UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 12, 2014

LICENSEE: Entergy Operations, Inc.

FACILITY: Arkansas Nuclear One, Units 1 and 2

SUBJECT: SUMMARY OF JULY 16, 2014, **CLOSED** MEETING BETWEEN REPRESENTATIVES OF THE U.S. ARMY CORPS OF ENGINEERS, U.S. NUCLEAR REGULATORY COMMISSION AND ENTERGY OPERATIONS, INC. TO DISCUSS FLOODING ANALYSIS ASSOCIATED WITH ARKANSAS NUCLEAR ONE, UNITS 1 AND 2 (TAC NOS. MF3041 AND MF3042)

On July 16, 2014, the U.S. Nuclear Regulatory Commission (NRC) staff held a closed meeting with the U.S. Army Corps of Engineers (USACE) and Entergy Operations, Inc. (Entergy) to discuss the flooding hazard reevaluation (FHR) for Arkansas Nuclear One, Units 1 and 2 (ANO). The meeting was held at the USACE's office in Little Rock, Arkansas. The closed meeting notice dated July 10, 2014, can be found in the Agencywide Documents Access and Management System (ADAMS) at Accession No. ML14184B243. The participants in the meeting included the following individuals:

- NRC – Andy Campbell, Ken See, Brad Harvey, Robert Kuntz, and Warren Sharp*
- USACE – Roger Kay, Padmanabhan Rajendran, Nathaniel Keen, Russ Wyckoff, David Blackmore, Glenn Proffitt, Larry Winters, Henry Himstedt, and Teresa Reinig
- Entergy – Don Bentley and Bryan Ford
- Entergy contractor (GZA) – David Leone

* indicates individual participated via phone

The purpose of the meeting was to discuss the portion of the FHR the USACE is performing under contract to the NRC for ANO. By letter dated September 30, 2013 (ADAMS Accession No. ML13275A067), Entergy requested NRC assistance in having the USACE perform a dam failure analysis to support Entergy's development of an FHR in response to the March 12, 2012, request for information (ADAMS Accession No. ML12073A348).

The USACE presented the methodology it used to perform a screening analysis to identify potentially critical dams within the ANO watershed. The USACE and NRC provided Entergy a high-level summary of the screening analysis results of the screening analysis and the next steps in the process. The next steps include USACE completing a detailed analysis of the potentially critical dams and the NRC transmitting the USACE results to Entergy.

The agenda for the July 16, 2014, meeting can be found in Enclosure 1. Entergy provided questions prior to the meeting regarding USACE's dam failure analysis. In addition, Entergy

asked several questions during the discussion. These questions and a high level summary of the NRC response discussed at the meeting can be found in Enclosure 2.

The following action items were identified during the meeting:

- Entergy took an action to inform the NRC staff if it wanted hydrographs for locations other than at the ANO site. For example, some licensees have requested hydrographs for locations upstream of the nuclear power plant so that they can use the hydrographs as inputs into a two-dimensional model that will provide river velocities at multiple locations at the nuclear power plant site. The USACE hydrographs are one-dimensional models that provide for only a main channel, left bank, and right bank velocity.
- Entergy took an action item to provide a list of available analysis tools for modeling the watershed near ANO that the utility has developed for the USACE to consider incorporating into their analysis.

Subsequent to the meeting and in response to the first action item above, Entergy provided the locations for the hydrographs it is requesting from the USACE. Entergy requested dam failure hydrographs at the following locations:

Location	Approximate River Mile	Comment
Downstream of Ozark Lock and Dam	256.5	To better understand tailwater condition just downstream of Ozark Lock and Dam
Six Mile Creek	240.5	Wide floodplain at Six Mile Creek confluence
Spadra Creek	230	Constriction at Spadra Creek confluence (Ragon Mountain)
Big Shoal Creek	221	Wider floodplain at Big Shoal Creek
Piney Creek	217	Constriction at confluence of Piney Creek
ANO Site	210	ANO Site
Illinois Bayou	209	Confluence near ANO site (and downstream of Huckleberry Lake Dam)
Upstream of Dardanelle Lock and Dam	205.5	USACE noted hydrograph location (at Dardanelle Lock and Dam) and downstream of natural constriction

Subsequent to the meeting and in response to the second action item above, Entergy provided a summary of available modeling tools. This summary can be found in Enclosure 3.

The USACE was provided an opportunity to comment on this summary prior to its issuance and their comments were addressed in the final version of this meeting summary.

Please direct any inquiries to me at 301-415-3733 or at Robert.Kuntz@nrc.gov.

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Docket Nos. 50-313 and 50-368

Enclosures:
1. Agenda
2. Entergy Questions and Answers
3. Summary of available modeling tools

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US Army Corps of Engineers

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC/USACE Scoping Meeting Arkansas NPP

July 16, 2014

USACE Little Rock District Office
CESWL-RD
700 West Capitol Avenue, Room 4329
Little Rock, AR 72201-3221

Attendees

NRC:	Andy Campbell, Ken See, Rob Kuntz, Brad Harvey, Warren Sharp (remotely)
USACE Omaha:	Roger Kay, Teresa Reinig
USACE Little Rock:	Glenn Proffitt, Henry Himstedt, Nathaniel Keen, Larry Winters
USACE Tulsa:	Russ Wykoff, David Blackmore, Rajendran (Raj) Padmanabhan
FERC:	Wayne King (remotely), Jeremy Varner (remotely)
Entergy:	Bryan Ford, Don Bentley, David M Leone

----- Agenda Topics -----		
WEDNESDAY MORNING JULY 16		
Licensee Meeting		
Arrival for Security Screening	NRC/FERC/Entergy	08:45 – 09:00
Introductions	ALL	09:00 – 09:15
• Arkansas NPP Watershed Management	USACE	09:15 – 09:45
• Hydrologic and Hydraulic Modeling Methods	USACE	09:45 – 10:15
• Licensee's questions and answers (see attached)	Entergy/NRC/USACE	10:15 – 11:00
BREAK		11:00 – 11:30
Continued discussions as necessary	Entergy/NRC/USACE	11:30 – 12:00

Entergy's Questions on USACE's Dam Failure Analysis

The Following are questions from Entergy Operations, Inc. (Entergy, the licensee) provided prior to the meeting regarding U.S. Army Corps of Engineers (USACE) Dam Failure Analysis for the Arkansas Nuclear One, Units 1 and 2 (ANO) watershed.

1. What information from Entergy and team is requested to support the analysis? Is the USACE's and NRC's intention to perform an independent analysis of the entire watershed system? Will the USACE / NRC be requesting information from the hydrologic and hydraulic analysis performed to date by Entergy in response to the NRC's request for Flood Hazard Re-evaluation?

   NRC Response: The NRC may request from the licensee information related to the Huckleberry Dam. The intention of the analysis is to perform an independent analysis per NRC guidance. The NRC staff requested that the licensee submit a summary of the analysis performed by Entergy to determine if it would be requested from the licensee.

2. Will USACE/NRC request Entergy's input on locations or dams for which the USACE may evaluate dam failure or produce flow hydrographs due to dam failure and/or flooding?

   NRC Response: The NRC will provide hydrographs to Entergy at the ANO site based on information provided by the USACE. In addition the licensee may request additional locations.

3. Will the USACE dam failure analysis be limited to USACE-owned structures?

   NRC Response: All dams identified as potentially critical will be evaluated.

4. If the USACE/NRC is developing their own inputs independently:
   a. Will all dam failure conditions (hydrologic, seismic, sunny day) be evaluated by USACE?

      NRC Response: All failure modes will be considered by the USACE during the analysis which will be completed in accordance with the NRC's guidance. All failure modes deemed credible will be analyzed.

   b. What is the approach to the development of coincident hydrologic flood inputs using current day methodology and up-to-date input data (e.g., PMF)?

      NRC Response: The USACE will apply its knowledge and experience, and consistent with NRC guidance, to develop the hydrologic inputs.

   c. We have found that the large watershed size creates physical limitations relative to simultaneous failure of all dams in a watershed during a single hydrologic event because even the Probable Maximum Precipitation (PMP) does not significantly affect all portions of the watershed. In other words, the PMP which was modeled for the development of the PMF is a full watershed scale event, which is not analogous to individual PMP's falling on the contributory watershed of each individual dam.

Some areas of the basin will experience little or no flooding while others extreme flooding, depending on storm orientation, center location, etc. In light of the watershed size, what are some of the approaches being considered to develop conceptual models for dam failure scenarios and in the development of coincident hydrologic river inputs (e.g., flood flow hydrographs, rainfall, etc.)?

NRC Response: The USACE will apply its knowledge and experience using NRC guidance to determine credible scenarios.

d. Will all USACE-owned structures be considered (including those many hundreds of miles away from the site)? How will hydrographs be routed through dams which are upstream or downstream of USACE-owned dams?

NRC Response: Yes, all the dams in the watershed will be considered.

e. Will the analysis account for a dam's design criteria (or experience data) for potentially withstanding resultant flood (or earthquake) conditions, including piping/internal erosion failure if a dam is not overtopped by the PMF?

NRC Response: NRC guidance, relevant professional and federal standards, and USACE judgment will be used to determine if failure is credible.

f. What are the criteria for assuming an overtopping failure (e.g., embankment overtopping by one foot has been referenced in other USACE studies for NRC)?

NRC Response: NRC guidance, relevant professional and federal standards, and USACE judgment will be used to determine if failure is credible.

g. For flood control structures, how will the initial water surface elevation in the impoundments and gate/lock operating rules be established?

NRC Response: NRC guidance will be followed.

5. A USACE report or other documentation of the analysis may be important if the results require an additional iteration of calculations for other coincident flood causing mechanisms by Entergy consistent with the Hierarchical Hazard Assessment approach. A significant portion of our original request to the USACE was intended to support development of the Probable Maximum Flood (hydrology and hydraulics). What level of information (qualitative or quantitative) and what form of information does USACE/NRC anticipate providing to Entergy (e.g., will it be similar to the work on the Missouri River; will a report/calculation be generated, will the assumptions used in the USACE analysis be stated, such as starting reservoir pool elevations, functionality of gates, locks, and outlet works, identification of dams not expected to fail during the hydrologic dam failure event, etc.)?

NRC Response: Entergy will be given, in electronic form, hydrographs (which include stage, flow, and velocity) at the ANO site. As discussed in the response to question 2, the licensee can request hydrographs at other locations. In addition the licensee may request an additional meeting after the licensee receives the results to discuss the analysis.

6. The Flood Hazard re-evaluation is employing the Hierarchical Hazard Assessment approach. To date, a considerable level of detail has been used to refine assumptions used in the analysis. What level of the Hierarchical Hazard Assessment approach described in the NRC's ISG does the USACE anticipate applying to the dam failure analysis? For example:

    a. What methods will be considered for computing attenuation of dam breach flows?

       NRC Response: The USACE will apply NRC and USACE guidance, along with available hydrologic and hydraulic models, where appropriate.

    b. Which software programs may be used (HEC-RAS unsteady flow module, HEC-HMS etc.)?

       NRC Response: To date USACE has used a variety of models for providing a response to similar requests.

    c. What level of calibration and verification of hydrologic input parameters will be performed if coincident flood hydrographs are generated?

       NRC Response: Existing information from recent events will be used.

    d. Will dams for the hydrologic dam failure scenario be assumed to fail regardless of whether or not they are anticipated to overtop during the coincident flood and will individual dams assumed to fail be specifically identified?

       NRC Response: NRC guidance, relevant federal standards, and USACE judgment will be used to determine if failure is credible. Only hydrographs from critical dams whose failure is either judged credible or assumed (e.g. sunny day dam failure) will be identified and hydrographs provided.

    e. Does the USACE anticipate consolidating clusters of dams into one or more single hypothetical dams? If so, how would such dams be grouped and positioned?

       NRC Response: Clustering of dams is a technique used for screening as described in the NRC's guidance. Screening can be used to identify non-critical dams, it cannot be used to identify critical dams. The method was used during the screening process to screen out two dams.

7. Entergy's calculation review process requires a check to ensure reasonableness of inputs, assumptions and results, and to verify that the calculation satisfies the site's expectations. In order to accomplish this, can an Entergy representative have a national security clearance in order to be provided view only access to the analysis performed by the USACE?

   NRC Response: Due to the sensitive nature of the information in the report, the report will not be provided, nor will viewer rights.

Entergy's Summary of Watershed Analysis Tools

The Following is a summary of analysis tools Entergy Operations, Inc. has developed. Entergy provided the following information subsequent to the meeting regarding United States Army Corps of Engineers (USACE) Dam Failure Analysis for the Arkansas Nuclear One, Units 1 and 2 (ANO) watershed.

Probable Maximum Precipitation

Summary:

The purpose of this calculation is to establish the Probable Maximum Precipitation (PMP) at ANO, both at the site and its upstream Arkansas River watershed. A site specific PMP study was conducted for the Arkansas River watershed near ANO because the contributory watershed (over 150,000 square miles) exceeds the watershed area upper limit of 20,000 square miles in Hydrometeorological Reports 51 and 52. The results on the site specific PMP study are that the maximum storm duration is 72-hours and the maximum storm size is 100,000 square miles. The 100,000 square mile PMP does not cover the entire watershed, but is the largest storm considered physically possible due to meteorological limitations on storm duration, size, and orientation. The average PMP rainfall depth for the portion of the watershed covered by the 100,000 square mile, 72 hour PMP centered at the watershed centroid is 7.7 inches. A higher average PMP rainfall depth of 10.2 inches for the 72-hour duration occurs with the PMP centered at the centroid of the Robert Kerr subwatershed.

Calculations and Computer Models:

Detailed report describing site-specific PMP study, storm analyses, procedures, and results
GIS shapefiles for:

- Depth-area-duration output
- Strom center locations
- Storm isohyets

Microsoft Excel spreadsheets applying depth-area-duration information to the watershed as per HMR-52 application guidance.

Probable Maximum Flood – Hydrology

Summary:

The purpose of this calculation is to develop the Probable Maximum Flood (PMF) hydrograph resulting from the application of the Probable Maximum Precipitation (PMP) to the Arkansas River watershed contributory to Arkansas Nuclear One. The large watershed was divided into 22 subwatersheds. A calibrated and verified HEC-HMS rainfall-runoff model was developed for the watershed. Snyder unit hydrograph methodology and Muskingum (or Muskingum-Cunge) river routing was used. The Snyder and Muskingum (or Muskingum-Cunge) parameters for each subwatershed were calibrated using three floods and verified used three (separate) floods. Non-linearity adjustments were included for the PMF simulations as per recommendations in NUREG/CR-7046.

Calculations and Computer Models:

GIS shapefiles for:
- Watershed and subwatershed delineation
- preliminary subwatershed constant loss values
- initial subwatershed lag time
- Thiessen polygons for weighting precipitation

Multiple HEC-HMS files for:
- Calibration floods
- Verification floods
- PMF candidate storms (five scenarios)
- Non-linearity adjustments for the PMF candidate storms

Probable Maximum Flood – Hydraulics

Summary:

The purpose of this calculation is to establish the water surface elevation resulting from the Probable Maximum Flood (PMF) on the Arkansas River near Arkansas Nuclear One. A HEC-RAS computer model (unsteady) was developed for a 117-mile long reach of the Arkansas River, from upstream of Trimble Lock and Dam No. 13 to downstream of the Arthur V. Ormond Lock and Dam No. 9, respectively. The Arkansas State Highway Route 109 Bridge and the Dardanelle Bridge were incorporated into the model. The HEC-RAS model was calibrated using the flood of record (May 1990).

Calculations and Computer Models:

GIS shapefiles for:
- Cross section locations

Drawings for the bridges incorporated into HEC-RAS

Multiple HEC-RAS files for:
- Calibration flood
- PMF candidate storms (five scenarios) adjusted for non-linearity

Dam Failures

Summary:

The purpose of this calculation is to assess the effect of upstream dam failures on the maximum water surface elevation of the Arkansas River near Arkansas Nuclear One. Three dam failure scenarios were evaluated: 1) Hydrologic dam failure, coincident with the PMF, 2) Seismic dam failure, coincident with a 500-year flood and 3) Sunny day dam failure, coincident with a typical base flow. The dams within each subwatershed were "combined" and modeled as hypothetical dams located at the most downstream point of each subwatershed. The peak breach outflow for the hypothetical dams was estimated using Froehlich regression equation. Peak breach outflow for each hypothetical dam was attenuated using the USBR attenuation equation. Peak dam breach outflow from individual dams (not included in the hypothetical dams) was calculated using HEC-HMS and calibrated based on the results of a sensitivity analysis using the Froehlich regression equations. Breach parameters were selected based on FERC guidance. The most severe PMF scenarios were evaluated to determine the controlling combined dam breach and PMF flow at ANO using HEC-HMS. The peak water surface elevation resulting from the combination of upstream dam breach and the PMF at ANO was calculated using HEC-RAS.

Calculations and Computer Models:

GIS shapefiles for:

- Dam locations
- Hypothetical dam locations

Multiple HEC-HMS files for the three dam failure scenarios:

- Peak breach outflow for hypothetical dams
- Peak breach outflow for individually modeled dams
- Combining upstream dam breach and the PMF flows

Multiple HEC-RAS files for:

- Combining upstream dam breach and the PMF flows for the three dam failure scenarios

Microsoft Excel spreadsheets for calculating hypothetical dam properties, calculating peak breach outflows using Froehlich regression equations, and calculating attenuated peak breach outflow using the USBR attenuation equations.

The USACE was provided an opportunity to comment on this summary prior to its issuance and their comments were addressed in the final version of this summary.

Please direct any inquiries to me at 301-415-3733 or at Robert.Kuntz@nrc.gov.

/RA/

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