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

December 4, 2017

Mr. John Dent, Jr.
Vice President-Nuclear and CNO
Nebraska Public Power District
Cooper Nuclear Station
72676 648A Avenue
P.O. Box 98
Brownville, NE 68321

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF NEBRASKA PUBLIC POWER DISTRICT'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR COOPER NUCLEAR STATION (CAC NO. MF4712)

Dear Mr. Dent:

By letter dated May 6, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15125A060), the U.S. Nuclear Regulatory Commission (NRC) informed you of the staff's plan to conduct a regulatory audit of Nebraska Public Power District's (NPPD, the licensee) Flood Hazard Reevaluation Report (FHRR) submittal related to the Near-Term Task Force Recommendation 2.1-Flooding for Cooper Nuclear Station (Cooper). The audit was intended to support the NRC staff review of the licensee's FHRR and the subsequent issuance of a staff assessment.

The audits conducted on May 13, 2015, June 24, 2015, August 12, 2015, September 16, 2015, October 13, 2015, and November 20, 2015 were performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008, (ADAMS Accession No. ML082900195). Therefore, the purpose of this letter is to provide you with the final audit report, which summarizes and documents the NRC's regulatory audit of the licensee's FHRR submittal. Based on shared site characteristics, this audit was combined with the audit of Omaha Public Power District's Fort Calhoun Station, Unit 1.

If you have any questions, please contact me at (301) 415-1056 or by e-mail at Lauren.Gibson@nrc.gov.

Sincerely,

Lauren Kate Gibson

Lauren K. Gibson, Project Manager
Beyond-Design-Basis Management Branch
Division of Licensing Projects
Office of Nuclear Reactor Regulation

Docket No. 50-298

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

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

NUCLEAR REGULATORY COMMISSION AUDIT REPORT FOR THE AUDIT OF NEBRASKA PUBLIC POWER DISTRICT'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR COOPER NUCLEAR STATION

BACKGROUND AND AUDIT BASIS

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) "Conditions of license" (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant, as documented in The Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident. Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with Commission Papers SECY 11-0124 and SECY-11-0137, instructed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f).

By letter dated February 3, 2015, Nebraska Public Power District (NPPD, the licensee) submitted its Flood Hazard Reevaluation Reports (FHRRs) for Cooper Nuclear Station (Cooper) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15041A523). The NRC is in the process of reviewing the aforementioned submittal and has completed a regulatory audit with the licensee to better understand the development of the submittal, identify any similarities/differences with past work completed and ultimately aid in its review of the licensees' FHRR. This audit summary was completed in accordance with the guidance set forth in NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008 (ADAMS Accession No. ML082900195).

AUDIT LOCATION AND DATES

The audit meetings were completed by document review via a webinar sessions in conjunction with the use of the licensee's established electronic reading room (ERR) and teleconferences on May 13, 2015, June 24, 2015, August 12, 2015, September 16, 2015, October 13, 2015, and November 20, 2015.

Enclosure

AUDIT TEAM

Title	Team Member	Organization
Team Leader, NRR/JLD	Tekia Govan	NRC
Technical Monitor	Laura Quinn-Willingham	NRC
Technical Staff	Ken See	NRC
Technical Division Director	Andy Campbell	NRC
Technical Branch Chief	Aida Rivera-Verona	NRC
Technical Branch Chief	Christopher Cook	NRC
NRC Contractor	Scott DeNeale	Oak Ridge National Lab
NRC Contractor	Kevin Stewart	Oak Ridge National Lab
NRC Contractor	David Watson	Oak Ridge National Lab
NRC Contractor	Greg Zimmerman	Oak Ridge National Lab

A list of the Licensee's participants can be found in Attachment 2.

DOCUMENTS AUDITED

Attachment 1 of this report contains a list which details the documents that were reviewed by the NRC staff, in part or in whole, as part of this audit. The majority of the documents were located in an ERR during the NRC staff's review. Table 1 lists the information needs requested by the NRC staff and a summary of the licensee's responses.

AUDIT ACTIVITIES

In general, the audit activities consisted mainly of the following actions:

- Review background information on site topography and geographical characteristics of the watershed.
- Review site physical features and plant layout.
- Understand the selection of important assumptions and parameters that would be the basis for evaluating the individual flood causing mechanisms described in the 50.54(f) letter.
- Review model input/output files to computer analyses such as the U.S. Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS) and Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) and TUFLOW to have an understanding of how modeling assumptions were programmed and executed.

Table 1 summarizes specific technical topics (and resolution) of important items that were discussed and clarified during the audit. The items discussed in Table 1 may be referenced/mentioned in the staff assessment in more detail.

EXIT MEETING/BRIEFING

On December 22, 2015 (ADAMS Accession No. ML15355A416), the NRC staff issued the Interim Staff Response letter for the reevaluated flood-causing mechanisms described in the FHRR. The licensee submitted Revision 1 of the FHRR on September 29, 2016, which addressed a subset of information needs and the audit was henceforth considered closed. There are no outstanding information needs remaining as a result of this audit.

ATTACHMENT 1
Cooper Nuclear Station Audit Document List

1. Chow, Ven Te 1959, *Open-Channel Hydraulics*, McGraw-Hill Book Co., New York, 680 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 60, "Chow Reference".

2. Fread, 1989, *Flood Routing Models and the Manning n*, International Conference on Channel Flow and Catchment Runoff, University of Virginia, Charlottesville, Virginia, May 22-26, 1989, pp 421-435. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 59, "Fread Reference".

3. NPPD (Nebraska Public Power District), No date, "Cooper Nuclear Station FSAR Question No. 2.36," Amendment No. 17, No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 52, "FSAR Question No. 2.3.6 Amendment 17".

4. NPPD (Nebraska Public Power District), No date, "Cooper Nuclear Station FSAR Question No. 2.1," Amendment No. 9, No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 51, "FSAR Question No. 2.1 Amendment 9".

5. NPPD (Nebraska Public Power District), No date, "HEC-HMS Version 3.5 Software V&V Statement," Calc. No.: 2013-03087, Revision 0, Appendix 8, 33 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 39, "Calculation 2013-03087 – Appendix 8 – HEC-HMS Version 3.5 Software V&V Statement".

6. NPPD (Nebraska Public Power District), No date, "HEC-RAS Version 4.1 Software V&V Statement," Calc. No.: 2013-03087, Revision 0, Appendix 9, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 41, "Calculation 2013-03087 – Appendix 9 – HEC-RAS Version 4.1 Software V&V Statement".

7. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, December 14, 2011, 12 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 10, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11)".

8. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 1, December 14, 2011, 2 pages, letter dated June 2, 2011. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 11, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 1 PMF Hydrograph Review Letter".

9. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 2, December 14, 2011, 2 pages, email dated April 1, 2011. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations,

Item ID 12, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 2 - Email from COE".

10. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 3, December 14, 2011, 3 pages, letter dated July 7, 2011. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 13, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 3 COE Review Letter".

11. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 4, December 14, 2011, 4 pages, letter dated July 7, 2011. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 14, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 4 - Review Comment Resolution Letter".

12. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 5, December 14, 2011, 52 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 15, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 5 - FTN Report".

13. NPPD (Nebraska Public Power District), 2011, "External Flood Events Review," Revision 1, NEDC 11-076, Attachment 6, December 14, 2011, 1011 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 16, "NEDC 11-076, Revision 1, Hydrodynamic Computer Modeling to Predict Missouri River PMF Elevations and Flow Velocities at CNS (8/8/11) - Attachment 6 - FTN Report Appendix".

14. NPPD (Nebraska Public Power District), 2011, "USAR", Section 4, August 10, 2011, 15 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 17, "5.1FLOOD Rev 13".

15. NPPD (Nebraska Public Power District), 2012, "CNS Operations Manual Emergency Procedure 5.1 Flood," Revision 13, Effective date November 9, 2012, 11 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 2, "USAR II-4".

16. NPPD (Nebraska Public Power District), 2012, "Flooding Walkdown Report – Nebraska Public District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.3 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station," Letter from Nebraska Public Power District to U.S. Nuclear Regulatory Commission Document Control Desk, November 27, 2102, ADAMS Accession No. ML12333A319 (publicly available). Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 6, "NLS2012124 - CNS Flooding Walkdown Report".

17. NPPD (Nebraska Public Power District), 2013, "Review of 2012 Topographic Survey of CNS," Revision 0, Engineering Evaluation Number: 12-035, signed date March 15, 2013. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 5, "EE 12-035 Rev. 0.pdf".

18. NPPD (Nebraska Public Power District), 2013, "Clarification of the Cooper Nuclear Station Flooding Walkdown Report Cooper Nuclear Station," Letter from Nebraska Public Power District to U.S. Nuclear Regulatory Commission Document Control Desk, November 21, 2013, Accession No. ML13330B276 (publicly available). Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 7, "NLS2013094 - Clarification to CNS Flooding Walkdown Report".

19. NPPD (Nebraska Public Power District), 2014, "Evaluation of Probable Maximum Flood (PMF) for the Missouri River at CNS," Calc. No.: 2013-03087, Revision 0, Signed October 23, 2014, 24 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 18, "Calculation 2013-03087 - Evaluation of PMF for the Missouri River at CNS".

20. NPPD (Nebraska Public Power District), 2014, "Task 610 Update/Calibrate Existing FEMA HEC-RAS Steady State Model," Calc. No. 2013-03087, Appendix 1, Revision 0, October 22, 2014, 16 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 21, "Calculation 2013-03087-Appendix 1 Task 610 Update/Calibrate Existing FEMA HEC-RAS Steady-State Model".

21. NPPD (Nebraska Public Power District), 2014, "Task 610 Update/Calibrate Existing FEMA HEC-RAS Steady State Model," Calc. No. 2013-03087, Appendix 1, Revision 0, Attachment 1 through Attachment 10-1, October 22, 2014, 147 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 22, "Calculation 2013-03087 - Appendix 1 - Attachment 1 Figures - Update/Calibrate Existing FEMA HEC-RAS Steady-State Model".

22. NPPD (Nebraska Public Power District), 2014, "Task 620 Probable Maximum Precipitation (PMP) for calculation of the Probable Maximum Flood (PMF) at Cooper Nuclear Station for the Platte River Basin and the Lower Basin of the Missouri River below Fort Calhoun Station (FCS)," Calc. No. 2013-03087, Appendix 2, Revision 1, October 12, 2014, 22 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 23, "Calculation 2013-03087 - Appendix 2 - Task 620 Probable Maximum Precipitation (PMP) for calculation of the Probable Maximum Flood (PMF) at Cooper Nuclear Station for the Platte River Basin and the Lower Basin of the Missouri River below FCS".

23. NPPD (Nebraska Public Power District), 2014, "Task 620 Probable Maximum Precipitation (PMP) for calculation of the Probable Maximum Flood (PMF) at Cooper Nuclear Station for the Platte River Basin and the Lower Basin of the Missouri River below Fort Calhoun Station (FCS),"Calc. No. 2013-03087, Appendix 2, Attachment 1 through Attachment 4, Revision 1, October 15, 2013, 160 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 25," Calculation 2013-03087 - Appendix 2 - Attachments - Task 620 Probable Maximum Precipitation (PMP) for calculation of the Probable Maximum Flood (PMF) at Cooper Nuclear Station for the Platte River Basin and the Lower Basin of the Missouri River below FCS".

24. NPPD (Nebraska Public Power District), 2014, "Task 620 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station," Calc. No. 2013-03087, Appendix 3, Revision 0, October 22, 2014, 58 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 27, "Calculation 2013-03087 - Appendix 3 - Task 630 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station".

25. NPPD (Nebraska Public Power District), 2014, "Task 620 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station," Calc. No. 2013-03087, Appendix 3, Attachment 1 through Attachment 11, Revision 0, October 22, 2014, 593 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 28, "Calculation 2013-03087 - Appendix 3 - Attachment 1 Figures - Task 630 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station".

26. NPPD (Nebraska Public Power District), 2014, "Task 620 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station," Calc. No. 2013-03087, Appendix 3, Attachment 1 through Attachment 11, Revision 0, October 22, 2014, 593 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 28, "Calculation 2013-03087 - Appendix 3 - Attachment 1 Figures - Task 630 Develop Hydrographs for the Missouri River and Tributary Basins that Contribute to the Probable Maximum Flood (PMF) at Cooper Nuclear Station".

27. NPPD (Nebraska Public Power District), 2014, "Task 640 PMF Routing using HEC-RAS Unsteady Model," Calc. No. 2013-03087, Appendix 4, Revision 0, October 22, 2014, 18 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 29, "Calculation 2013-03087 - Appendix 4 - Task 640 PMF Routing using HEC-RAS Unsteady Model".

28. NPPD (Nebraska Public Power District), 2014, "Task 640 PMF Routing using HEC-RAS Unsteady Model," Calc. No. 2013-03087, Appendix 4, Attachment 1 through Attachment 7, Revision 0, October 22, 2014, 800 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 30, "Calculation 2013-03087 - Appendix 4 - Attachment 1 Figures - Task 640 PMF Routing using HEC-RAS Unsteady Model".

29. NPPD (Nebraska Public Power District), 2014, "Task 660 PMF Develop 2D Hydraulic Model and Evaluate Site-Specific Effects at CNS due to the PMF in the Missouri River," Calc. No. 2013-03087, Appendix 6, Revision 0, October 22, 2014, 20 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 31, "Calculation 2013-03087 - Appendix 6 - Task 660 Develop 2D Hydraulic Model and Evaluate Site-Specific Effects at CNS due to the PMF in the Missouri River".

30. NPPD (Nebraska Public Power District), 2014, "Task 660 PMF Develop 2D Hydraulic Model and Evaluate Site-Specific Effects at CNS due to the PMF in the Missouri River," Calc. No. 2013-03087, Appendix 6, Revision 0, Attachment 1 through Attachment 11G, October 22, 2014, 809 pages. Located in the Certec Portal, Cooper Fukushima

Response, Flooding Reevaluations, Item ID 33, "Calculation 2013-03087 - Appendix 6 - Attachment 1 Figures - Task 660 Develop 2D Hydraulic Model and Evaluate Site-Specific Effects at CNS due to the PMF in the Missouri River".

31. NPPD (Nebraska Public Power District), 2014, "TUFLOW FV Verification and Validation," Calc. No.: 2013-03087, Revision 0, Appendix 10, October 22, 2014, 26 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 43, "Calculation 2013-03087 – Appendix 10 – TUFLOW FV Verification and Validation".

32. NPPD (Nebraska Public Power District), 2014, "TUFLOW FV Verification and Validation," Calc. No.: 201-03087, Revision 0, Appendix 10, Attachments 1 through 6, October 22, 2014, 428 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 44, "Calculation 2013-03087 – Appendix 10 – Attachment 1 – TUFLOW FV Verification and Validation".

33. NPPD (Nebraska Public Power District), 2014, "Evaluation of Upstream Dam Failure Flooding Effects at CNS," Calc. No. 2014-00223, Revision 0, October 23, 2014, 27 pages, prepared by Sargent & Lundy. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 19, "Calculation 2014-00223 - Evaluation of Upstream Dam Failure Flooding Effects at CNS".

34. NPPD (Nebraska Public Power District), 2014, "Evaluation of Upstream Dam Failure Flooding Effects at CNS," Calc. No. 2014-00223, Revision 0, Attachment 1 through Attachment 3, October 23, 2014, 30 pages, prepared by Sargent & Lundy. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 34, "Calculation 2014-00223 - Appendix 6 - Attachment 1 Figures -Task 760 Evaluate Site-Specific Effects at CNS due to Upstream Dam Failures using the Results of the 1D Hydraulic Analysis".

35. NPPD (Nebraska Public Power District), 2014, "Task 760 Evaluate Dam Failure Consequences at CNS for Missouri/Platte River Basin Dams Upstream of CNS," Calc. No. 2014-00223-Appendix 2, Revision 0, Appendix 2, October 23, 2014, 30 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 24, "Calculation 2014-00223 - Appendix 2 - Task 720 Evaluate Dam Failure Consequences at CNS for Missouri/Platte River Basin Dams Upstream of CNS".

36. NPPD (Nebraska Public Power District), 2014, "Evaluate Dam Failure Consequences at CNS for Missouri/Platte River Basin Dams Upstream of CNS," Calc. No. 2014-00223-Appendix 2, Revision 0, Attachments 1 through 3, October 23, 2014, 228 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 26, "Calculation 2014-00223 - Appendix 2 - Attachment 1 Figures - Task 720 Evaluate Dam Failure Consequences at CNS for Missouri/Platte River Basin Dams Upstream of CNS".

37. NPPD (Nebraska Public Power District), 2014, "Task 760 Evaluate Site-Specific Effects at CNS due to Upstream Dam Failures using the Results of the 1D Hydraulic Analysis," Calc. No. 2014-00223-Appendix 6, Revision 0, Appendix 6, October 23, 2014, 13 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 32, "Calculation 2014-00223 - Appendix 6 - Task 760 Evaluate Site-Specific

Effects at CNS due to Upstream Dam Failures using the Results of the 1D Hydraulic Analysis".

38. NPPD (Nebraska Public Power District), 2014, "Evaluate Wind Setup, Wind-Wave Run-up, and Hydrostatic and Hydrodynamic Forces on Safety-Related SSCs at CNS due to Upstream Dam Failures," Calc. No.: 2014-00223, Revision 0, Appendix 7, Revision 0, 13 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 36, "Calculation 2014-00223 - Appendix 7 - Task 770 Evaluate Wind Setup, Wind-Wave Run-up, and Hydrostatic and Hydrodynamic Forces on Safety-Related SSCs at CNS due to Upstream Dam Failures".

39. NPPD (Nebraska Public Power District), 2014, "Evaluate Wind Setup, Wind-Wave Run-up, and Hydrostatic and Hydrodynamic Forces on Safety-Related SSCs at CNS due to Upstream Dam Failures," Calc. No.: 2014-00223, Revision 0, Appendix 7 - Attachments 1 through 9, 108 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 38, "Calculation 2014-00223 – Appendix 7 – Attachment 1 Figures – Task 770 Evaluate Wind Setup, Wind-Wave Run-up, and Hydrostatic and Hydrodynamic Forces on Safety-related SSCs at CNS due to Upstream Dam Failures".

40. NPPD (Nebraska Public Power District), 2014, "HEC-HMS Version 3.5 Software V&V Statement," Calc. No.: 2014-00223, Revision 0, Appendix 8, 33 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 40, "Calculation 2014-000223 – Appendix 8 – HEC-HMS Version 3.5 Software V&V Statement".

41. NPPD (Nebraska Public Power District), 2014, "HEC-RAS Version 4.1 Software V&V Statement," Calc. No.: 2014-00223, Revision 0, Appendix 9, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 42, "Calculation 2014-00223 – Appendix 9 – HEC-RAS Version 4.1 Software V&V Statement".

42. NPPD (Nebraska Public Power District), 2014, "Flood Hazard Re-evaluation Interim Action Monitoring and Trigger Points," EDP-048, Revision 2, August 20, 2014, 8 pages, Cooper Nuclear Station Engineering Division. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 1, "Commitment NLS2014052-D1 – Missouri River Basis Monitoring".

43. NPPD (Nebraska Public Power District), 2014, "Evaluation of Local Probable Maximum Precipitation (PMP)," Calc. No.: 2012-12283, Revision 0, Includes Attachments 1 through 22, 271 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 45, "Evaluation of Local Probable Maximum Precipitation".

44. NPPD (Nebraska Public Power District), 2014, "Ice Induced Flooding Assessment," Report No. SL-012467, Revision 0, September 5, 2014, 30 pages, prepared by Sargent & Lundy. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 46, "SL-012467 – Ice Induced Flooding Assessment".

45. NPPD (Nebraska Public Power District), 2014, "Ice Induced Flooding Assessment," Report No. SL-012467, Revision 0, Appendix 1 – Ice Jam Database Downloaded from Reference 1 for the Missouri, James, Big Sioux. Little Sioux, Elkhorn, Platte and Nishnabotna, 582 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 47, "SL-012467 - SL-012467 - Ice Induced Flooding Assessment - Appendix 1 Ice jam database downloaded from Reference 1 for the Missouri, James, Bix Sioux, Little Sioux, Elkhorn, Platte, and Nishnabotna Rivers".

46. NPPD (Nebraska Public Power District), 2014, "Ice Induced Flooding Assessment," Report No. SL-012467, Revision 0, Appendix 2 – Historical Field Measurement Data for USGS Gages Listed in Table 1 Obtained from the USGS (Reference 8.2)," 643 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 48, "SL-012467 - Ice Induced Flooding Assessment - Appendix 2 - Historical field measurement data for USGS gages listed in Table 1 obtained from USGS".

47. NPPD (Nebraska Public Power District), 2014, "Ice Induced Flooding Assessment," Report No. SL-012467, Revision 0, Appendix 3 – Historical Monthly Flow Statistical Data for USGS Gages Listed in Table 1 Obtained from the USGS (Reference 8.2)," 84 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 49, "SL-012467 - Ice Induced Flooding Assessment - Appendix 3 - Historical monthly flow statistical data for USGS gages listed in Table 1 obtained from USGS".

48. NPPD (Nebraska Public Power District), 2014, "Ice Induced Flooding Assessment," Report No. SL-012467, Revision 0, Appendix 4 – USGS Gage Water-Data Report," 31 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 50, "SL-012467 - Ice Induced Flooding Assessment - Appendix 4 - USGS gage water-data report."

49. NPPD (Nebraska Public Power District), 2014, "CNS Operations Manual Maintenance Procedure 7.0.11 Flood Control Barriers," Revision 29, Effective date February 19, 2014, 73 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 3, "7.0.11 Rev 29".

50. NPPD (Nebraska Public Power District), 2014, "Cooper Nuclear Station Flood Debris Impact Loads," Calc. No. 2014-06655, Revision 0, September 18, 2014, 12 pages, prepared by Sargent & Lundy. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 20, "Calculation 2014-06655 Rev 0 - CNS Flood Debris Impact Loads".

51. NPPD (Nebraska Public Power District), 2015, "Task 810 – Missouri River Channel Geomorphic Evaluation at CNS," Revision 0, Calc. No. 2014-00225, October 30, 2014, 29 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 8, "Calculation 2014-00225, Revision 0, Task 810 - Missouri River Channel Geomorphic Evaluation at CNS".

52. (Nebraska Public Power District), 2015, "Task 810 – Missouri River Channel Geomorphic Evaluation at CNS," Revision 0, Calc. No. 2014-00225, Attachments 1 through 5, October 30, 2014, 58 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 9, "Calculation 2014-00225,

Revision 0, Task 810 - Missouri River Channel Geomorphic Evaluation at CNS - Attachments".

53. NPPD (Nebraska Public Power District), 2015 "Cooper Nuclear Station Flood Hazard Reevaluation Report," Security-Related and Redacted Versions, January 26, 2015, Enclosure to letter from Oscar A. Limpias to the U.S. Nuclear Regulatory Commission, Document Control Center, Subject: "Nebraska Public Power District's Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station, Docket No 50-298, DPR-46," February 3, 2015, ADAMS Accession No. ML15041A523 (publicly available - redacted version).

54. NPDD (Nebraska Public Power District), 2015, "Cooper Nuclear Station Flood Hazard Reevaluation Report Addendum A," Security-Related and Redacted Versions, Enclosures to letter from Oscar A. Limpias, to U.S. Nuclear Regulatory Commission Document Control Desk, Subject: Addendum to Nebraska Public Power District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station, Docket No. 50-298, DPR-46," July 31, 2015, ADAMS Accession No. ML15224B438 (non-publicly available).

55. NPDD (Nebraska Public Power District), 2015, "Cooper Nuclear Station Flood Hazard Reevaluation Report Addendum B," Security-Related and Redacted Versions, Enclosures to letter from Kenneth Higginbotham, to U.S. Nuclear Regulatory Commission Document Control Desk, Subject: Addendum to Nebraska Public Power District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station, Docket No. 50-298, DPR-46," October 29, 2015, ADAMS Accession No. ML15310A011 (non-publicly available).

56. NPPD (Nebraska Public Power District), 2015,"Response to Nuclear Regulatory Commission for Request for Additional Information Regarding Near Term Task Force Recommendation 2.1 – Flood Hazard Reevaluation Report Cooper Nuclear Station, Docket NO. 50-298, DPR-46," Letter from Oscar A. Limpias, to U.S. Nuclear Regulatory Commission Document Control Desk, June 18, 2015, ADAMS Accession No. ML15173A023 (non-publicly available).

57. NPPD (Nebraska Public Power District), 2015,"Cooper Nuclear Station Flood Hazard Revaluation Report Input and Output Files," Enclosed hard drive to letter from Oscar A. Limpias, to U.S. Nuclear Regulatory Commission Document Control Desk, June 18, 2015, ADAMS Accession No. ML15173A023 (non-publicly available).

58. NPPD (Nebraska Public Power District), 2015,"NPPD – Cooper Nuclear Station Task 730 Electronic Input/output Files Withhold from Public Disclosure under 10 CFR 2.390, Contains Security-Related Information," Hard drive submitted to NRC for the audit.

59. NPDD (Nebraska Public Power District), 2016, "Cooper Nuclear Station Flood Hazard Reevaluation Report, Revision 1 – Revision Summary Table," Security-Related and Redacted Versions, Enclosures to letter from Oscar A. Limpias, to U.S. Nuclear Regulatory Commission Document Control Desk, Subject: Revision to Nebraska Public Power District's Flood Hazard Reevaluation Report Cooper Nuclear Station, Docket No. 50-298, DPR-46," September 29, 2016, ADAMS Accession No. ML16279A426 (non-publicly available).

60. NPPS and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015," September 22, 2105, 9 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 66, "CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses".

61. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015, Attachment 1," September 22, 2105, 12 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 67, "CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses".

62. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015, Attachment 2," September 22, 2105, 12 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 68, "CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses ATTACHMENT 2".

63. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015, Attachment 3," September 22, 2105, 1 page. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 71, "CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses ATTACHMENT 3".

64. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Fort Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 1," No date, 10 pages, Curtiss-Wright Online SharePoint Portal, Fort Calhoun Fukushima, FCS – CNS Audit Webinar Part 2, "20150608 FCS – CNS FHRRs - Audit Webinar Part 2 Info Needs Draft Responses Not Password Protected," posted on June 10, 2015. Located on the Curtiss-Wright electric reading room.

65. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fort Calhoun Station/Cooper Nuclear Station Flood hazard Reevaluation Report Preliminary TUFLOW Methodology Discussion," August 12, 2015, 11 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 58, "August 12 Audit – TUFLOW Methodology".

66. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fort Calhoun Station/Cooper Nuclear Station Flood Hazard Reevaluation Reports, Scoping and Planning Discussion," July 8, 2015, 7 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 57, "Plan to Address Information Requests #1 and #2".

67. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 3 – Flooding in Rivers and Streams – Combined Effects Assumptions," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 55, "Information Request #3".

68. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 4 – Flooding in Rivers and Streams – Comparison with 2011 Flood Event," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 53, "Information Request #4".

69. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 5 – Flooding in Rivers and Streams – 1-D/2-D Model Interface," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 56, "Information Request #5".

70. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 6 – Flooding in Rivers and Streams – Modeling of Levees," No date, 1 page. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 54, "Information Request #6".

71. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, No title, No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 62, "Manning's Justification 9/16/2016".

72. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, "Fort Calhoun Station/Cooper Nuclear Station Flood Hazard Reevaluation Report 1D and 2D Dam Failure Models Methodology Discussion, September 16, 2015, 21 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 63, "FCS/CNS FHRs NRC Audit Webinar Part 5 Presentation 9/16/2015".

73. NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015, No title, No date, 5 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 65, "CNS-FCS Mannings Roughness Adjustment Graphics".

Table 1: Cooper Nuclear Station Information Needs and Response Summary

Information Need No.	Information Need Description	Response Summary
1	The staff would like to discuss the lateral velocity distribution and velocity values for the following scenarios. • Fort Calhoun – Probable Maximum Flood (PMF) and Dam breach scenarios that result in flood levels above site grade. These are also discussed in Table 2.3-10, and similar. Figure 2.3-23 graphically displays this information. Is it possible to show vector arrows? If possible, it may be helpful to review this information in the model GUI (or post-processing viewer). Are additional sensitivity runs available to review and discuss at the meeting? • Cooper – Similar to Fort Calhoun, however we realize the basin PMF does not flood the site so, these questions only pertain to the dam failure scenarios (NPPD, 2015a).	The licensee presented graphical illustrations of how in-stream and overbank velocities varied laterally. The NRC staff concluded that the original velocity distributions presented provided unrealistically low velocities, considering the relatively high depth of flow and lack of influence from boundary layer effects (i.e., river bed drag) (NPPD and OPPD, 2015g). Subsequent follow-up needs were issued to discuss this topic in further audits, with the eventual conclusion that the licensees assigned Manning's roughness coefficients were playing a major role in influencing the resulting river velocities, with abrupt changes in n values resulting in abrupt changes in velocity values (NPPD and OPPD, 2015g). Per the response to Info Need 2, the licensee agreed to resubmit its dam failure evaluation by modeling the scenario using a two-dimensional TUFLOW model. The licensee presented preliminary model results after decreasing Manning's n values by up to 20% for wetland, grassland, and row crop land uses (NPPD and OPPD, 2015h). Reductions for other land use categories were not made (NPPD and OPPD, 2015h). The NRC suggested that the Urban land use (specifically at the nuclear plant site) was far higher than traditional values and should be decreased to match the LIP model. The final version of this model incorporated refined Manning's n values, including lower n values at the Cooper powerblock

Information Need No.	Information Need Description	Response Summary
		and lower overall n values for certain land cover categories to account for the significant depth of flow experienced during the dam failure flood (NPPD, 2016). This model refinement provided more reasonable variation in river velocities, with increases in onsite velocities and decreases in main channel velocity (NPPD and OPPD, 2015a): • Original right overbank (ROB) velocity: 2.0 feet per second (fps) • Revised ROB velocity: 9.9 fps (at ISFSI - N) • Original channel velocity: 18.0 fps • Revised channel velocity: 7.1 fps (at Intake Structure - E) The staff reviewed the new model assumptions in the revised FHRR submitted in September 2016 (NPPD, 2016) and determined this information need request was resolved.
2	**Dam Breach Flooding – Model Selection** Background: The licensee simulated flooding impacts at the nuclear station from upstream dam failure impacts using a one-dimensional (1-D) U.S. Army Corps of Engineer's Hydrologic Engineering Center River Analysis System (HEC-RAS) model calibrated to the 2011 flood event along the Missouri River (NPPD, 2015a). In contrast, the licensee simulated flooding in streams and rivers using a two-dimensional TUFLOW model calibrated to the 2011	After discussion over several audit meetings, the licensee decided to incorporate the use of a 2-D TUFLOW model for modeling certain aspects of the dam failure flooding. The switch in modeling tools allows for more refined simulation of dam failure flooding impacts (including flooding depths and onsite velocities) and enables consistency in simulating flooding along the Missouri River. The HEC RAS 1-D model was still used to determine flood arrival times and duration.

Information Need No.	Information Need Description	Response Summary
	flood event along the Missouri River, with boundary conditions informed by HEC-RAS (NPPD, 2015a). The two-dimension model offers a more refined simulation of the distributions of water levels, timing, and velocities compared to the one-dimensional model. Request: Explain why the two-dimensional TUFLOW model was not used for dam breach flooding simulation, despite being used for river flooding simulation. The two-dimensional (2-D) TUFLOW model should provide better predictions of flooding depths and flow velocities in the vicinity of the nuclear facilities than the 1-D HEC-RAS simulations.	The revised model results for CNS was provided October 29, 2015, in Addendum B to the Flood Hazard Reevaluation Report (FHRR) (NPPD, 2015). The staff reviewed the revised FHRR (NPPD, 2016) and determined that this information need is resolved.
3	**Flooding in Rivers and Streams – Combined Effects Assumptions** Background: In developing the Combined Effects PMF for Streams and Rivers, the licensee selected Alternative 1 as described in NUREG/CR-7046, Appendix H (NRC, 2011), which assumes the combination of mean monthly base flow, median soil moisture, a 40% Probable Maximum Precipitation (PMP) antecedent storm, a full-PMP, and wind-wave effects from a 2-year return-period wind speed (NPPD, 2015a). The licensee decided to exclude Alternatives 2 and 3 due to engineering judgment, with an assumption that these scenarios would not bound Alternative 1 (NPPD, 2015a). The licensee's Alternatives 2 and 3 include combining variations of	The licensee explained in its response (NPPD and OPPD, 2015b) that its scenario for Flooding in Streams and Rivers is a modified version of Alternative 1 as described in NUREG/CR-7046 (NRC, 2011). To provide a more conservative PMF analysis, the licensee simulated excess discharge from the Missouri River Mainstem Reservoir System (System), totaling 160,000 cubic feet per second (cfs). This discharge of 160,000 cfs is equivalent to the System release experienced in 2011 and is the highest since the construction of the System. Such a release could be expected due to the need to release storage accumulated from large mountain snowpack runoff combined with spring/summer rainfall runoff into the System. The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.

Information Need No.	Information Need Description	Response Summary
	snow-season rainfall events with variations of extreme snowpack/snowmelt (Note: these Alternatives were originally recommended in ANSI/ANS (1992) and are guidance only). Given the complexity and size of the Missouri River watershed, which is one of the largest watersheds in the world and covers both mountainous terrain and a range of central to northern latitudes, it is reasonable to assume that historically extreme snowmelt events could realistically coincide with near-all-season PMP events and not just a "snow-season rainfall" event. Considering that the Missouri River has had some very large historical floods resulting from snowpack melt over large areas of the northern portions of the watershed in the spring well after snow season is over, the selection of Alternative 1 that does not include any snowpack melt does not appear to be conservative. In addition, the recent 2011 flood event that occurred in June and July was the result of a combination of snowmelt and heavy rains suggesting this combination of events is reasonable to assume. Request: Describe the professional judgment that was used to qualitatively screen out Combined Effects Alternatives 2 and 3 for Flooding in Streams and Rivers that include a combination of snowpack melt and an extreme rainfall event. Also provide technically based rationale for why a combination of extreme all-season PMP events with historically extreme snowmelt events was not considered as an	

Information Need No.	Information Need Description	Response Summary
	alternative. As a part of the discussion, describe what impacts may be expected should extreme snowmelt be included in Alternative 1.	
4	**Flooding in Rivers and Streams – Comparison with 2011 Flood Event** Background: As a part of the simulation of flooding in rivers and streams, the licensee used the 2011 Missouri River flood event to calibrate its models (NPPD, 2015a). Request: Describe how the peak flows and effects from the 2011 flood compare with the predicted PMF peak flows and effects. Also, discuss how the timing, distribution, and intensity of rainfall during the 2011 flood compare with the PMP selected and how similarities and differences in the two may inform the analyses and plant safety.	The licensee described several important differences between the simulated PMF event and the 2011 Missouri River flood event (which was used for calibration) (NPPD and OPPD, 2015c). First, the dynamics of the PMF event assume PMP from the eastern Dakotas/Western Iowa/Nebraska, while the dynamics of the 2011 Missouri River flood event occurred from mountain snowpack/rainfall runoff in the Montana/Wyoming mountains and high plains. Also the 2011 Missouri River flood event was a less than a third of the PMF at the nuclear power plant site. The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.
5	**Flooding in Rivers and Streams – 1-D/2-D Model Interface** Background: In developing a 2-D TUFLOW model simulation for river flooding at the nuclear station, a 1-D HEC-RAS model was used to establish boundary conditions for the 2-D model (NPPD, 2015a). The 2011 flood event was used for calibration purposes (NPPD, 2015a). Request: Describe the locations of the upstream and downstream 1-D/2-D model interfaces and how	The licensee responded that the boundaries of the 2-D model are placed where flows are primarily one-dimensional and located far enough away from the site (approximately 5 miles) such that any effects of the boundaries wouldn't affect the flows at the site (NPPD and OPPD, 2015d). The staff found this study useful, but not comprehensive and requested further study (see Info Need #10). The licensee further commented on the role of the model in modeling the dynamic between the channel and floodplain since the 1-D model cannot accurately handle this (NPPD and OPPD, 2015d). The licensee conducted model runs to

Information Need No.	Information Need Description	Response Summary
	hydrodynamic effects or other differences in the models may affect the results of the 2-D modeling.	investigate two different boundary conditions – 1) all flow in floodplains, and 2) all flow in the main channel area (bluff to bluff). Based on their simulations, it was found that most of the flow would be conveyed in the floodplain and decided that full flood plain conditions were best used. The staff determined the response was sufficient for this portion of the information need request. The licensee also conducted a sensitivity study for various distributions of conveyance flow proportions for main channel and the overbanks area to assess the effect of flow and elevation at the site. The staff found the study useful, but not comprehensive and requested further study (see Information Need Request #10).
6	**<u>Flooding in Rivers and Streams – Modeling of Levees</u>** <u>Background</u>: The 1-D hydraulic model (HEC-RAS) was used to evaluate two unsteady bounding PMF conditions: 1) complete levee failure (full-floodplain) and 2) levees remain in place (levee constrained). The results show that the full-floodplain simulation resulted in the highest peak discharge and was thus used for the upstream inflow conditions in the 2-D (TUFLOW) model. According to FHRR Section 2.2.3.3.1 for Cooper; however, the 2-D model assumed that no levees would be compromised during the PMF (NPPS, 2015a). <u>Request</u>: Explain why it was assumed for the Cooper TUFLOW modeling that the levees are	The licensee explained that the upstream boundary condition in the 2-D PMF model (TUFLOW) was informed by the HEC-RAS output using the full floodplain modeling assumption (NPPD and OPPD, 2015d). The licensee noted that this assumption resulted in a conservative water surface elevation and pointed to Calc. No: 2013-03087, which documents the use of sensitivity analysis to demonstrate this conservatism, including the use of a low weir coefficient of 1.6 to allow for less conveyance of flow beyond the levees. The licensee also explained that the levees in the 2-D domain were treated as a rigid boundary, which allows for a more conservative water surface elevation compared to a levee-overtopping scenario (NPPD and OPPD, 2015d). The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.

Information Need No.	Information Need Description	Response Summary
	constrained but has an upstream boundary condition from the 1-D model simulating a full-floodplain PMF scenario. Describe the sensitivity of water surface elevations at CNS (and Ft Calhoun) during the PMF to the way levees are modeled in TUFLOW and HEC-RAS and provide results from any sensitivity runs that show the conservativeness of using a constrained levee scenario in the Cooper TUFLOW simulations.	
7	**Input to integrated assessment: Mechanisms considered (This information was only requested from Fort Calhoun)**	This information need request is applicable to Ft Calhoun only.
8	**Input to integrated assessment: Mechanisms considered (This information was only requested for Cooper)** Background: Sections 2.1, 2.2, 2.3, and 2.7, of the Cooper FHRR (NPPD, 2015a) state that the site flood levels from LIP, Ice-Induced Flooding, and Combined Effects were not previously considered in the USAR. The FHRR also states these hazards are considered bounded (NPPD, 2015a). The NRC guidance (NRC, 2012) provides the conditions requiring an integrated assessment to be performed. Request: The NRC staff noted from section 2.1, 2.2, 2.3, and 2.7, of the Cooper FHRR (NPPD, 2015a) that the reevaluated site flood levels from LIP, Ice-Induced Flooding, and Combined Effects were not	The licensee clarified during audit interactions that the following hazards: LIP, Ice-induced flooding, streams and rivers, channel diversion and migration, and failure of dams are not bounded and would be included in an additional assessment. The licensee's revised FHRR also stated the information provided during the audit (NPPD, 2016).

Information Need No.	Information Need Description	Response Summary
	previously considered in the USAR, triggering an Integrated Assessment for these hazard mechanisms. The licensee is requested to confirm that a "limited" integrated assessment for LIP and a full integrated assessment will be submitted addressing the Ice-Induced Flooding and Combined Effects hazard mechanisms. The licensee is also requested clarify which flood hazard mechanisms will be included in the Integrated Assessment.	
9	**<u>Velocity distribution in 2-D TUFLOW model and selection of Manning's *n* values for both flooding in streams and rivers (PMF) and dam breach</u>** <u>Background</u>: Just as it was for the 1-D model, the predicted velocities on-site will be highly dependent on the selection of Manning's roughness coefficients. The figures the licensees provided in the ERR on September 18, 2017, shows that the distribution of Manning's *n* in the model is very coarse and the licensees have assigned a higher Manning's *n* to a large area in the vicinity of each of the nuclear plant sites compared to the lower Manning's *n* assigned to surrounding areas. The staff does not believe that the use of a high Manning's *n* for the entire site is justified since a significant portion of the site is paved or open and they have explicitly included the on-site buildings in the TUFLOW model. The higher Manning's *n* assigned to the whole site vicinity plus the high Manning's *n* assigned to the row of trees on the river bank is probably responsible for the lower flows and velocities predicted at the sites. Note a	The licensee addressed the issue of high Manning's roughness coefficients (*n*) on-site by decreasing the values to 0.025 for most land cover on-site and to 0.08 for the switchyard (NPPD and OPPD, 2015f). The licensee maintained its position regarding limiting the reduction in Manning's *n* values to 20% for deep overbank flow conditions, referencing literature from Chow (1959) and Fread (1989) (NPPD and OPPD, 2015f). The licensee explained that the seemingly round structure of buildings as presented in material for a previous audit was the result of a software visualization feature and that the actual TUFLOW model simulated on-site buildings as rigid structures with vertical walls (NPPD and OPPD, 2015f). The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.

Information Need No.	Information Need Description	Response Summary
	much lower Manning's *n* for the site is used in the LIP analysis, which does not seem to be consistent. According to the Manning's document uploaded to the ERR for the September 18, 2017, webinar, the urban land cover corresponds to a Manning's *n* value of 0.12, which would appear high for the type of land cover at the power plants (especially when inundated). The use of a 0.05 Manning's *n* value in the licensees LIP analysis and 0.12 in the riverine model appears contradictory, and the simulation of buildings as elevated flow obstruction structures in the model already introduces energy loss. Review of the FCS FHRR, Figure 2.3-10 indicates that a value of 0.099 was used at the site in the previous HEC-RAS dam breach model, with no flow obstruction. <u>Request</u>: Outstanding information needs related to the predicted velocity distribution at the sites include the following: • Justification of the high Manning's *n* value selected for the entire site(s) should be provided and sensitivity analysis using lower Manning's *n* values near the site should be conducted for both dam breach and flooding in streams and rivers scenarios, including using the value of 0.05 that was used in the LIP model. Provide justification for using only a 20% reduction in Manning's *n* in the overbank areas under the dam breach flooding scenario with such high water	

Information Need No.	Information Need Description	Response Summary
	surface elevations (WSEs). For example in USACE EM 1110-2-1416 (1993) for the Lower Mississippi River, it is estimated that during low flow the Manning's *n* value is about 0.06 and for high flow the Manning's *n* value is about 0.025. Provide justification (for both dam breach and flooding in streams and rivers) for simulating the onsite buildings as rounded (mound) features instead of buildings that have vertical walls (see September 16, 2015, webinar presentation material). The predicted site specific energy losses and velocities are likely to be very different if the buildings are simulated as vertical instead of rounded.	
10	**<u>Upstream interface boundary between 1-D and 2-D models for both dam breach and flooding in streams and rivers (PMF) Upstream Boundary Location</u>** <u>Background</u>: It was requested that the licensee demonstrate the effect of moving the upstream boundary for the 2-D model for Fort Calhoun to a location further upstream to judge the occurrence of any differences in flow distribution and effects at the site under both dam breach and flooding in streams and rivers flooding scenarios. The licensee presented a graphic depicting the flow lines and velocity contour results from a model run with the upstream boundary condition moved to above the confluence of the Soldier River and Missouri under	The licensee provided the information/plots requested (NPPD and OPPD, 2015i; NPDD and OPPD, 2015j; NPDD and OPPD, 2015k). The plots indicated a negligible effect of the WSE at the site. The large differences in flow illustrated in the plots were discussed in the webinar and are a function of the differences in how the main channel and left and right overbank areas were defined spatially between the original and extended models (NPPD and OPPD, 2015i; NPDD and OPPD, 2015j; NPDD and OPPD, 2015k). The staff also included the possibility that the overall geometry of the Cooper TUFLOW model would allow for proper redistribution of flow by the time the flood wave reached the site, meaning the flow patterns at the site would not be

Information Need No.	Information Need Description	Response Summary
	peak WSE conditions during dam breach only. The licensee provided only a verbal confirmation that, "there is no difference in the flow" shared with a written statement in the presentation Slide 17 that a special case was executed to maximize the potential for recirculation at Soldier River. The reason staff requested model runs with an extended upstream boundary does not solely pertain to whether a recirculation pattern is evident, but, rather what is the effect of the flow distribution and WSE at the upstream boundary location for both the original TUFLOW PMF model and the subsequently developed dam breach model. Apart from the results presented in the graphic on Slide 19 (containing streamlines and velocity contours), which appears to contain some solution development issues indicative of the non-smooth velocity contours – there's no information to substantiate issues regarding flow distributions, WSEs, or other effects at the site for the dam breach and PMF scenarios. <u>Request</u>: The staff requests the licensee to document and provide results of flow and WSE distribution for both PMF and dam breach flooding scenarios the cases of (1) *Model run with original boundary location* and (2) *Model run with the extended boundary location*. For each of these two cases, for PMF and dam breach scenarios provide the following:	sensitive to the location of the upstream boundary location, given the original location was sufficiently far upstream. The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.

Information Need No.	Information Need Description	Response Summary
	1. Flow distributions (conveyance percentages) along the original upstream boundary (denoted as "...Boundary A" in Figure 1) for the left, center and right bank sections. 2. WSEs along the original upstream boundary (denoted as "...Boundary A" in Figure 1). 3. Flow distributions (conveyance percentages) along a section at the site (denoted as "Section at site" in Figure 1) for the left, center and right bank sections. 4. WSEs along a section at the site (denoted as "Section at site" in Figure 1)	
11	**Upstream interface boundary between 1-D and 2-D models for both dam breach and flooding in streams and rivers (PMF) Upstream Boundary Condition** Background: The upstream boundary for both the Fort Calhoun and Cooper 2-D models is specified using the 1-D flow in the main channel and right and left overbanks obtained from the HEC-RAS model. The staff's review of the unsteady 2-D model results at the upstream boundary identifies a condition that does not necessarily replicate realistic flow behaviors expected in rivers due to flooding. For example, during the early rise of the limb on the inflow hydrograph, observation of flow entering the 2-D model domain through the upstream boundary depicts flow entering the right and left overbanks over the entire domain. Realistic flooding of rivers would expect a consistent swelling of the river	The licensee's response included discussions on the difficulty in assessing channel and overbank hydraulic connectivity with respect to using a flow hydrograph (NPPD and OPPD, 2015j). The licensee maintains that the goal is to identify the peak water velocities and WSEs at the site after overbank conveyance is completely engaged. The licensee further discussed difficulty in the concept of specifying the inflow hydrograph at the main channel at a distance far enough away from the site to allow for the model to determine evolving flow distributions across the river section (NPPD and OPPD, 2015j). The licensee conducted a sensitivity analysis to evaluate the effect of reducing the left overbank flow at the upstream boundary by 20% and redistributing the flow to the right overbank (where the site is located). The results demonstrate that discharge near the site in the right overbank and in the channel actually decreased very slightly, while discharge in the

Information Need No.	Information Need Description	Response Summary
	expanding out from the main channel flow followed by increased flow in the overbank areas. Instead, the licensee's 2-D model depicts flow entering the model at the upstream boundary all across the right and left overbanks (see Figure 2). This is due to the fact that the input flow at the right and left overbanks, as obtained from HEC-RAS, is being specified as flow conveyance across the entire extent of the overbank cross-sections as an average – whereas, in reality, it is not equally distributed. Furthermore, the issue may be further compounded by the way in which the HEC-RAS model was constructed, which allows for flow to instantaneously transfer well outside of the normal channel in order to meet its solution. The fact that the Missouri River floodplain is modeled using wide cross-sections (15 miles at the upstream boundary) may also contribute to unrealistic flow distribution. It is expected that the 2-D model would be more representative of actual conditions and replicate the gradual development of flow in the overbank areas if: 1. The total flow at the upstream boundary were specified in the main channel only (not including overbank areas) at a distance far enough upstream and let the flow redistribute itself out and away from the main channel based on the topography, or, 2. The horizontal discretization in HEC-RAS and the 2-D model boundary condition were	left overbank increased very slightly. The corresponding maximum WSE did not change. The staff reviewed the licensee's response and determined it was sufficient to resolve the information need request.

Information Need No.	Information Need Description	Response Summary
	increased more appropriately simulate the flow distribution. Request: The staff requests the licensee to discuss the potential differences in flow and elevation at the site given a case whereby the flooding were allowed to develop outward naturally within the 2-D model from the main channel and into the overbank areas rather than the current methodology in which an average flow distribution is specified in the overbank areas.	

Sources:

ANSI/ANS (American National Standards Institute/American Nuclear Society), 1992, ANSI/ANS-2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites," American Nuclear Society, LaGrange Park, IL, July 1992.

NPPD (Nebraska Public Power District), 2015a "Cooper Nuclear Station Flood Hazard Reevaluation Report (Redacted Version)," January 26, 2015, Enclosure to letter from Oscar A. Limpias to the U.S. Nuclear Regulatory Commission, Document Control Center, Subject: "Nebraska Public Power District's Response to Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near-Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station, Docket No 50-298, DPR-46," February 3, 2015, ADAMS Accession No. ML15041A523 (publicly available).

NPPD (Nebraska Public Power District), 2015b, "Cooper Nuclear Station Flood Hazard Reevaluation Report Addendum B," Enclosure to letter from Kenneth Higginbotham, to U.S. Nuclear Regulatory Commission Document Control Desk, Subject: Addendum to Nebraska Public Power District's Response to Nuclear Regulatory Commission Request for Information Pursuant to 10 CFR 50.54(f) Regarding the Flooding Aspects of Recommendation 2.1 of the Near Term Task Force Review of Insights from the Fukushima Dai-ichi Accident Cooper Nuclear Station, Docket No. 50-298, DPR-46," October 29, 2015, ADAMS Accession No. ML15310A011.

NPPD (Nebraska Public Power District), 2016, "Cooper Nuclear Station Flood Hazard Reevaluation Report, Revision 1 – Revision Summary Table," Security-Related and Redacted Versions, Enclosures to letter from Oscar A. Limpias, to U.S. Nuclear Regulatory Commission Document Control Desk, Subject: Revision to Nebraska Public Power District's Flood Hazard Reevaluation Report Cooper Nuclear Station, Docket No. 50-298, DPR-46," September 29, 2016, ADAMS Accession No. ML16279A426 (non-publicly available).

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015a, "Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015, Attachment 1," September 22, 2105, 12 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 67, "CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015b, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 3 – Flooding in Rivers and Streams – Combined Effects Assumptions," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 55, "Information Request #3".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015c, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 4 – Flooding in Rivers and Streams – Comparison with 2011 Flood Event," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 53, "Information Request #4".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015d, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 5 – Flooding in Rivers and Streams – 1-D/2-D Model Interface," No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 56, "Information Request #5".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015e, "Information Needs to Support the Flood Hazard Reevaluation Reports (FHRR) Review for Ft Calhoun Station, Unit 1 and Cooper Nuclear Station Information Need 6 – Flooding in Rivers and Streams – Modeling of Levees," No date, 1 page. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 54, "Information Request #6".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015f, No title, No date, 3 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 62, "Manning's Justification 9/16/2016".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015g, "Fort Calhoun Station/Cooper Nuclear Station Flood Hazard Reevaluation Reports, Scoping and Planning Discussion," July 8, 2015, 7 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 57, "Plan to Address Information Requests #1 and #2".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015h, "Fort Calhoun Station/Cooper Nuclear Station Flood hazard Reevaluation Report Preliminary TUFLOW Methodology Discussion," August 12, 2015, 11 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 58, "August 12 Audit – TUFLOW Methodology".

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015i, "Fort Calhoun Station/Cooper Nuclear Station Flood Hazard Reevaluation Report 1D and 2D Dam Failure Models Methodology Discussion, September 16, 2015, 21 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 63, "FCS/CNS FHRs NRC Audit Webinar Part 5 Presentation 9/16/2015".

NPPS and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015j, “Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015,” September 22, 2105, 9 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 66, “CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses”.

NPPD and OPPD (Nebraska Public Power District and Omaha Public Power District), 2015k, “Fukushima 2.1 FHHR Review for Fort Calhoun and Cooper, Update on Status on Information Needs – September 22, 2015, Attachment 2,” September 22, 2105, 12 pages. Located in the Certec Portal, Cooper Fukushima Response, Flooding Reevaluations, Item ID 68, “CNS/FCS FHR Audit Part 6 October 2015 - Info Needs Responses ATTACHMENT 2”.

NRC (Nuclear Regulatory Commission), 2011, “Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America,” NUREG/CR-7046, November 2011, ADAMS Accession No. ML11321A195 (publicly available).

NRC (U.S. Nuclear Regulatory Commission), 2012, Letter from David L. Skeen, Director, Japan Lessons-Learned Project Directorate, to Joseph E Pollock, Nuclear Energy Institute, Subject: “Trigger Conditions for Performing an Integrated Assessment and Due Date for Response,” December 3, 2012, ADAMS Accession No. ML12056A046 (publicly available).

USACE (U.S. Army Corps of Engineers), 1993, Engineering and Design, River Hydraulics, EM 1110-2-1416.

ATTACHMENT 2
List of Cooper Audit Participants

Name	Organization
Dan Buman	NPPD
Khalil Dia	NPPD
Gabe Gardner	NPPD
Jim Shaw	NPPD
Jerry Horn	NPPD
Rachid Dia	NPPD
Matt Nienaber	NPPD
Luke Jensen	NPPD
Brenda Kirkpatrick	NPPD
Jerry Long	NPPD
Jim Flaherty	NPPD
Roman Estrada	NPPD

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF NEBRASKA PUBLIC POWER DISTRICT'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR COOPER NUCLEAR STATION DATED December 4, 2017

DISTRIBUTION:

PUBLIC
LGibson, NRR
RidsNrrDorlLpl4Resource
RidsRgn4MailCenter Resource
RidsOpaMail Resource
SDevlin-Gill, NRO
MWillingham, NRO
MShams, NRR
PBMB R/F
LQuinn-Willingham, NRO
RidsNrrDorl Resource
RidsNrrLASLent
RidsACRS_MailCtr Resource
BHarvey, NRO
RidsNrrPMCooper Resource
RidsNRRDlp Resource
RidsNroDsea Resource
KSee, NRO
RidsOgcMailCenter Resource
CCook, NRO
ACampbell, NRO
RRivera-Lugo, NRO

ADAMS Accession No.: ML17310A290 ***via email**

OFFICE	NRR/DLP/PBMB/PM*	NRR/DLP/PBMB/LA	NRO/DSEA/RHM1/TR*	NRO/DSEA/RHM1/TM
NAME	LKGibson	SLent	KSee*	LQuinn-Willingham*
DATE	11/7/2017	11/6/2017	10/30/2017	10/30/2017
OFFICE	NRO/DSEA/RHM1/BC	NRR/DLP/PBMB/BC	NRR/DLP/PBMB/PM	
NAME	SDevlin-Gill*	MShams	LGibson	
DATE	10/30/2017	11/17/2017	12/4/2017	

OFFICAL RECORD COPY