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

August 12, 2016

Mr. Adam C. Heflin
President, Chief Executive Officer,
and Chief Nuclear Officer
Wolf Creek Nuclear Operating Corporation
P.O. Box 411
Burlington, KS 66839

SUBJECT: NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF WOLF CREEK NUCLEAR OPERATING CORPORATION'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR WOLF CREEK GENERATING STATION, UNIT 1 (CAC NO. MF3648)

Dear Mr. Heflin:

The purpose of this letter is to provide you with the final audit report, which summarizes and documents the U.S. Nuclear Regulatory Commission's (NRC) regulatory audit of Wolf Creek Nuclear Operating Corporation's (WCNOC, the licensee,) Flood Hazard Reevaluation Report (FHRR) submittal related to the Near-Term Task Force Recommendation 2.1-Flooding for Wolf Creek Generating Station (Wolf Creek). By letter dated October 5, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15274A243), the NRC informed you of the staff's plan to conduct a regulatory audit of WCNOC's FHRR submittal for Wolf Creek. The audit was intended to support the NRC staff review of the licensee's FHRR and the subsequent issuance of an interim hazard letter and staff assessment documenting the staff's review. The audit was conducted on November 10, 2015, and December 16, 2015, with an exit meeting held on December 18, 2015. The audit was performed consistent with NRC Office of Nuclear Reactor Regulation, Office Instruction LIC-111, "Regulatory Audits," dated December 29, 2008, (ADAMS Accession No. ML082900195).

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
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket No. 50-482

Enclosure:
Audit Report

cc w/encl: Distribution via Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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NUCLEAR REGULATORY COMMISSION REPORT FOR THE AUDIT OF WOLF CREEK NUCLEAR OPERATING CORPORATION'S FLOOD HAZARD REEVALUATION REPORT SUBMITTALS RELATING TO THE NEAR-TERM TASK FORCE RECOMMENDATION 2.1-FLOODING FOR: WOLF CREEK GENERATING STATION, UNIT 1

BACKGROUND AND AUDIT BASIS:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all operating 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 staff issue orders to all licensees to reevaluate seismic and flooding 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 March 10, 2014, Wolf Creek Nuclear Operating Corporation (WCNOC, the licensee) submitted its Flood Hazard Reevaluation Reports (FHRRs) for Wolf Creek Nuclear Generating Station, Unit 1 (Wolf Creek) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14077A280). The licensee supplemented this letter in response to requests for additional information by letters dated May 20, 2015 (ADAMS Accession No. ML15147A516) and February 23, 2016 (ADAMS Accession No. ML16061A256). The licensee revised its FHRR by letter dated January 19, 2016 (ADAMS Accession No. ML16032A190). The NRC is in the process of reviewing the aforementioned submittals and has completed a regulatory audit of WCNOC to aid in its review of licensees' FHRR. This audit summary was completed using the guidance 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 was completed over three sessions via teleconference and/or webinar over a period of 2 months and is described below:

- November 10, 2015 from 1:00 pm to 3:00 pm – webinar session
- December 16, 2015 from 11:00 am to 12:00 pm – teleconference session
- December 18, 2015 from 2:00 pm to 2:30 pm – teleconference session

AUDIT TEAMS:

Title	Team Member	Organization
Team Leader, NRR/JLD	Anthony Minarik	NRC
Branch Chief, NRO/DSEA	Aida Rivera-Varona	NRC
Technical Manager	Richard Lugo	NRC
Technical Lead	Nebiyu Tiruneh	NRC
Technical Support (NRC)	Rajiv Prassad	Pacific Northwest National Lab (PNNL)
Technical Support (NRC)	Nancy Boyd	PNNL
Supervisor Engineering	Brian Schaefer	Wolf Creek Nuclear Operating Corporation (WCNOC)
Regulatory Affairs Manager	Cindy Hafenstine	WCNOC
Supervisor Licensing	Bill Muilenburg	WCNOC
Superintendent of Outage	Bob Kopecky	WCNOC
Licensing Engineer	Nicole Good	WCNOC
Technical Support (WCNOC)	Jamie Dababneh	Rizzo Associates
Technical Support (WCNOC)	Mark Moenssens	Rizzo Associates
Technical Support (WCNOC)	Jeffrey Oskamp	Rizzo Associates

DOCUMENTS AUDITED:

Attachment 1 of this report details all the documents that were reviewed by the NRC staff, in part or in whole, as part of this audit. The documents were shared with the staff and destroyed following completion of the audit documentation. The documents, or portions thereof, that were used by the staff as part of the technical analysis and/or as reference in the completion of the staff assessment, were requested of the licensee as necessary (see "Exit Meeting" Section).

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 files such as, the Hydrologic Engineering Center - Hydrologic Modeling System and FLO-2D, to have an understanding of how modeling assumptions were programmed and executed

Table 1 below provides more detail and 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.

Table 1: Sample of Technical Topics of Discussion

Info Need No.	Information Need Description	Post-Audit Status
1	**Local Intense Precipitation** Background: The FHRR local intense precipitation (LIP) analysis used the modeling software FLO-2D to model flooding. The FHRR does not provide any information on the Wolf Creek site elevation dataset and how it was processed to generate the FLO-2D model grid. The process of transforming suitable terrain information into a model representation is a critical step in the process of developing an appropriate numerical model. Insufficient resolution in spatial information used to construct the Digital Terrain Model (DTM) may obscure features (e.g., a cinder block wall) that might obstruct flow. Even if these features are identified in the DTM, they may be obscured in the process of remapping the DTM to the FLO-2D grid (e.g., potential flow paths or connections and obstruction to these flowpaths smaller than the FLO-2D grid cell size can be misrepresented). Where overhangs exist, the elevations in spatial data may reflect the elevation of the overhang and not the ground. Request: Please provide a description of the process used to develop and validate the FLO-2D grid. The description should include sufficient detailed discussion of (1) any flowpaths and obstructions in the	The response is adequate – request for additional information (RAI) closed. (RAI response letter dated May 20, 2015, was submitted on docket). The licensee provided details regarding the processing of topographic data for the FLO-2D model and inclusion of the effects of sub-grid features.

Info Need No.	Information Need Description	Post-Audit Status
	validation process that are not represented in the FLO-2D grid, and (2) all available data that were used to identify and implement critical flowpaths in the FLO-2D model.	
2	**Local Intense Precipitation** Background: The FHRR description of the FLO-2D analyses of LIP flooding does not provide the required technical information on how buildings are incorporated into the model. There are several ways in which buildings can be incorporated in a FLO-2D model. The choice of representation of features in the model setup can significantly affect the magnitude and direction of precipitation that runs off the building roofs. Technical discussion and documentation of the model representation and setup is required to complete the review. Request: Provide clarification on how buildings and other permanent structures are accounted for in the DTM dataset and how their elevations are assigned in the FLO-2D model.	The response is adequate – RAI closed. (RAI response letter dated May 20, 2015, was submitted on docket). The licensee's response included details about how buildings and other permanent structures were accounted for in the FLO-2D model.
4	**Local Intense Precipitation** Background: The Wolf Creek FHRR does not provide a clear indication of whether the 6-hr LIP depth corresponds to a 1-mi^2 or a 10-mi^2 area. Also, the FHRR does not include the precipitation depth-duration curve for the LIP event.	The response is adequate – RAI closed. (RAI response letter dated May 20, 2015, was submitted on docket). The licensee's response included detailed clarifications on the LIP analysis using HMR and explained the process followed to determine the 1-mi^2 and 10-mi^2 area precipitation intensities.

Info Need No.	Information Need Description	Post-Audit Status
	Request: Please provide clarification on how the 6-hour, 1-mi^2 PMP depth was estimated and provide the precipitation depth-duration curve used for the LIP flood analysis.	
5	**Local Intense Precipitation** Background: The Wolf Creek FHRR states that the vehicle barrier system (VBS) used in the reevaluation analysis used the configuration from February 2013 and that changes to site layout have occurred since. Changes in configuration of the VBS could affect the flood analysis. Request: Please describe any changes to the VBS since February 2013. Also, provide a technical description of the process followed to incorporate these changes in the LIP flood analysis. *Caution:* treat appropriately any security-related information in your response.	The NRC staff evaluated the revised FLO-2D analysis for the changes in the site layout. Changes in the revised FLO-2D analysis include changes in VBS configuration; changes in roof elevations; addition of new buildings, trailers, and Sea-Vans; and changes in elevation from regrading in essential service water systems intake area and adjacent to the Control Building, Building roof elevations were assigned to allow overflow from one roof to another. Nailer strips on building roofs in powerblock area were implemented in the model. November 10, 2015 Audit Outcome: Wolf Creek verified that this was complete list of changes and provided clarification and details of the revised FLO-2D analysis. However, the docketed response to the original RAI-5 is outdated and should be updated with the revisions as described in the revised FLO-2D analysis. In addition, the FLO-2D model files and several clear figures depicting the revised site layout are needed to support the staff's FHRR review. **Revised Request**: Provide an updated response to RAI-5 that describes the changes in the site layout and LIP flood analysis as presented in the revised FHRR. Please provide the FLO-2D model input and output files for the revised LIP analysis, as well as publication-quality files (≥300 dpi, jpg or png format) of Figures 2-1 and 2-2 from Calculation No. 14-5262-F-02. Caution: treat appropriately any security-related information in your response. Please include the following items in the description: 1. whether the FLO-2D grid cell size changed 2. differences in elevation in regraded areas

Info Need No.	Information Need Description	Post-Audit Status
		3. the relative elevations of buildings in the powerblock area that allow overflow from one roof to another 4. whether there are potential gaps within the nailer strips along certain roof edges, and whether any walkdown was conducted to verify the condition of the nailer strips 5. differences in predicted water-surface elevations in the regraded areas and their effects on safety-related structures, systems and components. Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
6	**Local Intense Precipitation** Background: The Wolf Creek FHRR does not describe how precipitation runoff from building roofs was configured in the FLO-2D model. The NRC staff's review of the licensee's calculation packages in the NRC Library provided some FLO-2D model implementation details. The NRC staff confirmed that the licensee's FLO-2D model files are consistent with the description in the calculation packages. The staff noted that American National Standards Institute/American Nuclear Society (ANSI/ANS)-2.8-1992, Section 11.4 recommends that building runoff used in the LIP flood assessment allow evaluation of worst case roof drainage. This evaluation includes analysis of alternative points of roof drainage to maximize flood elevation adjacent to points of access	The RAI response provided on May 20, 2015, was adequate with respect to the licensee's original LIP analysis, but building roofs were treated differently in the revised LIP analysis. The response should be updated with respect to the revised LIP analysis. The licensee's response provided descriptions of the process followed to evaluate the "worst-case" roof drainage effects using the ANSI/ANS guidance (ANSI/ANS-2.8-1992, Section 11.4). In accordance with this guidance, the licensee's analysis assumed that all roof drainage systems were blocked (i.e., flow through downspouts were not credited). **Revised Request**: Provide an updated response to RAI-6 that addresses the revisions to the LIP analysis. Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).

Info Need No.	Information Need Description	Post-Audit Status
	and egress at safety-related structures, systems and components. Request: Please describe how drainage from facility roofs as represented in FLO-2D analyses is consistent with the recommendations of ANSI/ANS-2.8-1992, Section 11.4.	
7	**Local Intense Precipitation** Background: The values of Manning's roughness coefficients chosen to represent surface characteristics can significantly affect flow depths. The licensee used the lower end of the range of Manning's roughness coefficient values in the FLO-2D analyses. Request: Please provide justification for choosing Manning's roughness coefficient values at the lower end of the range which can result in lower flood water surface elevations.	The staff reviewed the licensee's revised FLO-2D calculation, which included a number of changes in surface characteristics of the site. For example, several grassy areas were converted to gravel, which would have a different range of Manning's roughness coefficient values. November 10, 2015 Audit Outcome: The licensee described the locations where land use changes had occurred. The licensee discussed assignment of land use categories and Manning's roughness coefficient values where changes occurred: categories were reassigned to an appropriate existing category, and the Manning's roughness coefficient for that existing category was used. The response should be updated with respect to the revised LIP analysis, and should include a map showing the changes in land use (surface characteristics). **Revised Request:** Provide an updated response to RAI-7 that describes any change to selection of Manning's roughness coefficient values related to the land use changes described in the revised FHRR. Provide a publication quality file (≥300 dpi, jpg or png format) of Figure 4-1 from Calculation No. 14-5262-F-02. Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information

Info Need No.	Information Need Description	Post-Audit Status
		needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
8	**Local Intense Precipitation** Background: The infiltration rates used during a precipitation event can significantly reduce the amount of runoff and therefore result in reduced flow depths. The FHRR used the Soil Conservation Service Curve Number method to estimate infiltration losses for the FLO-2D analyses. Request: Please provide a justification for accounting for infiltration losses during a high-intensity, extreme storm.	The NRC staff reviewed the licensee's revised FLO-2D calculation, which included a number of changes in surface characteristics of the site. November 10, 2015 Audit Outcome: The licensee described the locations where land use changes had occurred. The licensee discussed reassignment of land use categories to an appropriate existing category, and using the infiltration rate for that existing category. The response should be updated with respect to the revised LIP analysis. **Revised Request:** Provide an updated response to RAI-8 that describes any change to selection of infiltration loss rates related to the land use changes described in the revised FHRR. Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
9	**Local Intense Precipitation** Background: The Wolf Creek FHRR does not provide the locations of openings and penetrations for safety-related buildings and other plant components listed in FHRR Tables 3-1, 3-2, and 3-3. Because flow depths during the LIP event vary across the site, this information is needed to	The RAI response provided on May 20, 2015, was adequate with respect to the licensee's original LIP analysis; however, the site layout changes resulted in differences in the reevaluated LIP flow depths, and the staff could not determine whether the grid cell locations for the revised LIP analysis would be the same as for the original LIP analysis. The revised FHRR did not include the locations of openings and penetrations for safety-related buildings and other plant components listed in Tables 3-1, 3-2, and 3-3.

Info Need No.	Information Need Description	Post-Audit Status
	determine whether the reevaluated flood is bounded by the current design basis (CDB) at these locations. Request: Please provide FLO-2D model grid cell identifications from which the model results were extracted and processed to produce Tables 3-1, 3-2, and 3-3 in the FHRR.	November 10, 2015 Audit Outcome: The licensee noted that the locations (FLO-2D grid cell numbers) were provided in Appendix B of Calculation No. 14-5262-F-02, but not in the FHRR. The licensee also noted that some locations had changed with the revised site layout. The staff found that the results tables in Calculation No. 14-5262-F-02 provided additional information about critical locations related to new buildings and modified surface elevations that was not in the FHRR. This information is needed to document the staff's review of the revised LIP analysis. **Revised Request**: Please provide an updated response to RAI-9 that includes Tables 7-1 and 7-2 from Calculation No. 14-5262-F-02, with additional columns for structure description and grid cell number. For locations that have multiple grid cells associated with them (e.g., item numbers 30-36 in Table 7-2 of Calculation No. 14-5262-F-02), provide all grid cell numbers associated with the location. Provide a publication-quality file (≥300 dpi, jpg or png format) of Figure 4-3 from Calculation No. 14-5262-F-02. It is not necessary to revise Tables 9-1, 9-2, and 9-3 from the May 20, 2015, response in addition to Tables 7-1 and 7-2 from Calculation No. 14-5262-F-02. Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
10	**Hazard Input for the Integrated Assessment – Flood Event Duration Parameters** Background: Enclosure 2 of the 50.54(f) letter requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded	**Revised Request**: Please provide an updated response to RAI 10 since the original RAI response is based on the LIP FLO-2D simulation results which were subsequently updated as stated in the revised FHRR. The NRC staff has determined that the analysis has changed because of the revised FLO-2D and the revised RAI response that reflects the changes needs to be submitted on the docket.

Info Need No.	Information Need Description	Post-Audit Status
	by the CDB. The FHRR does not clearly describe effects of the selected flood scenarios that are proposed to be considered in the integrated assessment. Request: Please provide the applicable flood event duration parameters (see definition and Figure 6 of the NRC interim staff guidance document JLD-ISG-2012-05, "Guidance for Performing an Integrated Assessment," November 2012 (ADAMS Accession No. ML12311A214), associated with mechanisms that trigger an integrated assessment using the results of the flood hazard reevaluation. This includes (as applicable) the warning time the site will have to prepare for the event (e.g., the time between notification of an impending flood event and arrival of floodwaters on site) and the period of time the site is inundated for the mechanisms that are not bounded by the CDB. Also, please provide the basis or source of information for the flood event duration, which may include a description of relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and/or timing information derived from the hazard analysis.	Following the December 16, 2015, discussion, the NRC requested the licensee to provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
11	**Hazard Input for the Integrated Assessment - Flood Height and Associated Effects**	**Revised Request:** Please provide an updated response to RAI 11 since the original RAI response is based on the LIP FLO-2D simulation results which were subsequently updated as stated in the revised FHRR.

Info Need No.	Information Need Description	Post-Audit Status
	Background: Enclosure 2 of the 50.54(f) letter requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the flood hazard is not bounded by the CDB. The FHRR does not clearly describe effects of the selected flood scenarios that are proposed to be considered in the integrated assessment. Request: Please provide the flood height and associated effects (as defined in Section 9 of JLD-ISG-2012-05) that are not described in the FHRR for mechanisms that trigger an integrated assessment. This includes the following quantified information for each mechanism (as applicable): • wind waves and run-up effects • hydrodynamic loading, including debris • effects caused by sediment deposition and erosion • concurrent site conditions, including adverse weather conditions • groundwater ingress • other pertinent factors	Staff has determined that the analysis has changed because of the revised FLO-2D and the revised RAI response that reflects the changes needs to be submitted on the docket. Following the December 16, 2015, discussion, the licensee will provide the updated response on the docket and that would complete the information needs from the licensee. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256).
12	**Hazard Input for the Integrated Assessment - Comparison of Reevaluated Flood Hazard with Current Design Basis** Background: The request for information pursuant to the 50.54(f) letter dated March 12, 2012, provides	The licensee indicated in its response that the CDB flood parameters are the same as the CLB parameters. The May 20, 2015, RAI response was adequate.

Info Need No.	Information Need Description	Post-Audit Status
	guidance on the contents of the FHRR. Table 4-3 of the FHRR for Wolf Creek provides a comparison of the reevaluated flood hazards with the current licensing basis (CLB) instead of the CDB. Request: Please provide clarification for the inconsistencies identified in the FHRR with regard to the comparison of the reevaluated flood hazard to the CDB and submit a revised hazard comparison consistent with the instructions provided in the 50.54(f) letter. Provide an update to FHRR Table 4-3 that references the CDB and its comparison to the reevaluated flood hazard; provide updated FHRR information that is consistent with the updated table.	

I. EXIT MEETING/BRIEFING:

On December 18, 2015, the NRC staff closed out the discussion of the technical topics described above. The NRC staff determined that all staff questions were answered, but certain information would need to be provided to complete the documentation of the review. This information is described in Table 1, and amounts to changes made to the docketed response submitted on May 20, 2015, to staff's original RAI's. Because the licensee made changes to its FHRR after the submittal of that response, the staff requested that the licensee update those responses or explain how they were impacted by the changes to the evaluation. The licensee provided the updated response in a letter dated February 23, 2016 (ADAMS Accession No. ML16061A256)

ATTACHMENT 1

Table 1: List of References Reviewed by the NRC

Calculation No. 14-5262-F-02 Local Intense Precipitation FLO-2D Model Refinement Date: 10/12/2015
LIP Flooding Evaluation FLO-2D Simulation Model Computer Files

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

Sincerely,

/RA/

Lauren K. Gibson, Project Manager
Hazards Management Branch
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Docket Nos. 50-321 and 50-366

Enclosure:
Audit Report

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