



Tennessee Valley Authority, Post Office Box 2000, Spring City, Tennessee 37381-2000

September 16, 2013

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10 CFR 50.54(f)

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, D.C. 20555-0001

Watts Bar Nuclear Plant, Unit 2  
NRC Docket No. 50-391

**Subject: Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information Regarding Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors (TAC No. MD6726)**

The purpose of this letter is to provide information to support U.S. Nuclear Regulatory Commission (NRC) verification that the design of the WBN Unit 2 Emergency Core Cooling System, including the containment sump, addresses Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," for WBN Unit 2.

The NRC issued the Final Safety Evaluation on WCAP-16793-NP Revision 2, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid," on April 8, 2013 (Reference 1). Enclosure 1 provides a summary of the evaluation of WBN Unit 2 long-term core cooling consistent with the Limitations and Conditions of Reference 1. The unit-specific evaluation, in conjunction with previous TVA letters related to GL 2004-02 (References 2, 3, and 4), establishes that the WBN Unit 2 containment sump design conforms to the NRC requirements and regulations on recirculation from the containment sump during Design Basis Accidents.

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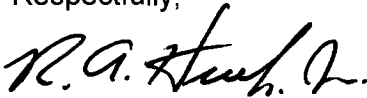
Supplemental Safety Evaluation Report (SSER) Open Item 59 states, "The staff's evaluation of the compatibility of the ESF system materials with containment sprays and core cooling water in the event of a LOCA is incomplete pending resolution of GSI-191 for WBN Unit 2 (Section 6.1.1.4)." This letter, in conjunction with Reference 4, provides the technical information that addresses this open item.

Enclosure 2 provides the status of the WBN Unit 2 commitments related to the resolution of GL 2004-02. The remaining outstanding commitments are associated with the physical installation of the plant modifications and the containment cleanliness walkdown to be performed prior to plant startup.

There are no new commitments in this letter. If you have any questions, please contact me at (423) 365-1260 or Gordon Arent at (423) 365-2004.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 16<sup>th</sup> day of September, 2013.

Respectfully,



Raymond A. Hruby, Jr.  
General Manager, Technical Services  
Watts Bar Unit 2

- References:
1. NRC Final Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report WCAP-16793-NP, Revision 2, "Evaluation of Long-Term Cooling Considering Particulate Fibrous and Chemical Debris in the Recirculating Fluid", dated April 8, 2013 (ADAMS Accession No. ML13084A154)
  2. TVA to NRC letter dated May 17, 2012, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Information to Generic Letter 2004-02, Potential Impact of Debris Blockage of Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors (TAC No. MD6726)" (ADAMS Accession No. ML12143A345)
  3. TVA to NRC letter dated April 29, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to Requests for Additional Information (RAIs) Regarding Generic Letter 2004-02, Potential Impact of Debris Blockage of Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors (TAC No. MD6726)" (ADAMS Accession No. ML11124A083)
  4. TVA to NRC letter dated March 4, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to Generic Letter (GL) 2004-02, Potential Impact of Debris Blockage of Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (ADAMS Accession No. ML110680248)
  5. NUREG-0847 Supplemental Safety Evaluation Report (SSER) 23, "Safety Evaluation Report Related to the Operation of Watts Bar Nuclear Plant, Unit 2, Docket No. 50-391, Tennessee Valley Authority," published July 2011 (ADAMS Accession No. ML11206A499)

Enclosures:

1. Summary of Watts Bar Unit 2 LOCADM Results and Response to Limitations and Conditions to WCAP-16793-NP
2. Status of TVA Commitments for Addressing Generic Letter 2004-02

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cc (Enclosures):

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**ENCLOSURE 1**  
**Tennessee Valley Authority**  
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**SUMMARY OF WATTS BAR UNIT 2 LOCADM RESULTS AND RESPONSE TO  
LIMITATIONS AND CONDITIONS TO WCAP-16793-NP**

The NRC approved Pressurized Water Reactor Owners Group (PWROG) Topical Report WCAP-16793-NP, Revision 2-A, "Evaluation of Long-Term Cooling Considering Particulate Fibrous and Chemical Debris in the Recirculating Fluid", in April 2013. Section 4.0 of the NRC Safety Evaluation Report (SER) specified 14 Limitations and Conditions associated with the use of WCAP-16793-NP, Revision 2-A. For plants that could show that there was a very low quantity of fibrous material inside containment that could impair Emergency Core Cooling System (ECCS) performance, NEI proposed and the NRC accepted that long-term core cooling was assured based on bounding criteria. TVA submitted Reference 2 that showed Watts Bar Nuclear Plant (WBN) Unit 2 was a low-fiber plant. TVA concluded that Reference 2, in conjunction with previous submittals related to the containment sump design, documented that TVA had addressed the corrective actions required by Generic Letter (GL) 2004-02 for WBN Unit 2. The NRC agreed that WBN Unit 2 was a low-fiber plant, but verbally requested that TVA perform a WBN Unit 2 specific LOCADM evaluation and provide a summary of the results of the evaluation.

The WBN Unit 2 specific LOCADM evaluation has been completed. The evaluation shows that long-term fuel clad temperatures and potential material deposition on the fuel cladding are much lower than the bounding conditions needed to verify long-term core cooling for a low-fiber plant. Specifically, the total fuel rod deposition thickness for the limiting case at WBN Unit 2 is 11.6 mils. This is well below the acceptance criteria of 50 mils. The maximum WBN Unit 2 fuel clad temperature with the core covered is 398°F. This is also well below the acceptance criteria average fuel clad temperature of 800°F.

The following provides a response to each of the limitations and conditions with respect to the application of WCAP-16793-NP, Revision 2-A to WBN Unit 2.

#### 4.0 LIMITATIONS AND CONDITIONS

- Licensees should confirm that their plants are covered by the PWROG sponsored fuel assembly tests by confirming that the plant available hot-leg break driving head is equal to or greater than that determined as limiting in the proprietary fuel assembly tests and that flow rate is bounded by the testing. Licensees should validate that the fuel types and inlet filters in use at the plant are covered by the test program (with the exception of LTAs). Licensees should limit the amount of fibrous debris reaching the fuel inlet to that stated in Section 10 of the WCAP (15 grams per fuel assembly for a hot-leg break scenario). Alternately, licensees may perform plant specific testing and/or evaluations to increase the debris limits on a site-specific basis. The available driving head should be calculated based on the core exit void fraction and loop flow resistance values contained in their plant design basis calculations, considering clean loop flow resistance and a range of break locations. Calculations of available driving head should account for the potential for voiding in the steam generator tubes. These tests shall evaluate the*

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*effects of increased fiber on flow to the core, and precipitation of boron during a postulated coldleg break, and the effect of p/f ratios below 1:1. The NRC staff will review plant specific evaluations, including hot- and cold-leg break scenarios, to ensure that acceptable justification for higher debris limits is provided. (Sections 3.1.2 (c), 3.1.2 (e), 3.3.1, 3.4.2, 3.8, 3.9 and 3.10 of this SE).*

**TVA Response**

TVA confirms that WBN Unit 2 is covered by the PWROG sponsored fuel assembly tests. WCAP-16793-NP, Revision 2A, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," states that the maximum delta pressure (dP) due to the presence of 15 grams of fiber is small and **all plants** (emphasis added) have a driving head greater than this value, so core flow will not be impeded. This statement was based on the AREVA testing conducted in support of WCAP-17057-P, Rev. 1, "GSI-191 Fuel Assembly Test Report for PWROG," that demonstrated that 15 grams of fiber per fuel assembly will not cause a blockage that can challenge long-term core cooling.

WBN Unit 2 fuel is Westinghouse Robust Fuel (RFA-2) with the Robust Protective Grid and the Standardized Debris Filter Bottom Nozzle. Testing established that the RFA-2 fuel is bounded by the limiting fuel used to establish the allowable limits presented in WCAP-16793.

The WBN Unit 2 fuel fiber content is 11.9 grams per fuel assembly. Because the WBN Unit 2 fuel fiber content is less than the 15 g per fuel assembly limit, WBN Unit 2 has adequate hot leg driving head to assure core cooling.

2. *Each licensee's GL 2004-02 submittal to the NRC should state the available driving head used in the evaluation of the hot-leg break scenario, the ECCS flow rates, and the results of the LOCADM calculations. Licensees should provide the type(s) of fuel and inlet filters installed in their plants, as well as the amount of fiber (gram per fuel assembly) that reaches the core. (Section 3.3.1 and 3.10 of this SE)*

**TVA Response**

The available driving head for the hot-leg break scenarios was developed generically, and the results were provided in WCAP-16793-NP, Rev. 2A. The WCAP evaluated a minimum available driving head that was acceptable for the fleet of Pressurized Water Reactors. This value was approximately 13 psid.

The LOCADM evaluation for WBN Unit 2 used plant-specific conditions and materials to determine a maximum cladding temperature and deposit thickness. The fuel cladding temperature and deposit thickness determined from the evaluation were compared to the conservative maximum deposition thickness of 50 mils (1,270 microns) and maximum acceptable temperature of 800°F as indicated in

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WCAP-16793-NP, Rev. 2A. The final calculated deposition thickness for WBN Unit 2 is 11.6 mils (294.7 microns), which is less than the recommended upper limit of 50 mils. The calculated maximum temperature of the fuel cladding during recirculation from the containment sump over the 30 days following the LOCA is calculated to be 398°F, which is less than the recommended maximum cladding temperature of 800°F.

WBN Unit 2 fuel is Westinghouse RFA-2 with the Robust Protective Grid and the Standardized Debris Filter Bottom Nozzle.

The low-fiber plant criterion from "Transmittal of GSI Resolution Criteria for 'Low Fiber' Plants", NEI, dated December 22, 2011, established that WBN Unit 2 is a low-fiber plant.

The WBN Unit 2 fuel fiber content is calculated assuming 15 pounds of fiber, 75% debris transport, 45% strainer bypass and 193 fuel assemblies (i.e.,  $[(15 \text{ lb} \cdot 0.75 \cdot 0.45 \cdot 453.6 \text{ gm/lb}) / 193] = 11.9 \text{ gm/assembly}$ ). The calculation uses NEI generic values adjusted for the plant-specific number of fuel assemblies as suggested by the NEI criteria. WBN Unit 2 has a fuel fiber content of 11.9 grams per fuel assembly.

3. *Section 3.1.4.3 of the WCAP states that alternate flow paths in the RPV were not credited. The section also states that plants may be able to credit alternate flow paths for demonstrating adequate LTCC. If a licensee chooses to take credit for alternate flow paths, such as core baffle plate holes, to justify greater than 15 grams of bypassed fiber per fuel assembly, the licensee should demonstrate, by testing or analysis, that the flow paths would be effective, that the flow holes will not become blocked with debris during a LOCA, that boron precipitation is considered, and that debris will not deposit in other locations after passing through the alternate flow path such that LTCC would be jeopardized. (Sections 3.3.1 and 3.4.2 of this SE)*

**TVA Response**

Alternate flow paths were not credited in determining the acceptability of the WBN Unit 2 ECCS design.

4. *Sections 3.2 and 3.3 of the WCAP provide evaluations to show that even with large blockages at the core inlet, adequate flow will enter the core to maintain LTCC. The staff recognizes that these calculations show that significant head loss can occur while maintaining adequate flow. However, the analyses have not been correlated with debris amounts. Therefore, the analyses cannot be relied upon to demonstrate adequate LTCC. (Sections 3.3.3 and 3.4 of this SE)*

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**TVA Response**

The determination that WBN Unit 2 has adequate Long Term Core Cooling (LTCC) was not based on the calculations of acceptable LTCC with large blockages and significant head loss. WBN Unit 2 core inlet head loss is bounded by the generic evaluations and test results for low fiber plants.

5. *In RAI Response number 18 in Reference 13, the PWROG states that numerical analyses demonstrated that, even if a large blockage occurs, decay heat removal will continue. The NRC staff's position is that a plant must maintain its debris load within the limits defined by the testing (e.g., 15 grams per assembly). Any debris amounts greater than those justified by generic testing in this WCAP must be justified on a plant-specific basis. (Sections 3.4.2 and 3.10 of this SE)*

**TVA Response**

The WBN Unit 2 fuel fiber content of 11.9 gm/assembly is less than the 15 gm/assembly target value. Thus, the WBN Unit 2 debris amounts are justified by generic testing in WCAP-16793-NP, Rev. 2A, consistent with the NRC's position.

6. *The fibrous debris acceptance criteria contained in the WCAP may be applied to fuel designs evaluated in the WCAP. Because new or evolving fuel designs may have different inlet fittings or grid straps that could exhibit different debris capture characteristics, licensees should evaluate fuel design changes in accordance with 10 CFR 50.59 to ensure that new designs do not impact adequate long term core cooling following a LOCA. (Section 3.4.2 of this SE)*

**TVA Response**

WBN Unit 2 fuel is Westinghouse RFA-2 with the Robust Protective Grid and the Standardized Debris Filter Bottom Nozzle. Testing and evaluations as required by this condition established that the WBN Unit 2 RFA-2 fuel is bounded by the limiting fuel used to establish the allowable limits presented in WCAP-16793.

7. *Sections 2 and 4.3 of the WCAP establish 800 degrees Fahrenheit as the acceptance limit for fuel cladding temperature after the core has been re-flooded. The NRC staff accepts a cladding temperature limit of 800 degrees Fahrenheit as the long-term cooling acceptance basis for GSI-191 considerations. Each licensee's GL 2004-02 submittal to the NRC should state the peak cladding temperature predicted by the LOCADM analysis. If a licensee calculates a temperature that exceeds 800 degrees Fahrenheit, the licensee must submit data*



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*to justify the acceptability of the higher clad temperature. (Sections 3.2, 3.4.3, 3.4.4, and 3.10 of this SE)*

**TVA Response**

The peak cladding temperature calculated by LOCADM for WBN Unit 2 is 398°F, which is less than the acceptance criterion of 800°F.

8. *As described in the Limitations and Conditions for WCAP-16530-NP (ADAMS Accession No. ML073520891) (Reference 21)5, the aluminum release rate equation used in TR WCAP-16530-NP provides a reasonable fit to the total aluminum release for the 30-day ICET tests but under-predicts the aluminum concentrations during the initial active corrosion portion of the test. Actual corrosion of aluminum coupons during the ICET 1 test, which used sodium hydroxide (NaOH), appeared to occur in two stages; active corrosion for the first half of the test followed by passivation of the aluminum during the second half of the test. Therefore, while the 30-day fit to the ICET data is reasonable, the WCAP-16530-NP-A model under-predicts aluminum release by about a factor of two during the active corrosion phase of ICET 1. This is important since the incore LOCADM chemical deposition rates can be much greater during the initial period following a LOCA, if local conditions predict boiling. As stated in WCAP16530-NP-A, to account for potentially greater amounts of aluminum during the initial days following a LOCA, a licensee's LOCADM input should apply a factor of 2 increase to the WCAP-16530-NP-A spreadsheet predicted aluminum release, not to exceed the total amount of aluminum predicted by the WCAP-16530-NP-A spreadsheet for 30 days. In other words, the total amount of aluminum released equals that predicted by the WCAP-16530-NP-A spreadsheet, but the timing of the release is accelerated. Alternately, licensees may choose to use a different method for determining aluminum release but licensees should not use an aluminum release rate equation that, when adjusted to the ICET 1 pH, under-predicts the aluminum concentrations measured during the initial 15 days of ICET 1. (Section 3.7 of this SE)*

**TVA Response**

The deposit thickness calculated for WBN Unit 2, 11.6 mils, accounts for the under-predicted aluminum release rate during the active corrosion phase by doubling the available aluminum surface area while maintaining the 30-day total aluminum release.

9. *In the response to NRC staff RAIs, the PWROG indicated that if plant-specific refinements are made to the WCAP LOCADM base model to reduce conservatisms, the user should demonstrate that the results still adequately bound chemical product generation. If a licensee uses plant-specific refinements to the WCAP-16530-NP-A base model that reduces the chemical source term considered*

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*in the downstream analysis, the licensee should provide a technical justification that demonstrates that the refined chemical source term adequately bounds chemical product generation. This will provide the basis that the reactor vessel deposition calculations are also bounding. (Section 3.7 of this SE)*

**TVA Response**

No plant-specific refinements were made to the LOCADM base model to reduce conservatism for WBN Unit 2.

10. *The WCAP states that the material with the highest insulating value that could deposit from post-LOCA coolant impurities would be sodium aluminum silicate. The WCAP recommends that a thermal conductivity of 0.11 BTU/(h-ft-°F) be used for the sodium aluminum silicate scale and for bounding calculations when there is uncertainty in the type of scale that may form. If plant-specific calculations use a less conservative thermal conductivity value for scale (i.e., greater than 0.11 BTU/(h-ft-°F)), the licensee should provide a technical justification for the plant-specific thermal conductivity value. This justification should demonstrate why it is not possible to form sodium aluminum silicate or other scales with thermal conductivities less than the selected value. (Section 3.7 of this SE)*

**TVA Response**

No plant-specific refinements were made to the LOCADM base model to reduce conservatism for WBN Unit 2. The recommended value of 0.11 BTU/(hr-ft-°F) was used in the WBN Unit 2 LOCADM deposition evaluation.

11. *Licensees should demonstrate that the quantity of fibrous debris transported to the fuel inlet is less than or equal to the fibrous debris limit specified in the proprietary fuel assembly test reports and approved by this SE. Fiber quantities in excess of 15 grams per fuel assembly must be justified by the licensee. Licensees may determine the quantity of debris that passes through their strainers by (1) performing strainer bypass testing using the plant strainer design, plant-specific debris loads, and plant-specific flow velocities, (2) relying on strainer bypass values developed through strainer bypass testing of the same vendor and same perforation size, prorated to the licensee's plant specific strainer area; approach velocity; debris types, and debris quantities, or (3) assuming that the entire quantity of fiber transported to the sump strainer passes through the sump strainer. The licensee's submittals should include the means used to determine the amount of debris that bypasses the ECCS strainer and the fiber loading expected, per fuel assembly, for the cold-leg and hot-leg break scenarios. Licensees of all operating PWRs should provide the debris loads, calculated on a fuel assembly basis, for both the hot-leg and cold-leg break cases in their GL 2004-02 responses. (Section 3.10 of this SE)*

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**TVA Response**

The following low-fiber plant criterion was extracted from "Transmittal of GSI Resolution Criteria for 'Low Fiber' Plants", NEI, dated December 22, 2011, and was addressed in Reference 2 to justify that WBN Unit 2 is a low-fiber plant.

The WBN Unit 2 fuel fiber content, calculated in accordance with the NEI low-fiber plant criteria, is 11.9 gm/assembly. This value is less than the 15 gm/assembly target value. Thus, no detailed WBN Unit 2 specific strainer performance bypass evaluations were required.

12. *Plants that can qualify a higher fiber load based on the absence of chemical deposits should ensure that tests for their conditions determine limiting head losses using particulate and fiber loads that maximize the head loss with no chemical precipitates included in the tests. (Section 3.3.1 of this SE.) Note that in this case, licensees must also evaluate the other considerations discussed in Item 1 above.*

**TVA Response**

WBN Unit 2 does not need to qualify a higher fiber load.

13. *Licensees should verify that the size distribution of fibrous debris used in the fuel assembly testing referenced by their plant is representative of the size distribution of fibrous debris expected downstream of the plant's ECCS strainer(s). (Section 3.4.2.1 of this SE)*

**TVA Response**

The size distribution of fibrous debris for WBN Unit 2 is appropriate. The only fiber available in the sump water is latent fiber. There is no fibrous insulation in the zone of influence. NUKON commercial fiberglass was assumed to be representative of latent fiber per NUREG/CR-6224. NUKON fiber was also used to represent fiber in WCAP-17057-P, Rev. 1.

14. *The "Margin Calculator," referenced in References 11 and 12, has not been submitted to the NRC under formal letter, and NRC staff has not performed a detailed review of the document. Therefore, NRC staff expects licensees to base their GL 2004-02 invessel effects evaluations on the information provided in the proprietary test reports and associated RAI responses (References 8, 16, 17, 11 and 12), including the conditions and limitations stated in this SE, and existing plant design-basis calculations and analyses.*

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**TVA Response**

WBN Unit 2 did not use the "Margin Calculator" to determine in-vessel effects. The "Margin Calculator" was available as a tool for use by the PWROG to perform a preliminary evaluation of debris effects on fuel. The WBN Unit 2 in-vessel effects were determined based on WCAP-17057-P-A, Rev. 1, and the plant-specific LOCADM analysis.

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**STATUS OF TVA COMMITMENTS FOR ADDRESSING GENERIC LETTER 2004-02**

The commitments TVA made to the NRC with respect to addressing GL 2004-02 were provided in TVA's March 4, 2011 letter to NRC titled "Watts Bar Nuclear Plant (WBN) Unit 2 – Response to Generic Letter (GL) 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." The commitments and their current status are provided below.

1. WBN Unit 2 will install sump modifications per the requirements of Generic Letter (GL) 2004-02 prior to Unit 2 fuel load.

**Open** – Engineering Document Construction Release (EDCR) 53580 has been issued to install the new sump strainers – confirmatory inspection item.

2. A confirmatory walkdown for loose debris will be performed on Unit 2 after containment work is completed and the containment has been cleaned. This walkdown will be completed prior to startup.

**Open** – confirmatory inspection item.

3. New throttle valves will be installed in the CVCS and SI injection lines to the RCS. The new valves will be opened sufficiently to preclude downstream blockage.

**Open** – EDCR 54783 has been issued to install the new valves – confirmatory inspection item.

4. The current WBN Unit 1 TVA protective coating program contains requirements for conducting periodic visual examinations of Coating Service Level I and Level II protective coatings. The Unit 2 program will be the same.

**Complete** – Watts Bar Procedure MAI-5.3, "Protective Coatings," contains the inspection requirements. This procedure applies to both units.

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**STATUS OF TVA COMMITMENTS FOR ADDRESSING GENERIC LETTER 2004-02**

5. Procedural controls will be put in place at WBN Unit 2 to ensure that potential quantities of post-accident debris are maintained within the bounds of the analyses and design bases that support ECCS and CSS recirculation functions.

**Complete** –The following WBN procedures have been issued to address material control and containment cleanliness: Watts Bar Surveillance Instruction 2-SI-304-2, "18 Month ECCS Containment Sump Inspection"; Technical Instruction 2-TI-61.003, "Containment Debris Log"; Technical Instruction TI-12.07A, "Containment Access Modes 1-4"; Technical Instruction TI-12.07B, "Containment Access Modes 5-6"; and Technical Instruction TI-279, "Modification Review for Sources and Quantities of Aluminum and Zinc." These procedures in conjunction with upper-tier TVA Nuclear Program Procedures provide the necessary procedural controls. These technical and programmatic controls assure design, maintenance, and modification activities are conducted in a manner that assures operability of the containment sump. Pages E1-55 and 56 of Enclosure 1 to Reference 4 provide the list of specific upper-tier program documents noted above.

6. TVA will complete the WBN in-vessel downstream effects evaluation discussed in the supplemental response to Generic Letter 2004-02 following issuance of the final NRC Safety Evaluation Report for Topical Report No. WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid."

**Complete** – This commitment is addressed in this letter.

7. The design basis of the modified emergency sump strainer has been incorporated into the plant's current licensing basis. The WBN Unit 2 Final Safety Analysis Report (FSAR) will be amended to include this information.

**Complete** – The design basis for the modified sump strainer was incorporated in the Unit 2 FSAR in Amendments 95 and 110.