked the licensee's probabilistic risk assessment group to evaluate the new 2003 external flood data, update the existing external flood analysis, and develop a set of recommended strategies to mitigate high risk external flood scenarios. This external flood analysis was completed in August 2005. The licensee realized the new flood elevations were approximately three feet higher for each flooding frequency. Additionally, when the 2003 data was extrapolated to a 1000-year flood frequency, the licensee found the 1000-year flood elevation to be 1010.5 feet MSL.

Following this discovery, the licensee updated the external flood analysis in 2005; however, no corrective action was written to evaluate the potential change to the plants design basis or operating procedures. Consequently, the 2005 external flood analysis was not mentioned in the USAR change initiated in January 2008. Furthermore, the licensee did not develop a corrective action plan to ensure the design basis and regulatory compliance was maintained, as required by corrective action program.

Analysis. The inspectors determined the failure to establish and maintain adequate procedures to protect the auxiliary building and intake structure to external flood heights between 1008 and 1014 feet MSL is a performance deficiency. Specifically, the licensee failed to maintain procedures for combating a significant flood as recommended by NRC Regulatory Guide 1.33, Appendix A, Section 6.w, "Acts of Nature." This performance deficiency is more than minor because it adversely affected the Mitigating Systems Cornerstone attribute of external events and affected the cornerstone objective of ensuring the availability and reliability of systems that respond to initiating events to prevent undesirable consequences. The inspectors determined the finding resulted in the degradation of equipment and functions specifically designed to mitigate a flooding initiating event. In addition, an external flood event would degrade two or more trains of a multi-train safety system. Therefore, the finding was potentially risk significant to flood initiators and a Phase 3 analysis of the significance determination process was required.

A Region IV senior reactor analyst performed the Phase 3 significance determination. The preliminary change in core damage frequency was calculated to be 3.1E-5/year indicating that the finding was of substantial safety significance (Yellow). The risk important sequence included a station blackout, loss of all dc power, failure of the turbine-driven auxiliary feedwater pump, and failure of the diesel-driven auxiliary feedwater pump. Remaining mitigation equipment that helped to limit the significance included the licensee's temporary gasoline powered pump system that can provide makeup water to the steam generators.

The inspectors determined the finding has a crosscutting aspect in the area of problem identification and resolution, corrective action program, for failure to take appropriate corrective actions to address safety issues and adverse trends in a timely manner, commensurate with their safety significance and complexity. Specifically, from 2003 to 2008, the licensee failed to initiate appropriate corrective actions to ensure regulatory compliance of the external flood design basis was maintained. [P.1(d)]

Enforcement. Technical Specification 5.8.1.a, "Procedures," states, "Written procedures and administrative policies shall be established, implemented, and maintained covering the following activities: (a) The applicable procedures recommended in Regulatory Guide 1.33, Revision 2, Appendix A, 1978." From 1976 to 1978, Fort Calhoun Station established written procedures recommended by NRC Regulatory Guide 1.33, Appendix A, Revision 1. NRC Regulatory Guide 1.33, Appendix A, Section 6 recommends procedures for combating emergencies and other significant events. Section 6.w, "Acts of Nature" recommends procedures for combating tornado, dam failure, flood, and earthquakes. Contrary to Technical Specification 5.8.1.a and NRC Regulatory Guide 1.33, since 1976, the licensee failed to maintain written procedures for combating a significant flood as recommended by NRC Regulatory Guide 1.33, Appendix A, Section 6.w, "Acts of Nature." Specifically, the licensee failed to establish and maintain station procedures that adequately prescribe steps to mitigate external flooding conditions in the auxiliary building and intake structure between 1008 and 1014 feet mean sea level. The licensee has entered this condition into their corrective action program as Condition Report 2010-2387. Pending completion of a final significance determination, the performance deficiency will be considered an apparent violation, AV 05000285/2010007-01, "Failure to Maintain External Flood Procedures."

4OA6 Meetings

Exit Meeting Summary

On June 21, 2010, the inspectors presented the inspection results to Mr. J. Reinhart, and other members of the licensee staff. The licensee acknowledged the issues presented. The inspectors asked the licensee whether any materials examined during the inspection should be considered proprietary. No proprietary information was identified.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel

H. Faulhaber, Manager, Nuclear Engineering
M. Frans, Manager, System Engineering
J. Gasper, Manager, Design Engineering
D. Guinn, Supervisor, Regulatory Compliance
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D. Trausch, Assistant Plant Manager

NRC Personnel

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M. Markley, Chief, Plant Licensing Branch IV-1
J. Wingebach, Resident Inspector, Fort Calhoun Station
L. Wilkins, Project Manager, Plant Licensing Branch IV-1
W. Schaup, Project Engineer, Projects Branch E

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05000285/2010007-01	AV	Failure to Maintain External Flood Procedures (4OA5.1)

Closed

05000285/2009006-03	URI	Failure to Update Flood Protection of Safety Related Buildings

DOCUMENTS REVIEWED

Section 4OA5: Other Activities

PROCEDURES

NUMBER	TITLE	REVISION
AOP-1	Acts of Nature	23
AOP-30	Emergency Fill of Emergency Feedwater Storage Tank	9
EPIP-TSC-2	Emergency Plan Implementing Procedure: Catastrophic Flooding Preparations	7

PROCEDURES

NUMBER	TITLE	REVISION
FCSG-24	Corrective Action Program Guideline	22
GM-RR-AE-1002	Repair-Rework: Flood Control Preparedness for Sandbagging	8
OCAG-1	Operation Contingency Action Guideline	12
PE-RR-AE-1001	Floodgate Installation and Removal	3
TBD-AOP-18	Loss of Raw Water	7
TBD-AOP-19	Loss of Shutdown Cooling	14
TBD-AOP-38	Blair Water Main Trouble	3

CALCULATIONS

NUMBER	TITLE	DATE
CCF-103-048-RPT	External Flooding Analysis	August 12, 2005

CORRECTIVE ACTION DOCUMENT NAME

200201296 200302664 200904166 201000225 201002101
201002387

MISCELLANEOUS DOCUMENTS

TITLE	DATE
Fort Calhoun External Action Plan	April 8, 2010

PHASE 3 ANALYSIS

FAILURE TO PROTECT SAFE SHUTDOWN EQUIPMENT FROM EXTERNAL FLOODING

A senior reactor analyst conducted a Phase 3 significance determination process (SDP) analysis in accordance with Manual Chapter 0609, Appendix A, "Determining the Significance of Reactor Inspection Findings for At-Power Situations." This Phase 3 SDP represents a best-estimate risk evaluation of the performance deficiency.

1. **SDP Assumptions**

a. NRC Manual Chapter 0609, Appendix G, "Shutdown Operations Significance Determination Process," was not used for this SDP. The appendix stated, in part:

> "Appendix G is applicable during refueling outages, forced outages, and maintenance outages starting when the licensee has met the entry conditions for RHR [residual heat removal] and RHR cooling has been initiated, <u>and ending when the licensee is heating up and RHR has been secured.</u>" [Emphasis added]

Since the initiating event would occur after RHR was secured by procedure (to prevent a containment bypass pathway) and the reactor coolant system heated up to Mode 3 conditions, the at-power SDP was used for this case. Further, the finding would have required a quantitative assessment (Phase 3) irrespective of which significance determination procedure was used.

b. The analyst considered the increase in risk from flooding for the:

- Intake structure: 1008 to 1014 feet mean sea level (MSL). The intake structure housed raw water pumps (service water pumps).

- Auxiliary building: 1010 to 1014 feet MSL. The auxiliary building was the primary risk driver. Most of the equipment that was negatively impacted by the performance deficiency was located in the auxiliary building – emergency diesel generators, safety related switchgear, auxiliary feedwater pumps (basement), safety injection pumps, etc.

c. The performance deficiency did not impact flooding of the turbine building. The licensee did not protect the turbine building above 1009.5 feet MSL by procedure. The non-safety related diesel-driven auxiliary feedwater pump was located in the basement.

d. Dam failures were not a factor in the performance deficiency, but could flood the site to well above 1014 feet MSL. Flooding frequencies above 1014 feet MSL (Technical Specification Bases 2.16 specified elevation) were not considered.

e. The performance deficiency existed for many years. Therefore, in accordance with Manual Chapter 0609, Appendix A, Attachment 1, Usage Rule 1.1, "Exposure Time," the analyst determined that the exposure period was one year.

f. When the auxiliary building, turbine building and intake structure were assumed lost, the conditional core damage probability (CCDP) was 1.0. This was expected because all normal plant equipment was assumed failed by the floodwaters. This did not include credit for the portable gasoline powered pumps to refill the steam generators. A correction to account for gasoline-powered pump failure was addressed separately. Consequently, the SDP reduced to: (1) the flooding frequencies; (2) the gasoline powered pump system failure probability; and (3) comparison to the baseline risk assuming a 10 percent probability that the sandbagging protection failed.

g. A fault tree to estimate the failure probability for the gasoline-powered pumps was constructed and solved using the simplified plant analysis risk (SPAR) model. After flooding greater than 1010 feet MSL, the gasoline powered pumps would be the only equipment available to provide makeup water to the steam generators. The fault tree assumed:

- Both pumps must function for the action to be successful.

- Human error probabilities associated with installing the gasoline powered pump system were evaluated using NUREG/CR 6883, "The SPAR-H Human Reliability Analysis Method," August 2005 (Attachment 3). From this evaluation, the analyst inserted a human error probability basic event into the system fault tree. The SPAR-H worksheets were broken up into two sections, a "diagnosis" section and an "action" section. The diagnosis section evaluated the probability that operators would fail to diagnose the problem, such that mitigating actions would not be taken. The action section estimated the probability that operators (or craftsmen) would fail to successfully install and operate the system.

    - The analyst assumed that operators would properly diagnose the flood.

    - The "action" portion of the SPAR-H worksheet was much more difficult to perform and the probability of failure was over-riding (when compared to the diagnosis portion).

- The analyst used the licensee's estimates for gasoline pump failure probability.

- Other basic components that would have very low failure probabilities, such as manual isolation valves, were not included in the fault tree.

- The action to obtain sufficient fuel for long-term pump operation was not modeled. While the licensee had a procedural step that instructed personnel to obtain gasoline, no other specifics were provided. The pumps' gasoline consumption was not readily known and the exact methods that might be used to obtain gasoline were unclear. Gasoline was on-site, located in an above ground tank at the 1004-foot elevation; however, flooding may make the tank inaccessible (it could float away). Nonetheless, the analyst assumed that plant personnel could obtain sufficient gasoline without undue difficulty.

h. The licensee's Individual Plant Examination of External Events (page 5-23) contained the following assumptions. The second, third and fourth table columns specified the assumed failure probabilities for equipment located in the buildings:

Elevation (ft MSL)	Intake	Turbine bldg	Aux bldg
1007.5-1009.5	0	0	0
1009.5-1010.8	.01	.05	0
1010.8-1012.3	.1	Lost	.1
1012.3-1013.5	.9	Lost	.9

Notes:

i. The licensee had assumed a sandbagging failure probability of 0.9 for flood elevations between 1012.3 and 1013.5 feet MSL. The analyst considered this assumption unreasonable for use in a base case evaluation. A base case evaluation is an assessment of the baseline risk, assuming that no performance deficiency occurred. If the performance deficiency did not exist, the licensee should have had a high level of assurance that mitigating actions (sandbagging) would be successful. For the purpose of this analysis, the sandbagging base case failure probability was assumed to be 0.1 when flood waters were above 1010.8 feet MSL.

ii. A current case evaluation is a risk estimate that includes the performance deficiency. The current case evaluation assumed that the sandbagging failed at 1008 feet MSL at the intake structure and at 1010 feet MSL at the auxiliary building. The delta-core damage frequency (CDF) was the difference between the base case and current case risk evaluations.

2. Calculation of Increase in CDF

a. Equipment lost because of the performance deficiency: The analyst identified the risk important pieces of equipment and when they would fail. This was accomplished by reviewing site procedures and interviewing licensee personnel.

Elevation (feet MSL)	Performance Deficiency Impact
1007.5 – Intake Structure Floor	Some water leaks into intake structure. Sandbag berms within the building should limit the affect of short duration crests. The analyst assumed that significant flooding would occur at 1008 feet MSL.
1008 – Loss of offsite power (LOOP) and loss of intake structure due to flooding	Loss of all four raw water pumps. (The LOOP was unrelated to the performance deficiency).

Elevation (feet MSL)	Performance Deficiency Impact
1009.5 – Top of auxiliary building floodgates and turbine building sandbags. The diesel-driven auxiliary feedwater pump was located in turbine building basement. All other remaining equipment (other than the gasoline-powered pumps) was located in the auxiliary building (pumps in the basement).	Flooding starts in auxiliary building, turbine building and technical support center above 1009.5 feet MSL. The analyst assumed that small crests above 1009.5 feet MSL would not result in substantial flooding in the buildings.
1010 – 0.5 feet above floodgate	All remaining normal plant equipment lost because of the performance deficiency.
1011 – Level when procedures estimate that floodwaters spill into emergency diesel generator rooms (assuming drains are appropriately plugged). The building structure prevents water from entering at lower elevations. However, switchgear is already lost.	

b. Base case and current case CCDPs**:** The analyst calculated the base and current case CCDPs using the Fort Calhoun SPAR model, Revision 3.45, assuming a truncation limit of 1E-13. This portion of the analysis did not credit the gasoline-powered pumps, as the SPAR model did not include the pumps. The gasoline-powered pumps were factored into the final SDP by use of a separate fault tree (Attachment 6).

- Base case CCDP for each flood elevation: Assuming no performance deficiency and no credit for gasoline-powered pumps. Credit for the gasoline powered system was provided later in this SDP:

Elevation(ft MSL)	CCDP	Equipment Lost, Increased Probability
1008-1009.5	1.017E-3	Non-recoverable LOOP initiating event
1009.5-1010.8	1.046E-3	Non-recoverable LOOP initiating event Probability of raw water pump failure (.01), Probability of diesel driven auxiliary feedwater pump failure (.05)
1010.8-1014	1.1E-1	Non-recoverable LOOP initiating event; Probability of raw pump failure (0.1), Probability of diesel driven auxiliary feedwater pump failure (1.0), Probability of emergency diesel generator failure (0.1), Probability of auxiliary feedwater pump failure (0.1)

- Current case CCDP for performance deficiency elevations: No gasoline pumps were provided in this step. Increased failure rates because of the performance deficiency are in **bold:**

Elevation(ft MSL)	CCDP	Equipment Lost, Increased Probability
1008 – 1010	1.25E-3	Non-recoverable LOOP, Probability of diesel driven auxiliary feedwater pump failure (.05). **Probability of raw water pump failure (1.0)**
1010 -1014	1.0	Non-recoverable LOOP; Probability of diesel driven auxiliary feedwater pump failure (1.0), **Probability of 4kV switchgear failure (1.0), Probability of all auxiliary feedwater pumps failing (1.0)**

c. Calculation of Increase in CDF: To obtain consistent elevation bins for analysis, the above bins must be broken up further. The frequency for a given elevation bin (λ) was the difference in the frequency of exceedance between the upper and lower bin elevation limits.

$$\textbf{Delta CDF} = \sum \lambda_{bin} * (\text{CCDP current} - \text{CCDP base}) * P_{gas\ pump\ fail}$$

Elevation (ft MSL)	λ	CCDP current	CCDP base	$P_{gas\ pump\ fail}$	Delta CDF/bin	Time After 1004 ft MSL*
1008-1009.5	3.2E-3/yr	1.25E-3	1.017E-3	2.56E-2	1.9E-8/yr	30 hrs
1009.5-1010	4E-4/yr	1.25E-3	1.046E-3	2.56E-2	2.1E-9/yr	41.25 hrs
1010-1010.8	8E-4/yr	1.0	1.04E-3	2.56E-2	2E-5/yr	45 hrs
1010.8-1014	5E-4/yr	1.0	1.1E-1	2.56E-2	1.1E-5/yr	51 hrs to 75 hrs
Total					**3.1E-5/yr**	

* Based on licensee's flood level increase rate of 4ft/30 hours

3. Sensitivity Cases

a. Operator can prevent intake structure flooding until 1010 feet MSL. This would assume that an operator could successfully maintain intake structure level, using raw water pumps and sluice gates, to prevent water from flooding through the traveling screen discharge trench. This had little impact on the SDP results. The first two delta-CDF elevation bins capture this aspect of the assumed event. Setting both to zero would reduce the delta-CDF by about 2E-8/yr.

b. Flooding frequencies differ by significant amounts. The uncertainty with the flooding frequencies was high. The licensee used the shape of the flooding frequency curve at another station (Cooper Nuclear Station) and applied it to the Fort Calhoun Station flooding frequencies that were provided by the United States Army Corps of Engineers. The Army Corps of Engineers only provided information out to the 500-year flood (2E-3/year). The licensee extrapolated the remainder of the information. Almost all of the calculated risk was in the extrapolated region. To address this uncertainty, the analyst assumed that the Army Corps of Engineers data was correct but the extrapolated information could vary significantly, either higher or lower.

For the sensitivity cases, the analyst targeted the flooding elevation at the 1E-5/year point for comparison. At the 1E-5/year point on the Fort Calhoun flood hazard curve, the flood level was 1013.5 feet MSL. The analyst then constructed alternate curves, two above and two below this base curve. The curves are shown in Attachment 4. The curves were numbered Case 1 through Case 5. Case 3 was the licensee's estimate and was considered the best available information for this assessment.

Using data from the 5 curves, the analyst generated a delta-CDF for each case. The analyst summarized the results below:

Delta-CDF by Sensitivity Case

Case 1	Case 2	**Case 3***	Case 4	Case 5
4E-6/year	2.5E-5/year	3.1E-5/year	3.3E-5/year	3.5E-5/year

*Licensee assumptions

It's important to note that Case 1 may be unrealistically low. After almost 100,000 years of additional exposure, the flood elevation at the1 E-5/year point was a little over 1 foot above that predicted by the Army Corps of Engineers at the 1/500 year point. Likewise, Case 5 may be unrealistically high. The plotted line deviates from the Army Corps of Engineers' estimates at a sharper angle.

c. Alternate Method of Refilling Essential Feedwater Tank (SPAR-H 2, Attachment 3): The licensee proposed an alternate method for refilling the essential feedwater tank. The offsite fire water tank (at a higher elevation across the highway) could be used to refill the essential feedwater tank. The advantage of using this tank was that the reliance on the gasoline-powered pumps would be reduced. Instead of requiring that both gasoline powered pumps remain functional (one to fill the steam generators and one to refill the essential feedwater storage tank), the licensee could have one pump fail and still satisfy the steam generator makeup function.

The alternate fill method required operators to attach a fire hose between fittings that could be used to connect the two tanks. It also required that the licensee have water trucks periodically refill the firewater tank. The procedure that drove these actions was normally performed following a loss of the Blair water supply. The procedural steps to use the firewater tank to refill the essential feedwater storage tank would be implemented after other sources of water became unavailable (it was the last option on the list). The floodwater was expected to eliminate the following water sources, as specified: (1) demineralized water system (1008 feet MSL); (2) condensate storage tank (1008 feet MSL); (3) Blair water (1007 feet MSL); (4) the diesel-driven auxiliary feedwater pump (1009.5 MSL); and (5) the on-site plant fire water system (1008 feet MSL). Therefore, operators would not likely initiate these actions until the 1009.5-foot elevation. At this flood level, two of the components that would require connection (with a fire hose) would be under water.

To evaluate the scenario, the analyst adjusted the gasoline power pumps system fault tree so that a failure of both fire pumps would be needed to fail the system (not just one pump). The analyst added a new basic event to account for the human error probability for the new manual actions. The analyst also made other adjustments to model use of the firewater tank. The adjusted fault tree is shown in Attachment 6, second fault tree.

As shown in the SPAR-H worksheet (Attachment 3, SPAR-H-2) the assumptions for the new human error probability included nominal available time, high stress (fittings hard to find and work under water), moderate complexity, low experience (connecting fittings under water), nominal procedures, missing/misleading ergonomics (location of fittings under water), nominal fitness for duty, and nominal work processes. Instead of a failure probability of 2.56E-2 for the failure of the gas pump system, a failure probability of 1.3E-2 was generated. This would reduce the overall delta-CDF by a factor of two. The resultant delta-CDF was 1.5E-5/year. However, since the challenge of locating and manipulating components under water invoked large uncertainties, this action was not credited in the SDP.

d. Use of Tabletop Generated, Non-Procedural Actions: The licensee asked the NRC to credit non-proceduralized actions that were identified during a tabletop exercise (installing metal plates over auxiliary building doorways). The licensee's probabilistic risk assessment team had not credited this action in an analysis themselves.

In response to the finding, the licensee conducted a tabletop exercise to determine what actions might be specified by the technical support center during a simulated flood. The tabletop team determined that metal plates could be installed over auxiliary building doors (on the water side). They specified that thick metal plates would be needed (3/4" to 1" thick), that craftsmen would weld supporting structures to the plates and that the plates would be secured, but not welded, to the outside of the doorways. The analyst noted that it was unclear if the actions would work, and they could cause failure of existing flood barriers before 1009.5 feet MSL (the leak tight floodgates and sandbag berms would have to be removed). The NRC's "Risk Assessment of Operational Events Handbook," Revision 1.03, Section 6.3.2 stated, in part:

> In general, no recovery or repair actions should be credited where… there is no procedure or training. It may be possible to justify exceptions in unique situations, such as a procedure is not needed because the recovery is skill of the craft…

Still, the analyst used the SPAR-H method to evaluate the action. The SPAR-H worksheet (see Attachment 3, SPAR-H-3) documented that the failure probability was very close to 1.0. To implement the proposed actions, craftsmen would need to construct and erect about 10 covers for doors, including some double doors and at least one rollup door. The licensee did not have an adequate supply of the thick plates on site to cover all of the doors. However, an abundant supply of thinner plates, some 3/8-inch thick and other rough deck plate material, were available. The yard that housed the plates was outdoors and the ground was covered with gravel, not asphalt (1005 feet MSL). The technical support center was not manned until floodwaters were near the yard elevation (1004 feet MSL); therefore, floodwaters may already be in the yard before meaningful recommendations could be made. If floodwaters entered the yard, getting the plates to a location to support cutting and welding may be difficult.

There were experienced welders onsite, but only three welding machines were available that could be operated on the three available portable electric generators. A loss of offsite power was expected at 1008 feet MSL. Cutting the plates to size would require a cutting machine that may not be available after a loss of offsite power.

No method was specified for installing the plates, but the team determined it was necessary to install them on the water side of the doors (to let the water pressure help keep them in place). To do this, at least some floodgates would likely need to be removed. The tabletop team specified that they would not weld the plates to the doorways. The current floodgates had rubber seals (some inflatable) to help prevent in-leakage, while the new plates would not have this feature. This would introduce a new failure mechanism not previously considered (substantial leakage past a plate at an elevation below 1009.5 feet MSL).

Flood projections often change and are rarely accurate. If the flood projections started out below 1009.5 feet MSL and then increased, floodwaters may be upon the floodgates (and sandbag berms) already, making removing them unmanageable. The bottoms of some auxiliary building floodgates sat at approximately 1007 feet MSL. Large sandbag berms would need to be removed from several doors.

<u>Alternate Evaluation</u>: The analyst also performed an alternate evaluation (Attachment 3, SPAR-H-3, Method 2), assuming that the licensee could be successful installing plates over auxiliary building doors 50 percent of the time. Assuming this chance of success, however, the delta-CDF would be reduced by a factor of two. No formal credit was provided in the SDP.

4. **<u>Large Early Release Frequency (LERF)</u>:**

Nominally, for large dry containments, the delta-LERF was less than 0.1 times the delta-CDF. However, the loss of all control room indications would make it more difficult to obtain the information needed to insure a timely public evacuation. The NRC processes to evaluate delta-LERF were not well suited for this finding. The analyst consulted with a LERF expert in the Office of Nuclear Reactor Regulation. The expert indicated that because of the large dry containment, and the relatively large pressure failure rating of containment, that a large amount of time would be available to evacuate the public. The analyst then spoke with regional emergency preparedness experts and found that the licensee had alternate means to identify core damage (radiation levels outside of containment). Further, the analyst reviewed Fort Calhoun Emergency Classification levels and noted that a general area emergency would be declared if - "conditions exist which in the judgment of the command and control position warrant declaration of a General Emergency." In conclusion, the analyst qualitatively determined that the color of the delta-LERF would not exceed that associated with the estimated delta-CDF.

SPAR-H WORKSHEETS

1. **SPAR-H-1**

Refill Steam Generators Using Gasoline Pumps (Only)				
Performance Shaping Factor	Diagnosis		Action	
	PSF Level	Multiplier	PSF Level	Multiplier
Time	Expansive	0.01	>5 times required	0.1
Stress	Nominal	1.0	High	2.0
Complexity	Nominal	1.0	Moderate	2.0
Experience	Nominal	1.0	Nominal	1.0
Procedures	Nominal	1.0	Nominal	1.0
Ergonomics	Nominal	1.0	Poor	10.0
Fitness for Duty	Nominal	1.0	Nominal	1.0
Work Processes	Nominal	1.0	Nominal	1.0
	Nominal Base	1.0E-2		
	PSFs	1.0E-2		4.0
	Total	1.0E-4		4E-3
Failure Probability				**4E-3**

Justifications for Action (over-riding), only items that departed from nominal:

Time: *Greater than 5 times necessary*. The river was expected to rise at a rate of four feet in 30 hours. The licensee would expect an approximate two-day notice of a river crest at 1009 feet MSL or higher, assuming that the licensee started taking actions at 1000 feet MSL and received early warning of the coming flood. The analyst assumed that the turbine building would be flooded at approximately 1009.5 feet MSL. Plant personnel should start installing the gasoline powered pump system when the Army Corps of Engineers projects flooding at or above 1009 feet MSL. The procedure for installing the system was detailed, all of the equipment was staged, and plant personnel should be able to assemble the equipment in less than one shift without much difficulty. Testing of one pump could only be accomplished after the floodwaters enter the turbine building. While this would occur after the loss of offsite power, the operators should have substantial time before the essential feedwater storage tank emptied.

Stress: *High*. Once installed, operation of the gasoline pump system would rely on alternate methods of measuring steam generator water level. Operators could either use a portable instrument to determine steam generator water level or overfill the steam generators and wait a given amount of time before the next filling evolution. The turbine building would be dark and uncomfortable.

The essential feedwater storage tank would need to be refilled as well. The pump to refill this tank must be located close to the floodwaters. When floodwaters increase, the pump would need to be moved to a higher elevation. Failure to do so could cause the gasoline engine to fail. The reliance on this temporary system to prevent core damage, with minimal indications of reactor coolant system or containment conditions, would contribute to the stress level.

Complexity: *Moderately complex*. Craftsmen would need to remove piping flanges and install new components that were manufactured to fit into the piping locations, which may be difficult. Some of the pieces were heavy. At approximately 1008 feet MSL, the plant would experience a loss of offsite power and the turbine building would lose artificial lighting and normal electrical power. While the system could be installed into position earlier, the system would need to be filled and tested to ensure that the pumps were not vapor-locked. The pump that was to refill the essential feedwater storage tank would take suction from the floodwaters, which would not enter the turbine building prior to the loss of offsite power. Operators would need to ensure that the pump was sufficiently close to the water level to allow for proper suction and filling.

Ergonomics: *Poor*. The analyst determined that the ergonomics for implementing Procedure PE-RR-AE-1002, "Installation of Portable Steam Generator Makeup Pumps," Revision 2, were "Poor." For system startup and subsequent operation, operators and maintenance personnel would be working under emergency lighting conditions or possibly in the dark. Workers would complete their tasks around and in flood waters. Operations would involve routine handling of gasoline. No procedural steps were provided to instruct the operators how to obtain or where to store the gasoline, so these actions would need to be developed. Operators would periodically need to tend the system to start and stop it, depending on the level in the steam generators. No steam generator indication was available at the location. Steam generator level indication was available at another location using a portable instrument.

2. SPAR-H-2

Connecting Fire Hose Between Firewater Tank and Essential Feedwater Tank				
Performance Shaping Factor	**Diagnosis**		**Action**	
	PSF Level	**Multiplier**	**PSF Level**	**Multiplier**
Time	Nominal	1.0	Nominal	1.0
Stress	Nominal	1.0	High	2.0
Complexity	Nominal	1.0	Moderate	2.0
Experience	Nominal	1.0	Low	3.0
Procedures	Nominal	1.0	Nominal	1.0
Ergonomics	Nominal	1.0	Missing/Misleading	50.0
Fitness for Duty	Nominal	1.0	Nominal	1.0
Work Processes	Nominal	1.0	Nominal	1.0
	Nominal Base	1.0E-2		1.0E-3
	PSFs	1.0		600
	Total	1.0E-2		3.7E-1
Failure Probability				**3.7E-1**

Justifications for Action (over-riding), only items that departed from nominal:

Stress: *High*. This action was expected to occur after floodwaters had entered portions of the site. The procedure that drove the action was used after other water sources were depleted, after floodwaters reached 1009.5 feet MSL. The floodwater was expected to fail the demineralized water system at 1008 feet MSL, condensate storage tank at 1008 feet MSL, the Blair water system at 1007 feet MSL, the diesel-driven auxiliary feedwater pump at 1009.5 feet MSL, and the plant fire water system at 1008 feet MSL. The action would align an outbuilding fire water tank up to the essential feedwater storage tank via a fire hose and a connection point on each system. Both connection points would likely be submerged and could be difficult to locate. Concerns about personal safety would also contribute to the stress level.

Complexity: *Moderately complex*. Under normal plant conditions, the action would not be complex. Having floodwaters cover needed connection points makes the task much more difficult.

Experience: *Low*. This action was not normally performed by plant personnel on a routine basis. The action of finding connection points below the water level and then connecting the fire hoses was not practiced. Even very experienced craftsmen may have difficulty accomplishing this task.

Ergonomics: *Missing/Misleading*. Needed information, labeling and location of the valves and connections, would be difficult to obtain for components under water.

3. **SPAR-H-3**

Construct and Install Steel Plates to Cover Auxiliary Building Doors				
Performance Shaping Factor	**Diagnosis**		**Action**	
	PSF Level	**Multiplier**	**PSF Level**	**Multiplier**
Time	Not evaluated		T= time required (actually may not have sufficient time)	10
Stress	Not evaluated		High	2.0
Complexity	Not evaluated		High	2.0
Experience	Not evaluated		Low	3.0
Procedures	Not evaluated		Not Available	50.0
Ergonomics	Not evaluated		Missing/Misleading	50.0
Fitness for Duty	Not evaluated		Nominal	1.0
Work Processes	Not evaluated		Nominal	1.0
	Nominal Base	1.0E-2		1.0E-3
	PSFs			300,000
	Total			.99
Failure Probability				**9.9E-1**

Justifications for Action (over-riding), only items that departed from nominal:

Time: *Equals time required.* This action was determined by a tabletop exercise after the issue was identified. The licensee wanted to demonstrate that the emergency response organization could develop an acceptable method to protect safe shutdown equipment under extreme flooding conditions. The analyst interviewed the tabletop team members. The members had varying levels of knowledge regarding NRC identified flooding concerns; most knew about a flooding seal issue (not part of this performance deficiency). A few were aware that the NRC had concerns with the plant's ability to cope with more significant floods. The exercise lasted about 90 minutes.

During the initial portions of the exercise, flooding projections were within those addressed by plant procedures. No additional actions were developed by the team during this phase. Then the scenario changed such that the projected flooding level was 1017 feet MSL. This was outside of the existing procedural guidance for a flood (other than the action to stack sandbags on top of the floodgates). The team determined that stacking sandbags on top of the floodgates would not work because the narrow ledge of the floodgates did not allow construction of a leak tight barrier to 1017 feet MSL. The team identified the following additional mitigation strategy:

> Fabricate and install steel plates in front of all of the auxiliary building doors.

The team specified that they would not weld the plates over the door openings but would fasten the plates in place. They were not confident that the doorframes would support welding. The team would have plant personnel weld supporting structures to the plates themselves for stability. The plates would be cut to size for all of the auxiliary building doorways and some plates would be welded together to cover rollup doors. They believed that they needed ¾-inch to 1-inch thick steel plate for the task. They did not take the simulation further.

Analyst Assessment: These actions were modeled using SPAR-H and the calculated failure probability was close to 1.0. However, no credit was provided in the SDP because it was not clear that the actions would work and the NRC's "Risk Assessment of Operational Events Handbook," Revision 1.03, Section 6.3.2 stated, in part:

> In general, no recovery or repair actions should be credited where… there is no procedure or training. It may be possible to justify exceptions in unique situations, such as a procedure is not needed because the recovery is skill of the craft…

In addition, a different group of individuals in the technical support center at the time of an actual flood might specify different recommendations.

Craftsmen would need to construct and erect about 10 covers for doors, including some double doors and at least one rollup door. The licensee did not have an adequate supply of the thick plates on site to cover all of the doors. However, an abundant supply of thinner plates, some 3/8 inch thick and other rough deck plate material, were available. The yard that housed the plates was outdoors and the ground was covered with gravel, not asphalt (1005 feet MSL). The technical support center was not manned until floodwaters were near the yard elevation (1004 feet MSL); therefore, floodwaters could be in the yard before meaningful recommendations could be made. If floodwaters entered the yard, getting the plates to a location to support cutting and welding may be difficult.

Experienced welders were onsite, but only three welding machines were available that could be operated on the three available portable electric generators. A loss of offsite power was expected at 1008 feet MSL; cutting the plates to size would require a cutting machine that would not likely be available after a loss of offsite power.

No method was specified for installing the plates, but the tabletop team determined it was necessary to install them on the water side of the doors, to utilize the water pressure to keep them in place. To do this, some floodgates would likely need to be removed. The floodgates had rubber seals, some inflatable, to help prevent in-leakage. The new plates would not have this feature. This could introduce a new failure mechanism not previously considered (substantial leakage past a plate at an elevation below 1009.5 feet MSL).

Flood projections often change and are rarely accurate. If the flood projections started out below 1009.5 feet MSL and then increased, floodwaters may be upon the floodgates and sandbag berms, making removal of floodgates and berms unmanageable. The bottoms of some auxiliary building floodgates sat at approximately 1007 feet MSL. Large sandbag berms would need to be removed from several doors.

The analyst had asked the licensee to demonstrate the site's capability to erect and install a steel panel over a representative door, preferably the rollup door. However, at the time the significance determination was issued, the licensee had not performed a demonstration. Based on the above, the analyst determined that the time required for the action was the same as that available.

<u>Stress</u>: *High*. The stress encountered by the workforce would be high. The welders and other craftsmen would not likely know that core damage could be imminent if they did not succeed. Nonetheless, the time pressure on the staff would be significant. In addition, struggling to complete the task with floodwaters already on site and with limited resources would add to the pressure.

<u>Complexity</u>: *High*. With no procedural guidance, the craftsmen would have to devise strategies on their own to fabricate and install the plates. Interference with floodgates and sandbag berms would also create obstacles.

<u>Experience</u>: *Low*. No personnel on site would have sufficient experience with this task. Welders would be experienced at welding, but the overall task was much more complex.

<u>Procedures</u>: *Not available*. No procedures were available.

<u>Ergonomics</u>: *Missing/Misleading*. Craftsmen would likely have to install the new plates over the doorways while the site was at least partially flooded. At night, it would be dark, if offsite power was lost, and floodwaters would present a hazardous condition. Obtaining the construction materials under flooded conditions could be difficult and large heavy machinery may not work in the steel plate storage area.

4. **Method 2**

Alternate Evaluation: This method was not part of the NRC's normal processes for evaluating the success of operator actions. The analyst assumed that the licensee could protect the auxiliary building from floods between 1009.5 and 1014 feet MSL by the alternate means described above 50 percent of the time. This assumption would reduce the delta-CDF associated with the performance deficiency by a factor of 2.0. Since this method was outside the NRC processes, no formal credit was provided in the SDP.

FLOODING FREQUENCY SENSITIVITY

1. **Flooding frequencies differ by significant amounts.**

The uncertainty with the flooding frequencies was high. The licensee used the shape of the flooding frequency curve at another station (Cooper Nuclear Station) and applied it to the Fort Calhoun Station flooding frequencies that were provided by the United States Army Corps of Engineers. The Army Corps of Engineers only provided information out to the 500-year flood (2E-3/year). The licensee extrapolated the remainder of the information. Almost all of the calculated risk was in the extrapolated region. To address this uncertainty, the analyst assumed that the Army Corps of Engineers data was correct but the extrapolated information could vary significantly, either higher or lower.

For the sensitivity cases, the analyst targeted the flooding elevation at the 1E-5/year point for comparison. At the 1E-5/year point on the Fort Calhoun flood hazard curve, the flood level was 1013.5 feet MSL. The analyst then constructed alternate curves, two above and two below this base curve. The Curves are shown on the following page. The curves were numbered Case 1 through Case 5. Case 3 was the licensee's estimate and was considered the best available information for this assessment.

Using data from the 5 curves, the analyst generated a delta-CDF for each case. The analyst summarized the results below:

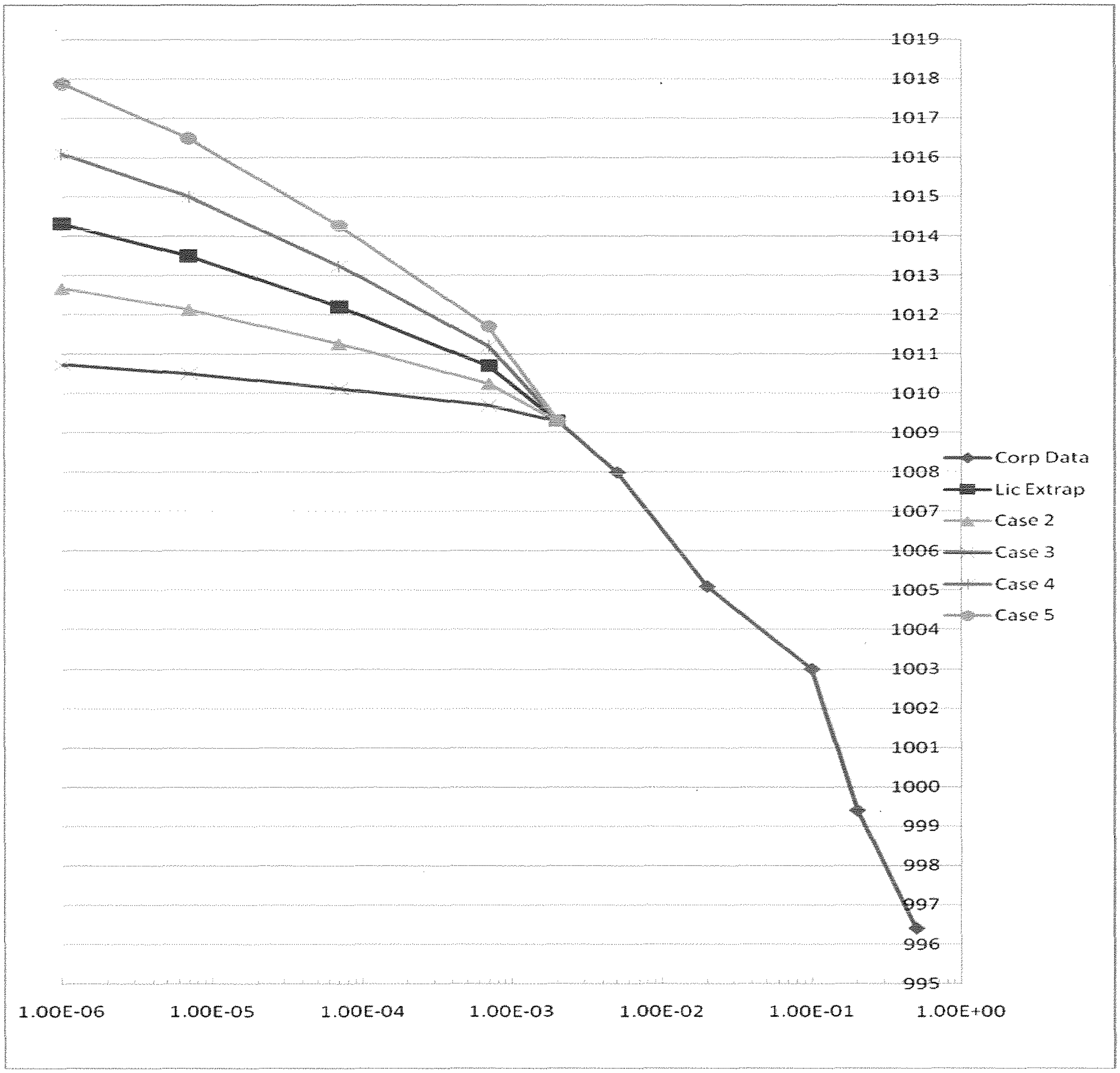
Delta-CDF by Sensitivity Case

Case 1	Case 2	**Case 3***	Case 4	Case 5
4E-6/year	2.5E-5/year	3.1E-5/year	3.3E-5/year	3.5E-5/year

*Licensee assumptions

It's important to note that Case 1 may be unrealistically low. After almost 100,000 years of additional exposure, the flood elevation at the1 E-5/year point was a little over 1 foot above that predicted by the Army Corps of Engineers at the 1/500 year point. Likewise, Case 5 may be unrealistically high. The plotted line deviated from the Army Corps of Engineers' estimates at a sharper angle.

Frequency Extrapolations – Height versus Logarithm of Flood Frequency Excedance



Case 3 was the best estimate case specified by the licensee.

Cases 1 and 2 were sensitivity cases that assumed that the licensee's best estimate was overly conservative.

Cases 4 and 5 were sensitivity cases that assumed that the licensee's best estimate was non-conservative.

SIGNIFICANCE DETERMINATION PROCESS COMBINATIONS

Target Case (Best Estimate)

Licensee's extrapolated flood frequencies
No credit for alternate essential feedwater tank filling method (components under water)
No credit for placing panels over doors (in accordance with SPAR-H)
Credit for gasoline powered pump system (without alternate filling method)

Delta-CDF = 3.1E-5 – Yellow

Best Case Assumptions

Best Case: flood frequency
Best Case: alternate essential feedwater tank fill (Attachment 3, SPAR H)
Best Case: alternate actions to place panels over doors (Failure probability = 50 percent, Not Using SPAR-H)

Delta-CDF = 4E-6 * 0.5 * 0.5 = 1E-6 - White

Worst Case Assumptions

Worst Case Flood Frequency
No Credit for alternate essential feedwater tank filling method
No Credit for placing alternate panels over doors
Credit for gasoline powered pump system (without alternate filling method)

Delta-CDF = 3.5E-5 – Yellow

Target Case + 50 percent Credit for Placing Panels on Doors

Delta-CDF = 1.5E-5 – Yellow

Target Case + Credit for Alternate Essential Feedwater Tank Fill

Licensee's extrapolated flood frequency
Credit for alternate feedwater tank filling procedure
No credit for placing panels over doors

Delta-CDF = 1.5E-5 – Yellow

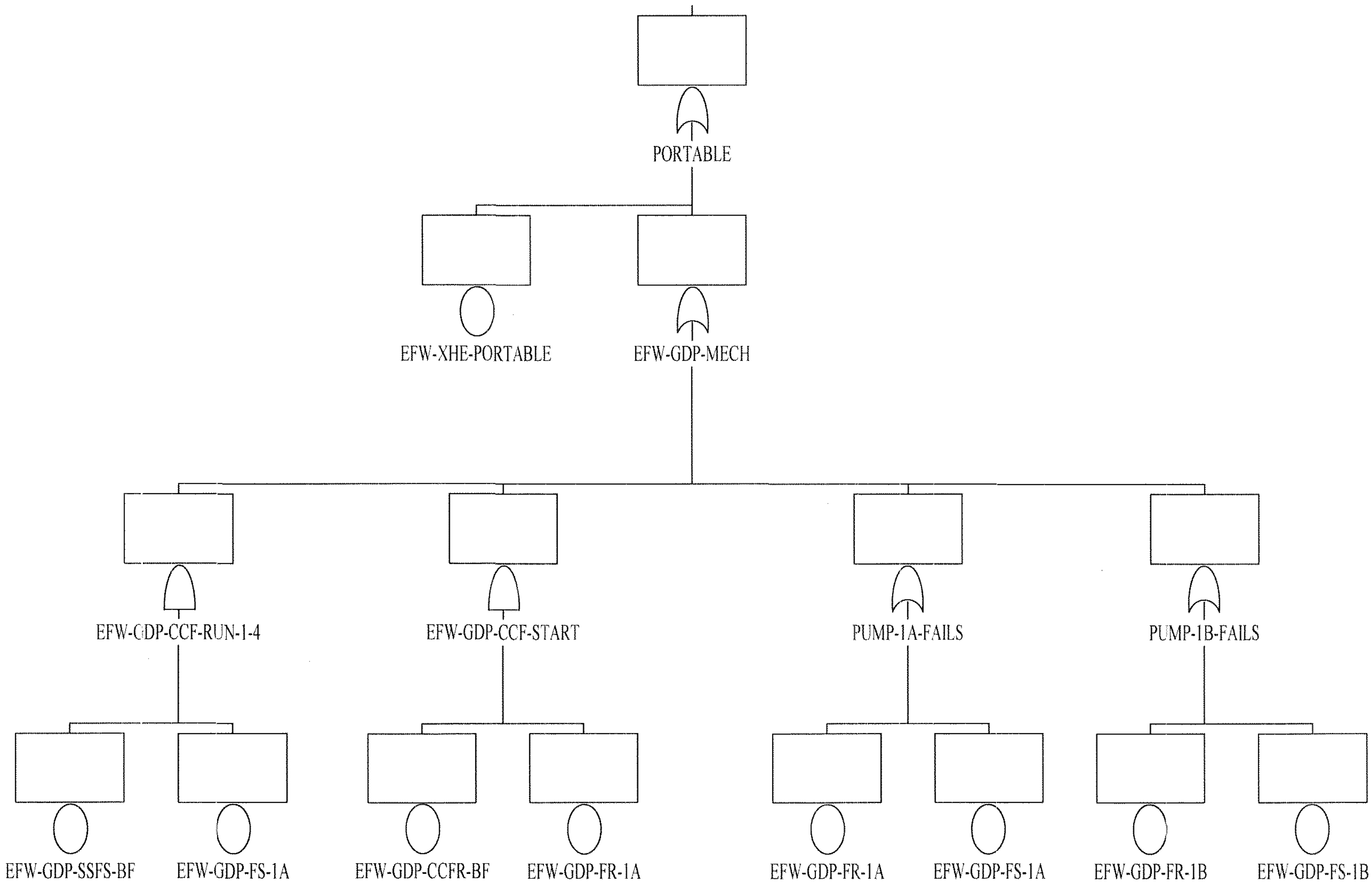
Target Case + Credit for Alternate Essential Feedwater Tank Fill + 50 percent Credit for Placing Panels on Doors

Licensee's extrapolated flood frequency
Credit for alternate feedwater tank filling procedure
50 percent credit for placing panels over doors

Delta-CDF = 7.5E-6 – White

ADDITIONAL FAULT TREES

Fault Tree 1
Gasoline Powered Pump System



Fault Tree 2
Gasoline Powered Pump System
with Essential Feedwater Storage Tank Refill from Firewater Tank