ENCLOSURE 3

Browns Ferry Nuclear
Units 1, 2 and 3
Licensee Event Report 50-259/2013-001-00

NRC FORM 366 (10-2010) U.S. NUCLEAR REGULATORY COMMISSION

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LICENSEE EVENT REPORT (LER)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Browns Ferry Nuclear Plant (BFN), Unit 1	05000259	1 of 8

4. TITLE: Latent Design Input Inconsistencies Adversely Affect Probable Maximum Flood Analysis

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
02	06	2013	2013	- 001 -	00	04	08	2013	BFN, Unit 2	05000260
									FACILITY NAME	DOCKET NUMBER
									BFN, Unit 3	05000296

9. OPERATING MODE

1

10. POWER LEVEL

100

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: *(Check all that apply)*

☐ 20.2201(b)	☐ 20.2203(a)(3)(i)	☐ 50.73(a)(2)(i)(C)	☐ 50.73(a)(2)(vii)
☐ 20.2201(d)	☐ 20.2203(a)(3)(ii)	☐ 50.73(a)(2)(ii)(A)	☐ 50.73(a)(2)(viii)(A)
☐ 20.2203(a)(1)	☐ 20.2203(a)(4)	☒ 50.73(a)(2)(ii)(B)	☐ 50.73(a)(2)(viii)(B)
☐ 20.2203(a)(2)(i)	☐ 50.36(c)(1)(i)(A)	☐ 50.73(a)(2)(iii)	☐ 50.73(a)(2)(ix)(A)
☐ 20.2203(a)(2)(ii)	☐ 50.36(c)(1)(ii)(A)	☐ 50.73(a)(2)(iv)(A)	☐ 50.73(a)(2)(x)
☐ 20.2203(a)(2)(iii)	☐ 50.36(c)(2)	☐ 50.73(a)(2)(v)(A)	☐ 73.71(a)(4)
☐ 20.2203(a)(2)(iv)	☐ 50.46(a)(3)(ii)	☐ 50.73(a)(2)(v)(B)	☐ 73.71(a)(5)
☐ 20.2203(a)(2)(v)	☐ 50.73(a)(2)(i)(A)	☐ 50.73(a)(2)(v)(C)	☐ OTHER
☐ 20.2203(a)(2)(vi)	☐ 50.73(a)(2)(i)(B)	☐ 50.73(a)(2)(v)(D)	Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER *(Include Area Code)*
Christopher Bennett, Licensing Engineer	256-729-2475

13. COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX

14. SUPPLEMENTAL REPORT EXPECTED

☒ YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* ☐ NO

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR
06	12	2013

ABSTRACT *(Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines)*

On July 28, 2009, the Tennessee Valley Authority (TVA) identified latent design input inconsistencies in hydrological computer modeling used for probable maximum flood (PMF) calculations.

The root causes of the condition were an organizational behavior which allowed the latent input inconsistencies to go undetected and management failure to provide oversight of the impact of river system changes on the calculated value of the PMF. The corrective actions to prevent recurrence are to procedurally require a Flood Protection Program, develop formal Flood Protection Program Management Implementing Procedure(s) and Design Standards/Guides, create a formal documented risk management process for all engineering products, formalize the elements of engineering technical rigor, and implement an upper tier integrated risk management process.

Upon discovery, TVA implemented both immediate and interim corrective actions to ensure the Fort Loudoun, Cherokee, Tellico and Watts Bar dams would not overtop during an assumed PMF event.

The TVA is currently performing an analysis to determine the safety significance of this condition at the Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3. Until the analysis is complete, TVA is reporting this condition as an unanalyzed condition that significantly degraded plant safety. The TVA will submit a supplement to the LER upon completion of the analysis.

FACILITY NAME (1)	DOCKET (2)	LER NUMBER (6)			PAGE (3)
		YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	
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NARRATIVE

I. Plant Operating Condition(s) Before the Event

At the time of discovery, the Browns Ferry Nuclear Plant (BFN), Units 1, 2, and 3, were in Mode 1 at approximately 100 percent rated thermal power.

II. Description of the Event(s)

A. Event

On July 28, 2009, Tennessee Valley Authority (TVA) identified latent computer modeling inconsistencies that adversely affected probable maximum flood (PMF) analyses. Specifically, TVA identified the potential to overtop and fail earthen embankments at Cherokee, Fort Loudon, Tellico and Watts Bar Dams. The potential to overtop and fail earthen embankments was identified based on an ongoing effort at that time to update, revalidate and verify the design basis flooding calculations for TVA nuclear plants.

The updating of the affected calculations included (1) unit hydrograph changes, (2) software code errors, (3) dam rating curve changes, (4) median reservoir level changes, (5) flood operation changes, (6) Dallas Bay omission (impacting BFN only), (7) and overflow areas at Watts Bar Dam. The overtopping and failure of the specified earthen embankments could have resulted in an increase in the PMF level at WBN, Sequoyah Nuclear Plant (SQN) and BFN and had the potential to affect systems required for safe shutdown. At the time, this condition represented an unanalyzed condition at all three sites. Subsequent analysis determined that the calculated increase in flood level at WBN from a PMF event in which the specified earthen embankments were overtopped and failed rendered existing flood mode procedures ineffective. This exposure existed for some period of time prior to the identification of the unanalyzed condition in 2009.

There have been subsequent studies for past operability that have shown that the PMF level for BFN remains below the licensing and design basis PMF level of 572.5 feet above sea level. However, those studies were for past operability and did not use inputs and assumptions in line with the licensing basis. TVA is currently performing analysis to determine the safety significance of this condition. Until the analysis is complete, TVA is reporting this condition as an unanalyzed condition that significantly degraded plant safety for BFN, Units 1, 2 and 3. TVA will submit a supplement to the LER upon completion of the analysis.

Upon discovery, TVA implemented interim and immediate corrective actions to ensure the Fort Loudoun, Cherokee, Tellico and Watts Bar dams would not overtop during an assumed PMF event.

B. Status of Structures, Components, or Systems that were Inoperable at the Start of the Event and that Contributed to the Event

There were no inoperable structures, components, or systems that contributed to the event.

C. Dates and Approximate Times of Occurrences

Date	Description
1960~1970s	TVA develops hydrology modeling software (Simulated Open Channel Hydraulics (SOCH)).
1982	TVA begins dam safety program consistent with Federal Guidelines for Dam Safety.
1985	TVA's Engineering Laboratory issues the spillway coefficient report, "Method for Estimating Discharge at Overflow Spillways with Curved Crests and Radial Gates." TVA estimates orifice discharges using a single curve in the U.S. Army Corps of Engineers' Hydraulic Design Criteria (HDC).
1998	TVA reassesses effects of dam safety modifications on PMF using SOCH.
2003	TVA Water Management initiates River Operations Study (ROS) Environmental Impact Statement (EIS) to evaluate impacts of potential changes to operation of the TVA reservoir system.
October 30, 2007	TVA submits the Bellefonte Nuclear Plant (BLN) Units 3 and 4 Combined License Application (COLA). The 1998 flood reassessment calculation is used as the basis for Final Safety Analysis Report section 2.4.
March 19, 2008	NRC issues Notice of Violation for failure to implement the quality assurance program for the SOCH modeling.
March 2008 to September 2012	During verification and validation of SOCH inputs and codes, latent inconsistencies and necessary changes in PMF calculations are identified. The cumulative effects of these inconsistencies and changes predict potential dam overtopping at Fort Loudoun, Cherokee, Watts Bar and Tellico dams during a PMF.
July 28, 2009	TVA determines that based on certain PMF modeling concerns the Fort Loudoun Dam could be overtopped and fail and the resulting PMF levels could exceed the original design and licensing basis elevations.

NARRATIVE

August 14, 2009	TVA determines that based on certain PMF modeling concerns the Fort Loudoun Dam could be overtopped and fail and the resulting PMF levels could exceed the original design and licensing basis elevations.
September 24, 2009	TVA determines that if the Cherokee Dam were to overtop and fail, the PMF levels could exceed the original design and licensing basis elevations.
December 30, 2009	HESCO modular flood barrier installation at affected dams to raise earthen embankments.
February 6, 2013	TVA notified the NRC that due to the potential to overtop and fail earthen embankments at four dams, BFN was in an unanalyzed condition that could have resulted in an increased PMF level.

D. Manufacturer and Model Number (or other identification) of Each Component that Failed During the Event

There were no failed components associated with this condition.

E. Other Systems or Secondary Functions Affected

There were no other systems or secondary functions affected by this condition.

F. Method of Discovery of Each Component or System Failure or Procedural Error

On July 28, 2009, as part of an ongoing validation of SOCH model and sub-codes, TVA concluded that the spillway discharge coefficient previously used in the Fort Loudoun Dam Rating Curve was inconsistent with more recent model test data. Additional research revealed that the same was true for Cherokee, Tellico and Watts Bar dams.

G. The Failure Mode, Mechanism, and Effect of Each Failed Component

There were no failed components.

H. Operator Actions

There were no operator actions.

I. Automatically and Manually Initiated Safety System Responses

There were no safety system responses.

III. Cause of the event

A. The cause of each component or system failure or personnel error, if known:

There were no component or system failures or personnel errors associated with this event.

NARRATIVE

B. The cause(s) and circumstances for each human performance related root cause:

TVA identified two root causes for this condition, each having human performance related aspects.

1. An organizational behavior, rooted in over-confidence that TVA was the industry hydrology expert, resulted in the input errors (latent computer modeling inconsistencies) during the development of the SOCH model going undetected.
2. TVA Nuclear management's failure to provide oversight of the impact of changes to the river system on the calculated PMF at BFN and failure to apply safety-significant conservative decision-making for those changes demonstrated that nuclear safety was not the overriding priority.

TVA identified two relevant contributing factors.

1. Formal process controls were not established that ensure the flood protection program protects critical safety systems for the TVA nuclear sites.
2. TVA demonstrated less than adequate shared understanding of the applicable regulatory requirements under which the nuclear sites, as integral components of the river system, must operate.

In 1998 and again in 2004, significant changes to the design of the dams and operation of the river system were implemented. In both cases, the model was used to calculate the impact to the nuclear sites. The Nuclear organization acted upon those results without questioning the validity of the model, the calculations that it supported, or its conclusions. TVA Nuclear remained over-confident in the belief of the accuracy of the model throughout this period.

Since they had been used to license the nuclear stations, the software and model were believed to be correct. The over-confidence in the model continued to exist as late as 2008 when the model was employed in support of the BLN license submittal.

It was not until 2009, during validation of the hydrology model, that TVA realized that there were inconsistencies in the model inputs which, when corrected, resulted in the realization that some upstream dams could overtop and fail. The failure of the dams would overwhelm the planned flood protection actions to protect the safety systems at the TVA nuclear stations.

In summary, the latent design input inconsistencies, and a lack of rigor and oversight due to the overconfidence in the evaluation of changes in the operation of the river system over time, resulted in unrecognized inaccuracies in the PMF calculations.

IV. Analysis of the event:

Reportability Analysis

This condition is being reported in accordance with Title 10 of the Code of Federal Regulations (10 CFR) 50.73(a)(2)(ii)(B) as any event or condition that resulted in the nuclear power plant being in an unanalyzed condition that significantly degraded plant safety.

NARRATIVE

Operational Analysis

TVA is currently performing analysis to determine the PMF elevations at BFN prior to the HESCO modular flood barrier installation. This analysis will determine the safety significance of this condition at BFN and a supplement to this report will be submitted once the analysis is complete.

Since installation of the HESCO modular flood barriers, the analyzed conditions at BFN regarding PMF are within design and licensing basis limitations and the interim actions completed in December 2009 will prevent the overtopping and failure of the embankments.

V. Assessment of Safety Consequences

Upon the discovery of the potential to overtop upstream dams during a PMF event, it was immediately recognized by TVA that interim measures were required to maintain operability of BFN, SQN, and WBN. If overtopping of earthen embankments occurred, the design basis flood was projected to increase to an unacceptable level beyond what SQN and WBN could reasonably protect against. The impacts at BFN would be to a lesser degree, but a specific value has not been determined. A study is currently underway to determine the probable maximum flood elevation at BFN prior to identification of this previously unanalyzed condition. Upon completion of the analysis, TVA will submit a supplement to this LER with the results of the additional analysis of safety consequences.

Since installation of the HESCO modular flood barriers, the analyzed conditions at BFN regarding PMF are within design and licensing basis limitations. TVA believes that the interim actions completed in December 2009 will prevent the overtopping and failure of the embankments.

A. Availability of systems or components that could have performed the same function as the components and systems that failed during the event:

Based on current analysis there are no components or systems that would have failed during a postulated PMF event.

B. For events that occurred when the reactor was shut down, availability of systems or components needed to shutdown the reactor and maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident:

Based on current analysis there are no components or systems needed to shutdown the reactor and maintain safe shutdown conditions, remove residual heat, control the release of radioactive material, or mitigate the consequences of an accident that would have failed during a postulated PMF event.

C. For failure that rendered a train of a safety system inoperable, an estimate of the elapsed time from discovery of the failure until the train was returned to service:

Based on current analysis there are no components or systems that would have rendered a train of a safety system inoperable during a postulated PMF event.

VI. Corrective Actions - Corrective Actions are being managed by TVA's corrective action program under Problem Evaluation Report (PER) 682212.

NARRATIVE

A. Immediate Corrective Actions:

In July and August 2009, TVA implemented interim measures to mitigate impacts of the potential increase in PMF levels. River Operations procedures were modified to require site notifications if greater than or equal to five inches of average rainfall over 72 hours occurs over the Fort Loudoun/Tellico dam watershed area. At the same rainfall threshold, TVA

would mobilize the necessary heavy equipment at the Fort Loudon Marina Saddle dam to effect the saddle dam removal to preserve the integrity of Fort Loudon Dam. During this period, TVA also began installation of HESCO modular flood barriers on the Cherokee, Fort Loudoun, Tellico, and Watts Bar dams. Post-HESCO PMF elevations at the BFN plant are within the Updated Final Safety Analysis Report (UFSAR) requirements.

B. Corrective Actions to Prevent Recurrence or to reduce probability of similar events occurring in the future:

1. Revise the Conduct of the Engineering Organization procedure, to include a Flood Protection Program within the Corporate Nuclear Engineering Organization with the primary function to ensure that the nuclear plant critical safety systems are protected from all postulated flooding conditions.
2. Develop a formal Flood Protection Program Management Implementing procedure or procedures. This procedure would (for example) define the Flood Protection Program policy, ownership of the procedures, roles and responsibilities; identify nuclear regulatory requirements; establish governance and oversight expectations, periodic program reviews, training and qualification requirements; and implement flood protection change control board process, and program health reports.
3. Develop a Flood Protection Program Design Standard(s) or Design Guide(s) in accordance with engineering programs and processes to control flood protection calculations.
4. Formalize the elements of engineering technical rigor in the Conduct of the Engineering Organization procedure.
5. Create a formal documented risk management process for all engineering products, informed by INPO 12-008, Excellence in Integrated Risk Management, which includes flood related issues to evaluate including river system operation changes, nuclear plant design changes, design input changes, procedure changes impacting flood protection, Environmental and/or National Environmental Policy Act (NEPA), and Project Management.
6. The TVA Nuclear Organization will implement an upper tier integrated risk management process, informed by INPO 12-008.

VII. Additional Information

A. Previous Similar Events at the Same Plant

A search of BFN Licensee Event Reports (LERs) for Units 1, 2, and 3 for the last several years did not identify any similar events.

A search was performed on the BFN corrective action program. Similar PERs related to the condition reported in this LER are PERs 147337, 158381, and 212253. These PERs involve conditions related to PMF calculations. A review of the corrective action for these PERs

concluded that the corrective actions associated with these PERs would not have prevented this event.

B. Additional Information

There is no additional information.

C. Safety System Functional Failure Consideration

In accordance with Nuclear Energy Institute (NEI) 99-02, this condition is not considered a safety system functional failure.

D. Scram with Complications Consideration

This event did not result in an unplanned scram with complications.

VIII. Commitments

There are no commitments.