Enclosure 3 is to be withheld from public disclosure under 10 CFR § 2.390. When separated from these enclosures, this letter is decontrolled.

TVA

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

July 18, 2011

10 CFR 50.4
10 CFR 2.390(b)(4)

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 – Response to Request for Additional Information Regarding June 28, 2011 NRC Audit**

References:

1. NRC letter to TVA dated April 27, 2011, "Watts Bar Nuclear Plant, Unit 2 - Audit Report of Westinghouse Documents Relating to Final Safety Analysis Report Accident Analyses (TAC NO. ME4620)"
2. TVA letter to NRC dated May 13, 2011, "Watts Bar Nuclear Plant (WBN) Unit 2 – Additional Responses to Request for Additional Information Regarding (1) Large Break Loss of Coolant Accident, (2) Steam Line Break, and (3) Miscellaneous Analysis"
3. Westinghouse Letter WBT-D-3298-NP, "Response to NRC Audit Questions on BMI SBLOCA," dated July 11, 2011
4. WCAP-16468-NP, "Risk Assessment of Potential Cracking in Bottom Mounted Instrumentation Nozzles," September 2005.
5. Westinghouse Document WBT-D-3306, "Revised WINCISE™ Response to Matrix Question 377 Items 5 and 7.a," dated July 11, 2011
6. Westinghouse Document WBT-D-3301, "Response to NRC Audit RAIs on LBLOCA," dated July 15, 2011, Proprietary
7. Westinghouse Document WBT-D-3299, "Response to NRC Questions on Post LOCA," dated July 11, 2011

The purpose of this letter is to provide responses to requests for additional information (RAIs) identified during a June 28, 2011 NRC audit at Westinghouse on (1) bottom mounted instrument (BMI) tube failure, (2) in-core instrumentation, (3) Large Break Loss of Coolant Accident (LBLOCA) analysis, and (4) boron precipitation.

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NRR

Reference 1 documented an audit performed by the NRC of various FSAR Chapter 15 accident analyses for WBN Unit 2. TVA provided responses to a number of the items identified in the audit report in Reference 2. The NRC subsequently concluded that a second audit should be performed to address remaining open items as well as additional questions. Reference 1 also requested a WBN Unit 2 specific analysis of a BMI tube failure. Reference 4 addressed the BMI tube failures including the thermal-hydraulic response for a number of different plant types. Additional questions were raised about the applicability of the report to WBN Unit 2 BMI tube failure thermal hydraulic response. Enclosure 1 of this letter provides additional information confirming the applicability of the BMI generic Small Break LOCA used in WCAP-16468 to WBN Unit 2.

Enclosure 2 provides updated responses to RAIs on WINCISE™ and the BEACON code as well as additional information on the verification and validation of the BEACON code as discussed during the June 28 audit.

Enclosure 3 provides additional information as discussed in the June 28 audit with regard to post LOCA core cooling. Specific items include downcomer boiling, plots of downcomer level for longer time periods, decay heat multipliers, and time step studies.

Enclosure 3 contains information proprietary to Westinghouse. Accordingly, TVA respectfully requests that this proprietary information be withheld from public disclosure in accordance with 10 CFR 2.390. Enclosure 4 provides the supporting affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.390. U.S. Nuclear Regulatory Commission correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should reference CAW-11-3149 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Enclosure 5 provides the non-proprietary version of Enclosure 3.

Enclosure 6 provides additional information relative to discussions during the June 28 audit with respect to boron precipitation and associated operator actions and timing of switchover to hot leg recirculation and steam condensation.

Enclosure 7 provides the new commitments made in this letter.

If you have any questions, please contact Bill Crouch at (423) 365-2004.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 18th day of July, 2011.

Respectfully,

David Stinson
Watts Bar Unit 2 Vice President

Enclosures:

1. Additional Responses to Request for Additional Information Regarding Bottom Mounted Instrument (BMI) Tube Failure
2. Response to New RAIs Received the Week of May 27, 2011, Regarding Incore Instrumentation
3. Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2-Proprietary
4. Watts Bar Nuclear Plant Unit 2 Affidavit for Withholding Proprietary Information from Public Disclosure
5. Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2-Non-Proprietary
6. Additional Responses to Request for Additional Information Long Term Post LOCA Core Cooling
7. New Regulatory Commitments

cc (Enclosures):

U.S. Nuclear Regulatory Commission
Region II
Marquis One Tower
245 Peachtree Center Ave., NE Suite 1200
Atlanta, Georgia 30303-1257

NRC Resident Inspector Unit 2
Watts Bar Nuclear Plant
1260 Nuclear Plant Road
Spring City, Tennessee 37381

Enclosure 1
TVA Letter Dated July 18, 2011
Additional Responses to Request for Additional Information
Regarding Bottom Mounted Instrument (BMI) Tube Failure

During the audit discussed in Reference 1, the staff requested an analysis of a BMI tube failure. During the audit a generic report (Reference 2) on instrument tube failure was provided. The staff again asked for a specific analysis of a tube failure for WBN. During the June 28 audit, Westinghouse provided additional information on the applicability of the generic thermal-hydraulic BMI Nozzle Failure Analysis to WBN Unit 2.

Response:

The following response to NRC audit questions regarding Generic BMI Nozzle Failure Analysis was provided in Westinghouse to TVA letter WBT-D-3298, Response to NRC Audit Question on BMI Small Break Loss of Coolant Accident (SBLOCA) dated July 11, 2011.

Core uncovery during a SBLOCA event is the result of a mass flow imbalance between the break flow and injected emergency core cooling system (ECCS) flow. If the break flow is in excess of the makeup flow provided by the ECCS, the potential for core uncovery exists. In the early phases of a typical SBLOCA transient the break flow consists of either sub-cooled liquid or a low quality two-phase mixture. Once the mixture level drains below the break elevation the break flow transitions to vapor, decreasing the rate of reactor coolant system (RCS) mass loss with respect to time and allowing RCS depressurization due to the venting steam. Due to its location, the BMI nozzle break flow will be sub-cooled liquid or a low quality two-phase mixture for the duration of the transient; therefore, the depressurization of the RCS can only be dictated by the operability of the steam dump system, Steam Generator (SG) (and possibly pressurizer) Power Operated Relief Valve (PORV) operation, and operator induced cooldown and depressurization of the primary system. The unique behavior of the break flow diminishes some of the effects that would be considered important for a cold leg small break scenario. With steam produced by the core unable to effectively vent through the break, the loop seal clearing phenomena that drive the RCS depressurization in an FSAR analysis become less important. Assuring that sufficient ECCS flow is delivered to mitigate a BMI LOCA event is dependent upon operator action to depressurize the RCS.

In 2005, the PWROG undertook an analysis effort to quantify the risk basis of BMI failures. This is reported in WCAP-16468-NP (Reference 1). While this WCAP is a risk based assessment, many SBLOCA analyses were performed in support of it which can be considered a good deterministic basis for quantifying successful mitigation of such an event. It should be noted that the thermal hydraulic (T & H) analysis provided in Reference 1 was performed using the NOTRUMP computer code to provide success criteria for the probabilistic risk assessment work provided therein. The BMI nozzles are considered part of the reactor vessel; therefore, BMI failures would be classified as a beyond design basis event as 10 CFR 50.46 dictates addressing only pipe breaks in the RCS. Vessel breaks are considered incredible events; as such, the Reference 1 SBLOCA analysis does not retain all of the conservatisms of an FSAR type Appendix K ECCS performance analysis. Among the more realistic assumptions considered in the BMI nozzle failure analysis are the ANS-5.1 1979 + 2σ decay heat standard and a combination of the Henry-Fauske and Homogeneous Equilibrium Critical Flow Models (H-F/HEM). The Moody break flow model required by Appendix K generally over predicts mass loss under two-phase break flow conditions; the H-F/HEM model was implemented in the NOTRUMP code to provide a more realistic calculation of break flow. Additionally, operator action to initiate a cooldown and depressurization of the RCS is credited to occur 45 minutes after the opening of the break. This time was based on solicitation of a number of operational staffs when the program was undertaken.

The following provides discussion on cooldown capability, ECCS performance, and power/mass comparisons to further show applicability of the Reference 1 analysis to Watts Bar Unit 2:

- ES-1.2: Post LOCA Cooldown and Depressurization

  Reference 1 initiates operator action to cooldown and depressurize the RCS 45 minutes from the start of the transient (time to initiate Emergency Response Guideline ES-1.2, "Post LOCA Cooldown and Depressurization", Step 8, "RCS cooldown to cold shutdown") with a cooldown rate not to exceed 100°F/hr. Discussions with TVA operational staff confirmed that RCS cooldown and depressurization will begin within 30 minutes from the start of the transient at a maximum cooldown rate of 100°F/hr. Only this cooldown was modeled in the BMI T&H analyses. However, other operator actions exist to further promote prompt core cooling in these type of events should they be required. They are as follows:

- FR-C.1: Response to Inadequate Core Cooling

  In the event that the 100°F/hr cooldown outlined in ES-1.2 is not sufficient to establish adequate core cooling the operations staff will enter Functional Restoration Guideline (FR)- C.1. This procedure is entered from a red path condition of the Core Cooling Critical Safety Function Status Tree (F-0.2) to restore adequate core cooling. If the core exit thermocouples display temperatures in excess of 1200°F, or the reactor vessel level indicating system (RVLIS) is at core mid-plane (or less) and core exit thermocouples exceed a temperature of 700°F, FR-C.1 is entered. Note that any of the functional restoration guidelines take priority over the EOP step in effect. Therefore, the operators will direct their attention to performing this FR immediately should the circumstances dictate. Among other things, FR-C.1 directs operators to:

  a) Dump steam using the steam dump system at the maximum possible rate. If the steam dump system is not available, steam is dumped to atmosphere via the SG PORVs at the maximum rate (no limit on RCS temperature time rate of change).

     Note that the steam dump system at Watts Bar Unit 2 is rated at 85% capacity and the SG PORVs are rated at ~25% capacity. With SG pressure near the design limit in this case, either option should produce ample primary side condensation and temperature reduction to effectively reduce break flow, increase ECCS flow and allow the accumulators to inject. In addition, there will be reflux condensation cooling benefits as well. If core exit temperatures are still in excess of 1200°F, then

  b) Start a reactor coolant pump to promote core cooling; this can only be done if auxiliary feedwater and off site power are available. If either is not available, or core cooling still cannot be established, then

c) Open all pressurizer PORVs and any other vent path from the RCS to containment.

Based on the above, should an inadequate core cooling condition occur, FR-C.1 will direct operators to use all means possible to depressurize the system and provide sufficient core cooling capability. This is not credited in the generic analysis; however, it provides sufficient means of plant depressurization to mitigate a BMI failure at Watts Bar Unit 2.

- Emergency Core Cooling System Performance

  WCAP-16468-NP groups plants based on ECCS configuration/capability. Watts Bar Unit 2 is classified as a 4-loop high pressure plant. The "high pressure" designation indicates the overall ECCS includes safety grade charging pumps that are capable of providing injection up to the pressure set-point of the pressurizer safety valves (minimum of 2500 psig).

  Typically these pumps can inject at even higher pressures. Also included in the ECCS are intermediate head safety injection pumps in which the shut-off head is on the order of 1500-1600 psig; as such, there will be at least two pumps providing ECCS injection during this time. Again, the use of the generic analysis flow rates is considered acceptable for Watts Bar Unit 2 since all of the 4-loop high pressure ECCS designs use essentially the same design criteria and functional specifications, including those for the ECCS pumps. Further, given the operator induced depressurization, any differences will become less prominent at lower RCS pressures since time rate of change on RCS pressure due to the cooldown is significant enough to compensate for this in a rapid manner. As such, the best estimate ECCS flows assumed in Reference 1 are deemed representative for Watts Bar Unit 2.

- Core Thermal Power and RCS Inventory

  The Reference 1 analysis considers a higher core thermal power than the rated thermal power of Watts Bar Unit 2 (3587 MWt vs. 3480 MWt, respectively) and comparable initial RCS inventories (~509,000 lbm, Reference 1 vs. ~496,000 lbm, Watts Bar Unit 2).

- Pressurizer PORV Capacity

  Although not utilized in the generic analysis, pressurizer PORVs can be opened to further accelerate RCS depressurization if necessary for core cooling. The pressurizer PORVs utilized at Watts Bar Unit 2 can pass greater than 180,000 lbm/hr vapor flow at 2250 psia (69.6 MW/lbm/s). The Watts Bar units have two of these relief valves. These will yield more than enough capacity to depressurize the RCS should this become necessary. Note that the use of pressurizer PORVs was not modeled in the Reference 1 generic analysis.

The SBLOCA analysis included in WCAP-16468-NP demonstrates, using realistic modeling assumptions, that with operators taking action within 45 minutes to cool down and depressurize the RCS, an equivalent 1.25-inch diameter break size (approximate BMI nozzle failure) can be mitigated in a high pressure 4-loop plant without uncovering the core. Additionally, generic analysis has shown (using best estimate ECCS flow rates) that if no failure of ECCS equipment is assumed to occur, a high pressure 4-loop plant can mitigate a BMI nozzle failure without uncovering the core with no credit taken for operator action to depressurize the RCS. Based on the above discussion of key parameters influencing the BMI SBLOCA response, the applicability of the generic evaluation provided in WCAP-16468-NP can reasonably be extended to include Watts Bar Unit 2. Additionally, it should be noted that the PRA analysis of Reference 1 concluded that the BMI nozzle failure was a small contributor to the core damage frequency (CDF) and large early release frequency (LERF).

Reference:

WCAP-16468-NP, "Risk Assessment of Potential Cracking in Bottom Mounted Instrumentation Nozzles," September 2005.

Enclosure 2
TVA Letter Dated July 18, 2011

Response to New RAIs Received the Week of May 27, 2011, Regarding Incore Instrumentation

The NRC requested clarifications and additional information regarding item 5 and 7.a from the May 12, 2011 public meeting on Instrumentation and Control and TVA letter to NRC, "Responses to Licensee Open Items to be Resolved for SER Approval," dated June 28, 2011.

Response:

Westinghouse to TVA letter WBT-D-3306, Revised WINCISE™ Responses to Matrix Question 377 Items 5 and 7a, dated July 11, 2011 provided the following requested information as was discussed during the June 28 audit.

5. The uncertainty methodology used to establish the number and distribution of required Self-Powered Detector (SPD) sensors is described in detail in WCAP-12472 Addendums 1 and 2. Specifically, the uncertainty methodology is described in Section 5 of Addendum 1 and the basis for the requirements on the number and distribution of sensors is provided Section 6 of Addendum 2. The power cutoff was established to provide a lower limit for power distribution related uncertainty analysis used to develop the total peaking factor measurement uncertainty limits described in Section 5 of Addendum 1. These documents have already been submitted and approved by the staff. The Watts Bar Unit 2 BEACON System does not use the Core Exit Thermocouple (CET) signals, so there is no relevant discussion possible.

   A Watts Bar Unit 2 specific analysis of the appropriate peaking factor uncertainties to apply to the core peaking factors measured using the Watts Bar Unit 2 WINCISE™ System as input will be performed shortly after completion of the BEACON 7 software version. The analysis will be performed as described in Section 5 of Addendum 1 to WCAP-12472. The resulting base peaking factor uncertainties, as well as the method required to adjust the peaking factor uncertainty based on the number and distribution of operable SPD elements, will be contained in the Watts Bar Unit 2 Core Operating Limits Report (COLR).

7a. WCAP-12472 Addendum 1-A was approved by the NRC for use with fixed in-core detector systems. The WINCISE™ System to be used at Watts Bar Unit 2 is a fixed incore detector system that is functionally identical to the fixed in-core detector systems described in Addendum 1 of WCAP-12472. The in-core detector assemblies used at Watts Bar Unit 2 are constructed using Vanadium detector elements as described in Addendum 2 to WCAP-12472. These facts support the conclusion that there are no changes to staff approved BEACON methodology in the Watts Bar Unit 2 BEACON System. Consequently, there are no planned addenda to WCAP-12472 that impact Watts Bar Unit 2.

Enclosure 4
TVA Letter Dated July 18, 2011

Watts Bar Nuclear Plant Unit 2 Affidavit for Withholding Proprietary Information from Public Disclosure

Westinghouse

Westinghouse Electric Company
Nuclear Services
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-4643
Direct fax: (724) 720-0754
e-mail: greshaja@westinghouse.com
Proj letter: WBT-D-3301

CAW-11-3210

July 15, 2011

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: "Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-11-3210 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Tennessee Valley Authority.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference this letter, CAW-11-3210 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance

Enclosures

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. A. Gresham

J. A. Gresham, Manager
Regulatory Compliance

Sworn to and subscribed before me
this 15th day of July 2011

Cynthia Olesky

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Cynthia Olesky, Notary Public
Manor Boro, Westmoreland County
My Commission Expires July 16, 2014
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390; it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in "Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2" (Proprietary), for submittal to the Commission, being transmitted by Tennessee Valley Authority letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with the NRC review of the Watts Bar Unit 2 license application.

This information is part of that which will enable Westinghouse to:

(a) Assist the customer in obtaining NRC review of the Watts Bar Unit 2 license.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of this information to its customers for purposes of plant specific LOCA analysis for licensing basis applications.

(b) Its use by a competitor would improve their competitive position in the design and licensing of a similar product for LBLOCA analyses.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar calculations and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

Tennessee Valley Authority

Letter for Transmittal to the NRC

The following paragraphs should be included in your letter to the NRC:

Enclosed are:

1. __ copies of "Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2" (Proprietary)

2. __ copies of "Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2" (Non-Proprietary)

Also enclosed is the Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-11-3210, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice.

As Item 1 contains information proprietary to Westinghouse Electric Company LLC, it is supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.390 of the Commission's regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should reference CAW-11-3210 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Enclosure 5
TVA Letter Dated July 18, 2011

Response to June 28 through June 30, 2011
NRC Audit RAIs on LBLOCA for
Watts Bar Unit 2-Non-Proprietary

Response to June 28 through June 30, 2011 NRC Audit RAIs on LBLOCA for Watts Bar Unit 2

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, PA 16066

RAI: The staff wishes to receive and review transient plots of the following parameters for the limiting large break LOCA (with respect to downcomer boiling) transient:

- **a. Downcomer level and fluid temperatures**
- **b. Containment pressure**
- **c. RCS pressure**
- **d. Heat transfer coefficient at the hot spot**
- **e. PCT**
- **f. Sink Temperature at the PCI location**
- **g. Core level**
- **h. LPSI and HPSI injection mass flow rates**
- **i. Heat transfer from the barrel wall and thermal shield**
- **j. RWST temperature**

The parameters from a case with downcomer boiling were provided as outlined below.

a. Downcomer Level and fluid temperatures: provided in Figures 3, 4, 7, and 8 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

b. Containment pressure: provided in Figure 9 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

c. RCS pressure: provided in Figures 5 and 6 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

d. Heat Transfer coefficient at the hot spot: provided in Figures 14 and 15 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

e. Peak cladding temperature (PCT): provided in Figure 11 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

f. Sink Temperature at the [PCT] location: provided in Figures 12 and 13 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

g. Core level: provided in Figure 16 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

h. Low pressure safety injection and high pressure safety injection mass flow rates: provided in FSAR Table 15.4-23

i. Heat transfer from the barrel wall and thermal shield: Response provided in RAI 3 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

j. Refueling water storage tank (RWST) temperature: Response provided in RAI 1 of LTR-LIS-11-278, Rev. 1 → WBT-D-3108 → 5-13-11 TVA Letter to NRC

RAI: Westinghouse will also be asked to provide information, previously requested by the staff, which pertains to:

1. **Condensation model and maximization of condensation**
2 **The effect of the time step size on the results, down to and including 0.001 sec.**
3. **Confirmation of the correct conductivity in the downcomer walls**
4. **Values for the lateral k-factors in the downcomer (e.g., based on Idlechik)**
5. **The decay heat multiplier used in the limiting large break LOCA analysis**
6. **The nodalization diagram for the WCOBR/TRAC model.**

1. Condensation model and maximization of condensation

Note that italics identify revision to previous response.

Validation and treatment of Emergency Core Cooling System (ECCS) condensation in Westinghouse Best-Estimate LOCA methodologies is discussed in detail in Section 15-3 and Section 25-9 of WCAP-12945-P-A (Reference 1). [

]^{a,c}

ECCS condensation is not maximized, [

]^{a,c} *If condensation were to be maximized, the water temperature in the downcomer will increase. The hotter water, if it is still subcooled, will reach saturation and begin to boil sooner. If condensation is not maximized, the colder water will contribute to continued subcooling of the water in the downcomer and delay downcomer boiling.*

The subcooling in various regions of the downcomer for the Watts Bar 2 limiting PCT/MLO case is inspected during the period of downcomer boiling (and corresponding cladding heatup), which occurs from about 100 seconds to 280 seconds (Figures 1 and 2). [

]^{a,c}

[

]^{a,c}

References:

1. Bajorek, S. M., et al., March 1998, "Code Qualification Document for Best Estimate LOCA Analysis," Volume 1 Revision 2, and Volumes 2 through 5, Revision 1, WCAP-12945-P-A (Proprietary).
2. Nissley, M. E., et al., January 2005, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," WCAP-16009-P-A (Proprietary).

Figure 1: Peak Clad Temperature

a,c

Figure 2: Vessel Fluid Inventory

a,c

Figure 3: Average Liquid Subcooling in the Downcomer at the Nozzle Elevation

a,c

Figure 4: Average Liquid Subcooling in the Downcomer at Vessel Section 5

a,c

Figure 5: Average Liquid Subcooling in the Downcomer at Vessel Section 4

a,c

[ ]

Figure 6: Average Liquid Subcooling in the Downcomer at Vessel Section 3 (Mid-Core)

a,c

Figure 7: Watts Bar 2 Vessel Noding Diagram

a,c

2. The effect of the time step size on the results, down to and including 0.001 sec. (Further clarification with the Staff specified that the concern with timestep sensitivity was related to the period of downcomer boiling.)

WCOBRA/TRAC timestep studies were documented in Section 22-5 of WCAP-12945-P-A, with the final timestep limits for PWR calculations provided in Table 22-5-4. [

$]^{a,c}$ From a practicality standpoint, the maximum timestep is typically not set lower than [$]^{a,c}$ due to excessive computation time. It is noted that the timestep size selected by the code can be as low as a user input minimum value to satisfy the convergence criteria convergence criteria. The Watts Bar Unit 2 case presented in the Final Safety Analysis Report (FSAR) applied a maximum timestep of [$]^{a,c}$ during the time period of downcomer boiling. The selection of [$]^{a,c}$ is typical for low pressure containment plants such as Watts Bar Unit 2, which allows for a higher rate of runs successfully completing.

In order to examine the effect of the maximum timestep on the results, a maximum timestep sensitivity study was performed using 5 top WCOBRA/TRAC Peak Clad Temperature (WCTPCT) cases from the Watts Bar Unit 2 FSAR analysis at the maximum and minimum values of the current Westinghouse guidance and at a timestep of [

$]^{a,c}$ The results of the sensitivity study are shown in Table 1.

Table 1: Timestep Sensitivity Study Peak Clad Temperature Results

a,c

The results in Table 1 show that the maximum timestep effect on PCT is less than 50°F within the range of current Westinghouse guidance and generally well behaved within the maximum timestep limitations set in WCAP-12945-P-A. Further, examination of the [ ]^{a,c} run set results shows that the change in maximum WCTPCT from the FSAR run set is 47°F. The effect of the timestep study on downcomer boiling behavior predicted by WCOBRA/TRAC is illustrated on a high level in Figures 8 through 12, which show the WCTPCT versus the vessel fluid mass. Again it can be observed that less than a ± 50°F PCT delta is observed within the maximum timestep range of [ ]^{a,c} and generally similar behavior is shown for the higher [ ]^{a,c} maximum timestep. The sensitivity results appear to be consistent with what Westinghouse typically observes.

Based on the above observations, the conclusions drawn in the related RAI responses on lateral K-factor and condensation behavior remain applicable over the maximum timestep range applied in Westinghouse BELOCA applications.

Figure 8: WCOBRA/TRAC Peak Clad Temperature versus Vessel Fluid Mass for Run 018

a,c

Figure 9: WCOBRA/TRAC Peak Clad Temperature versus Vessel Fluid Mass for Run 073

a,c

Figure 10: WCOBRA/TRAC Peak Clad Temperature versus Vessel Fluid Mass for Run 093

a,c

Figure 11: WCOBRA/TRAC Peak Clad Temperature versus Vessel Fluid Mass for Run 100

a,c

Figure 12: WCOBRA/TRAC Peak Clad Temperature versus Vessel Fluid Mass for Run 118

a,c

3. Confirmation of the correct conductivity in the downcomer walls

Response provided in RAI 4 of LTR-LIS-11-278, Rev. 1 → WBT-D-3108 → 5-13-11 TVA Letter to NRC

4. Values for the lateral k-factors in the downcomer (e.g., based on Idlechik)

Note that italics identify revision to previous response.

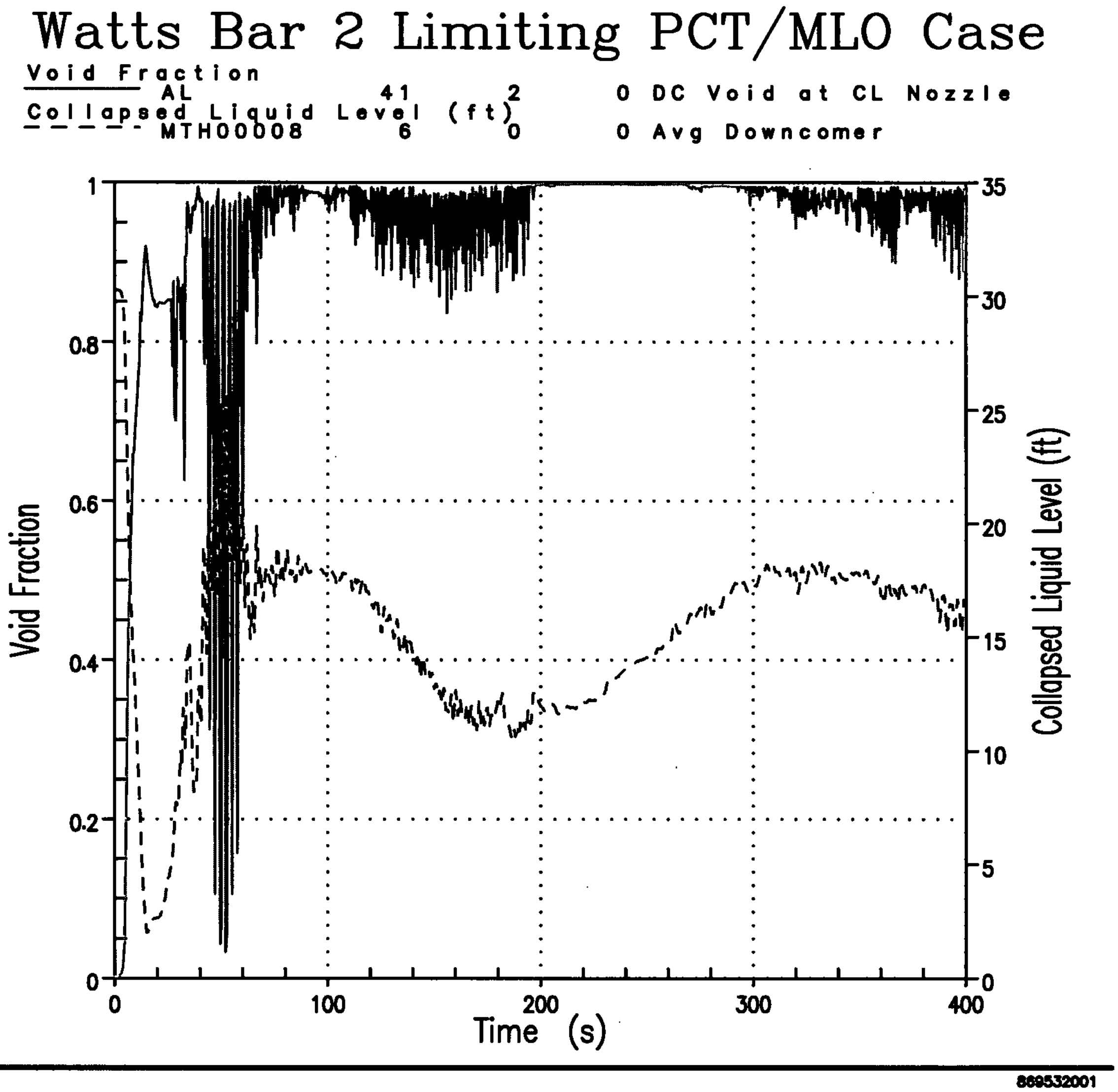
Responses to similar questions recently transmitted to the USNRC for D.C. Cook Unit 2 are generally also applicable to Watts Bar Unit 2. Information regarding how the lateral k-factors are modeled in the downcomer and comparisons to Idel'chik calculations on a plant specific basis are provided therein.
[

]a,c

Based on the physical nature of this argument, similar conclusions can be drawn for Watts Bar Unit 2.

Specific to the Watts Bar Unit 2 limiting PCT/MLO case, the effects of the two-phase swell level during downcomer boiling are examined. The void fraction in the fluid cell connected to the broken cold leg nozzle and the average downcomer collapsed liquid level are shown in Figure 13. The void fraction at the cold leg nozzle elevation is near 0.9 as boiling in the downcomer begins and near 1.0 as boiling in the downcomer progresses downward. As such, the two-phase swell level is below the cold leg nozzle elevation and does not significantly affect the downcomer liquid inventory during downcomer boiling.

Figure 13: Void Fraction in the Downcomer at the Nozzle Elevation and Average Downcomer Collapsed Liquid Level



5. The decay heat multiple used in the limiting large break LOCA analysis

The 95/95 Peak Clad Temperature / Maximum Local Oxidation Case used a decay heat multiplier of 1.0064.

Background on the treatment of the decay heat multiplier in the ASTRUM Methodology was provided in RAI 1 of LTR-LIS-11-216 → WBT-D-3039 → 4-1-11 TVA Letter to NRC

6. The nodalization diagram for the WCOBRA/TRAC model

The noding diagram is shown in Figure 7.

RAI: The analysis results for the limiting large break LOCA shows the downcomer and core average channel liquid levels decreasing from 350 to 400 seconds after opening of the break. The end time of the limiting large break LOCA is 400 sec. Although the PCT has been reduced to near fluid saturation temperature levels of 250 F at 400 sec., the analysis should be continued until the liquid inventories in the core display a steadily increasing trend. In this condition, assurance is provided to demonstrate that the core two-phase level will remain above the top of the core and uncover will not develop later in the event, so that core cladding temperatures can be maintained near the fluid saturation temperature. The statement in the submittal that the core temperatures can be maintained at acceptably low levels so long term cooling is assured is not verified for the limiting large break LOCA. The applicant needs to extend the analysis beyond 400 seconds to show a steadily increasing fluid inventory in the core and downcomer regions to demonstrate the core remains covered with a two-phase mixture and can be cooled for an indefinite period of time.

The run time of the limiting Peak Clad Temperature (PCT) and Maximum Local Oxidation (MLO) case presented in the Final Safety Analysis Report (FSAR) has been extended to 800 seconds to show a steadily increasing trend in the vessel liquid inventory.

Figure 14 provides the PCT for the five (5) rods modeled in WCOBRA/TRAC. It is observed that a small PCT excursion occurs around 410 seconds, but the core quickly re-quenches and remains quenched for a remainder of the simulation. It is noted that the PCT and MLO results are not affected by the extended simulation.

Figures 15 and 16 provide the collapsed liquid level in the average core channel and the four (4) downcomer channels, respectively. A steadily increasing trend is observed in the core and a stable level is shown in the downcomer from 400 to 800 seconds.

Finally, Figure 17 presents the vessel liquid mass and indicates a stable and increasing trend in the overall vessel liquid inventory. This indicates that the pumped safety injection is more than offsetting the loss of inventory through the break, due to stored energy removal, and due to decay heat removal.

Based on these results, it is concluded that stable and sustained quench has been established for the Watts Bar Unit 2 Large Break LOCA analysis, and the core will remain covered with a two-phase mixture and can be cooled for an indefinite period of time.

Figure 14: Watts Bar Unit 2 Peak Clad Temperature for Rods Model in WCOBRA/TRAC

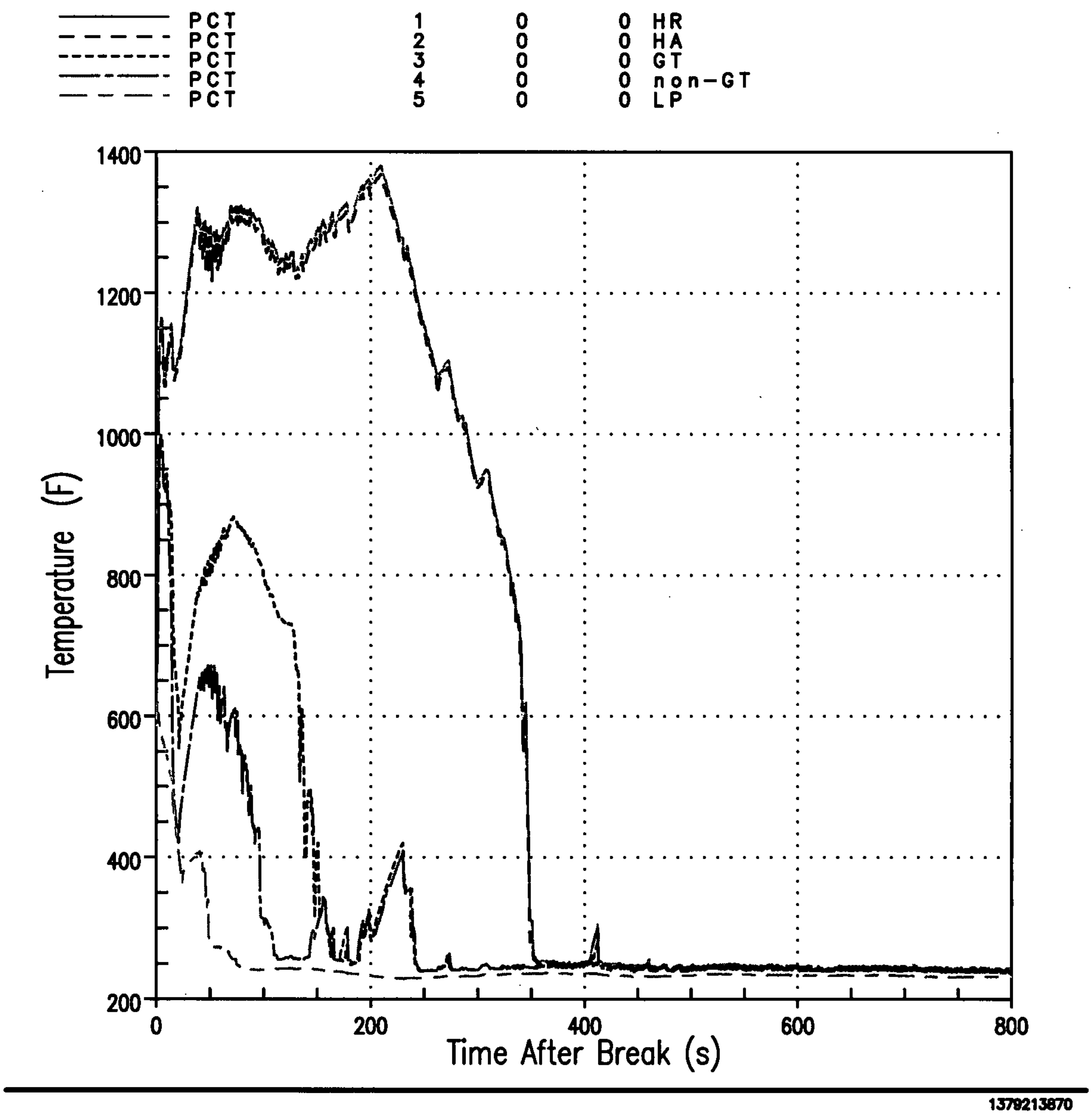


Figure 15: Watts Bar Unit 2 Collapsed Liquid Level in the Average Core Channel

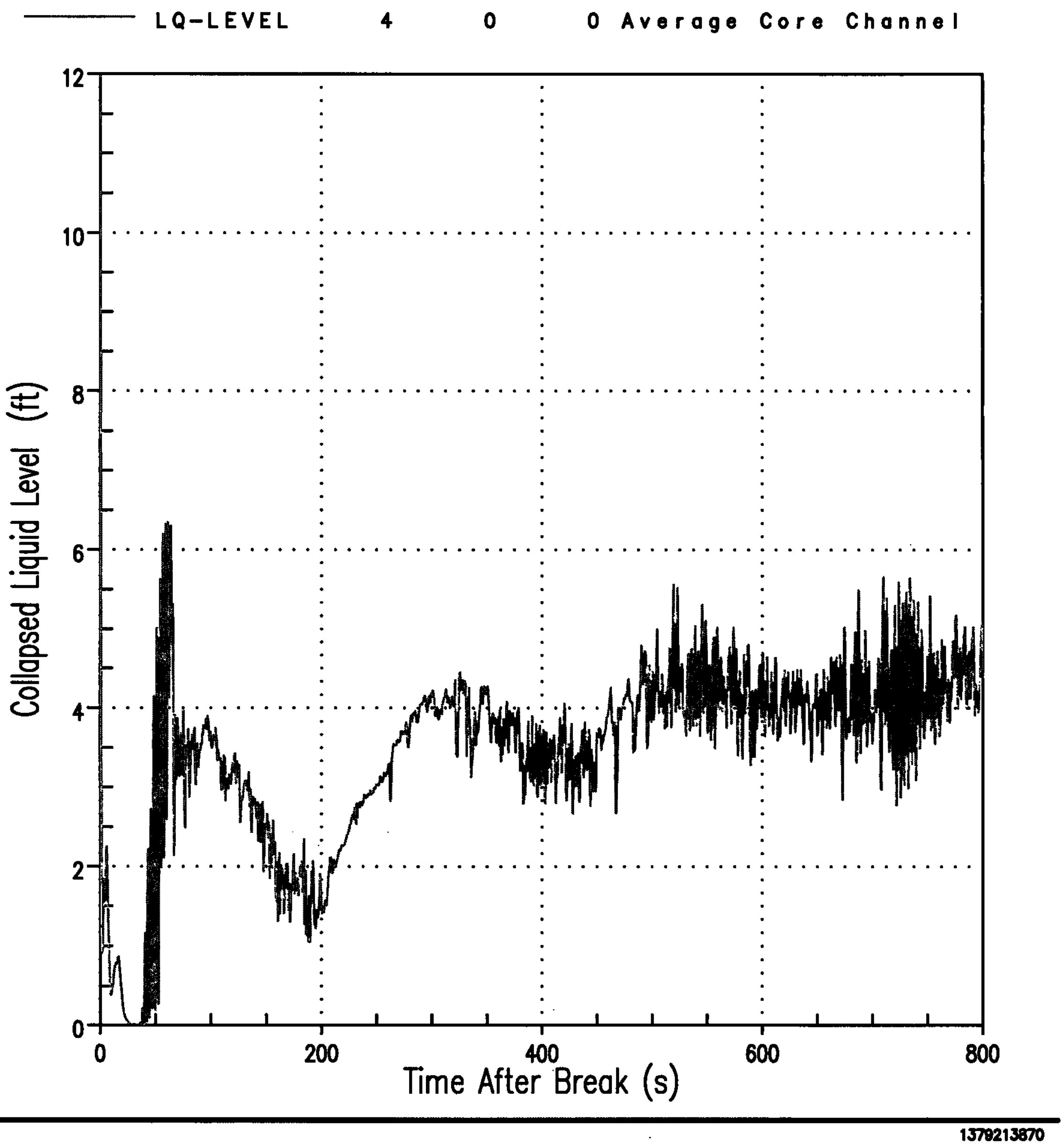


Figure 16: Watts Bar Unit 2 Collapsed Liquid level in the Downcomer Quadrants

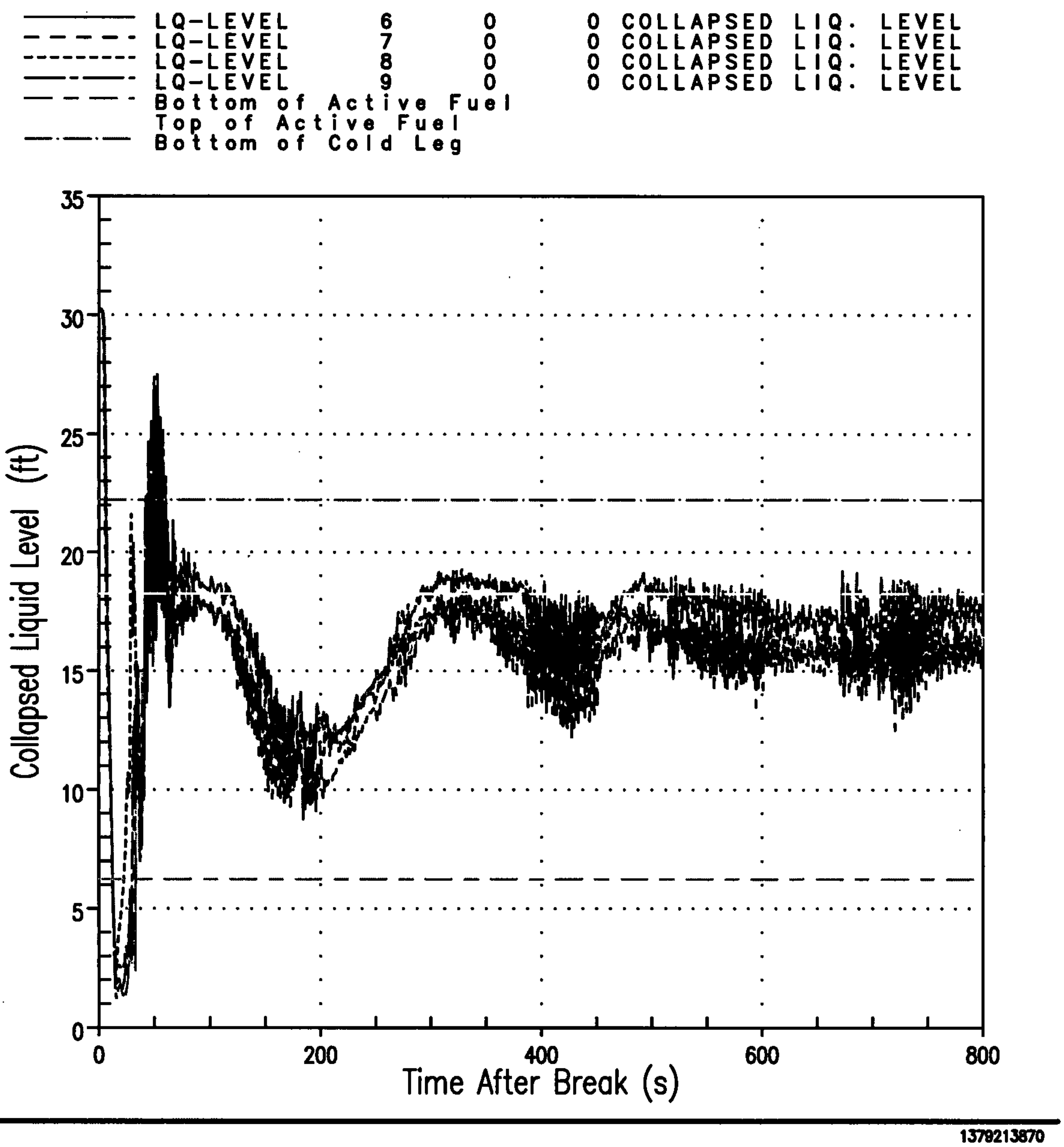
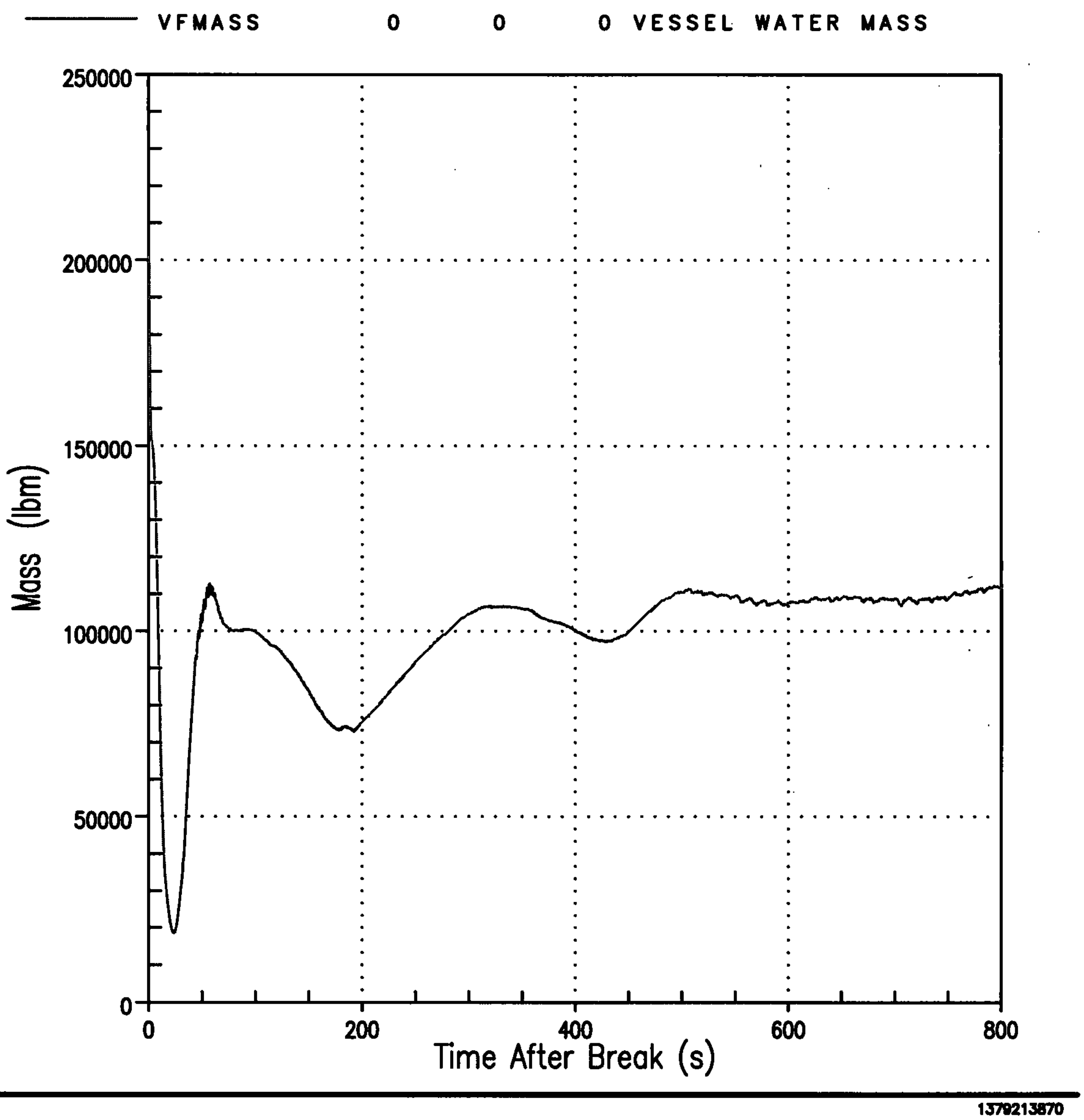


Figure 17: Watts Bar Unit 2 Vessel Liquid Inventory



Enclosure 6
TVA Letter Dated July 18, 2011

Additional Responses to Request for Additional Information
Long Term Post LOCA Core Cooling

The following discussion is from Westinghouse letter to TVA WBT-D-3299, Response to NRC Audit Question on Post LOCA dated July 11, 2011

1. Provide correlation used in the hot leg entrainment correlation and discuss the applicability for this application.

Response:

The calculation of the hot leg entrainment used the Ishii-Grolmes correlation[a]. The applicability of this correlation is discussed in [a]. A sample calculation is provided in Attachment 2a.

[a] Ishii, M.; Grolmes, M. A., "Inception Criteria for Droplet Entrainment in Two-Phase Concurrent Film Flow," AIChE Journal, Vol.21, No. 2, pp. 308-319, 1975.

2. What is the sensitivity to the assumption of 100% condensation of boil-off steam (i.e. sump dilution) and the conservative assumption of core boil-off replaced with safety injection exclusively from the RWST?

Response:

The effect of containment condensation efficiency on the boric acid precipitation calculations was discussed during the audit. Westinghouse performed undocumented sensitivity calculations showing the effect of assuming worst case 0% containment condensation. The boric acid precipitation time decreased from 6.41 hours to 4.90 hours for boiloff makeup using a sump boron concentration of 2881.7 ppm. An undocumented sensitivity calculation was also performed showing the effect of both 0% containment condensation and replacing core boiloff exclusively with safety injection from the RWST. The boric acid precipitation time decreased from 4.90 hours to 3.96 hours. Note that even with this most conservative approach (RWST concentration, 0% condensation efficiency) the calculated precipitation time was approximately 1 hour after the EOP-prescribed HLSO time.

The licensing submittal calculations (from an 11-09-2010 letter from TVA to the NRC), and the two sensitivity calculations discussed above are provided in Attachment 2b.

Additional Responses to Request for Additional Information
Long Term Post LOCA Core Cooling

Attachment 2a – Hot Leg Entrainment Calculation

The liquid entrainment threshold in the hot leg can be established by applying the Ishii-Grolmes[1] and Wallis-Steen[2] liquid entrainment onset criteria as shown below. These entrainment correlations are valid for flow conditions where the liquid phase does not take up a significant volume of the pipe (such as in the hot legs during hot leg recirculation) and viscous effects in the liquid are not dominant (the liquid phase is in the turbulent regime). Note that the correlations have very similar form; however, the Ishii-Grolmes entrainment onset criterion uses liquid phase viscosity whereas Wallis-Steen uses gas phase viscosity.

Ishii-Grolmes Liquid Entrainment Onset Criterion

The liquid entrainment onset correlation can be expressed as follows:

$$j_g \geq N_\mu^{0.8}\left(\frac{\rho_f}{\rho_g}\right)^{0.5}\left(\frac{\sigma}{\mu_f}\right) \quad \text{for } N_\mu < \tfrac{1}{15} \text{ where } \quad N_\mu = \frac{\mu_f}{\left[\rho_f\sigma\left(\sqrt{\frac{\sigma}{g\Delta\rho}}\right)\right]^{1/2}}$$

where N_μ is the viscosity number and j_g is the superficial velocity of the gas phase.

However, due to the conversion of units used in the initial forming of this equation and the units used as standard practice by Westinghouse, the equation has been slightly modified as follows:

$$j_g \geq N_\mu^{0.8}\left(\frac{\rho_f}{\rho_g}\right)^{0.5}\left(\frac{\sigma}{\mu_f}\right) \quad \text{for } N_\mu < \tfrac{1}{15} \text{ where } N_\mu = \frac{\mu_f}{\left[\rho_f \frac{\sigma}{g_c}\left(\sqrt{\frac{\sigma * g_c}{g\Delta\rho}}\right)\right]^{1/2}}$$

where $g = 32.2$ ft/s^2
$g_c = 32.2$ ft-lbm/lbf-s^2

Wallis-Steen Liquid Entrainment Onset Criterion
The liquid entrainment onset correlation per Reference 1 can be expressed as follows:

$$j_g \geq \pi_2\left(\frac{\rho_f}{\rho_g}\right)^{0.5}\left(\frac{\sigma}{\mu_g}\right)$$

where π_2 represents the dimensionless gas velocity. Steen suggested a value of 2.46E^{-04} for π_2, however, a more conservative value of 2.0E^{-04} will be used for this calculation.

Sample HL Entrainment Calculation

The following properties of saturated liquid and gas phases of water at atmospheric conditions (14.7 psia) can be used to calculate the onset of hot leg entrainment:

σ = surface tension of liquid = 4.037E^{-03} lbf/ft
μ_f = viscosity of liquid = 5.794E^{-06} lbf-s/ft^2

μ_g = viscosity of gas = 2.541E^{-07} lbf-s/ft^2

ρ_f = density of liquid = 59.813 lbm/ft^3

ρ_g = density of gas = 0.0373 lbm/ft^3

Liquid Entrainment Threshold in Terms of Hot Leg Superficial Steam Velocity

Using the above properties as input, the following results are obtained for the liquid entrainment threshold in terms of superficial steam velocity in the hot leg:

$j_{g,ISHII-GROLMES}$ = **87.09 ft/s** with N_μ = 7.38 x 10^{-04}

$j_{g,WALLIS-STEEN}$ = **127.24 ft/s**

Applying the lower value of 87.09 ft/s obtained from Ishii-Grolmes, along with the flow area of the hot legs, a mass flow rate of core steam is generated. This core steam generation rate can then be related to the respective Appendix K decay heat fraction, which further yields a respective time after transient start. With no subcooling and atmospheric conditions (in accordance with licensing basis assumptions), a decay heat fraction is obtained that corresponds to approximately 3800 seconds after transient start. Therefore, steam flow in the hot legs will drop below the entrainment threshold at about 1 hour, 3 minutes based upon Appendix K decay heat.

[1] Ishii, M.; Grolmes, M. A., "Inception Criteria for Droplet Entrainment in Two-Phase Concurrent Film Flow," AIChE Journal, Vol.21, No. 2, pp. 308-319, 1975.

[2] Wallis, G. B., "One-Dimensional Two-Phase Flow," pp. 390-393, 1969.

Attachment 2b – Boric Acid Buildup and Core Dilution Sensitivity Calculations

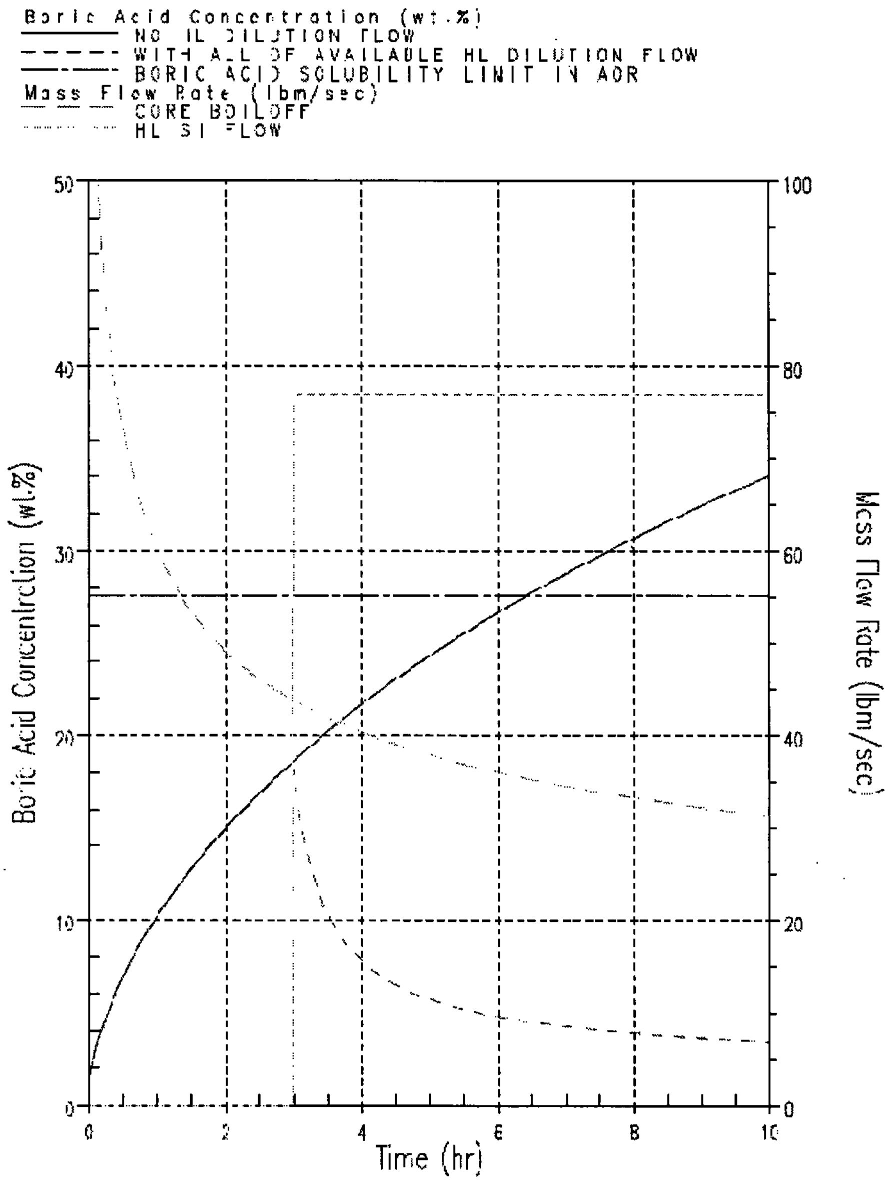


Figure 1 – As-Submitted Boric Acid Buildup and Core Dilution

Additional Responses to Request for Additional Information
Long Term Post LOCA Core Cooling

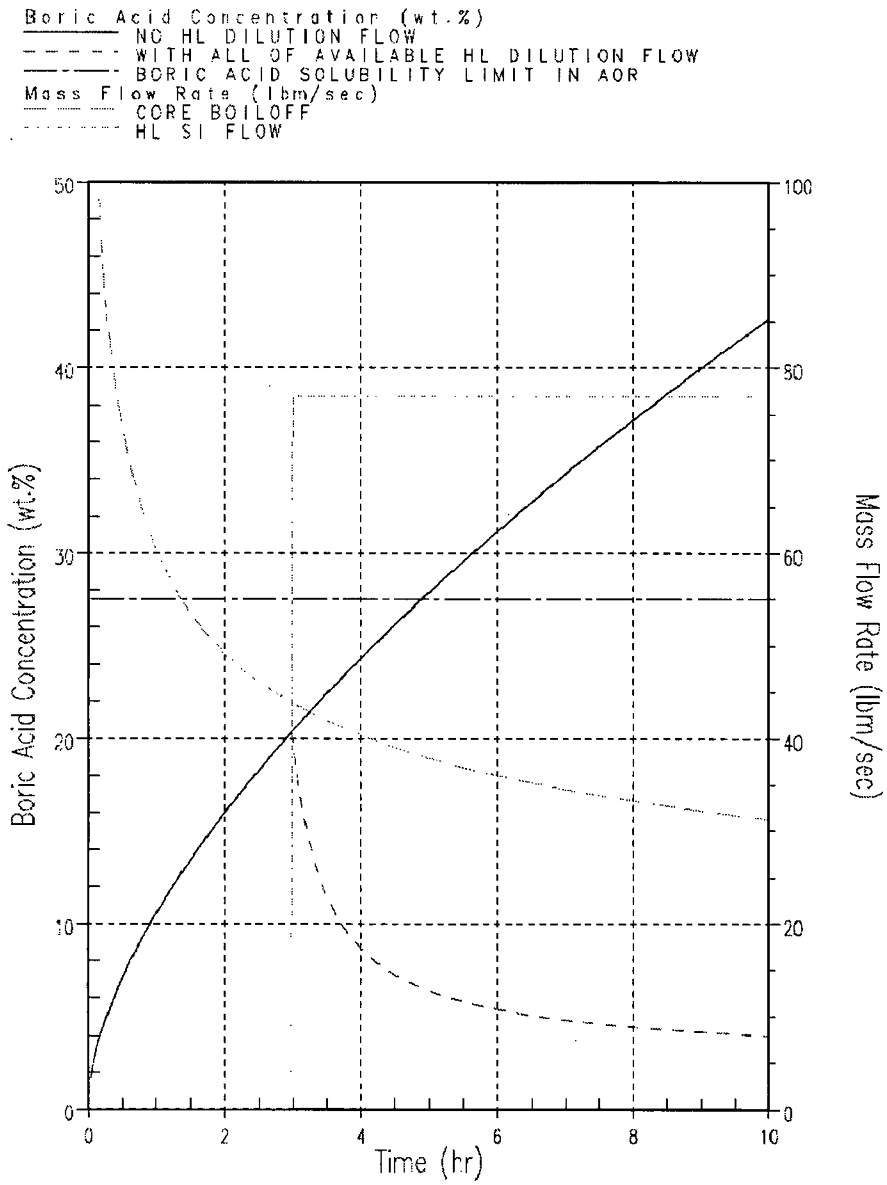


Figure 2 –Boric Acid Buildup and Core Dilution Assuming 0% Containment Condensation

Additional Responses to Request for Additional Information
Long Term Post LOCA Core Cooling

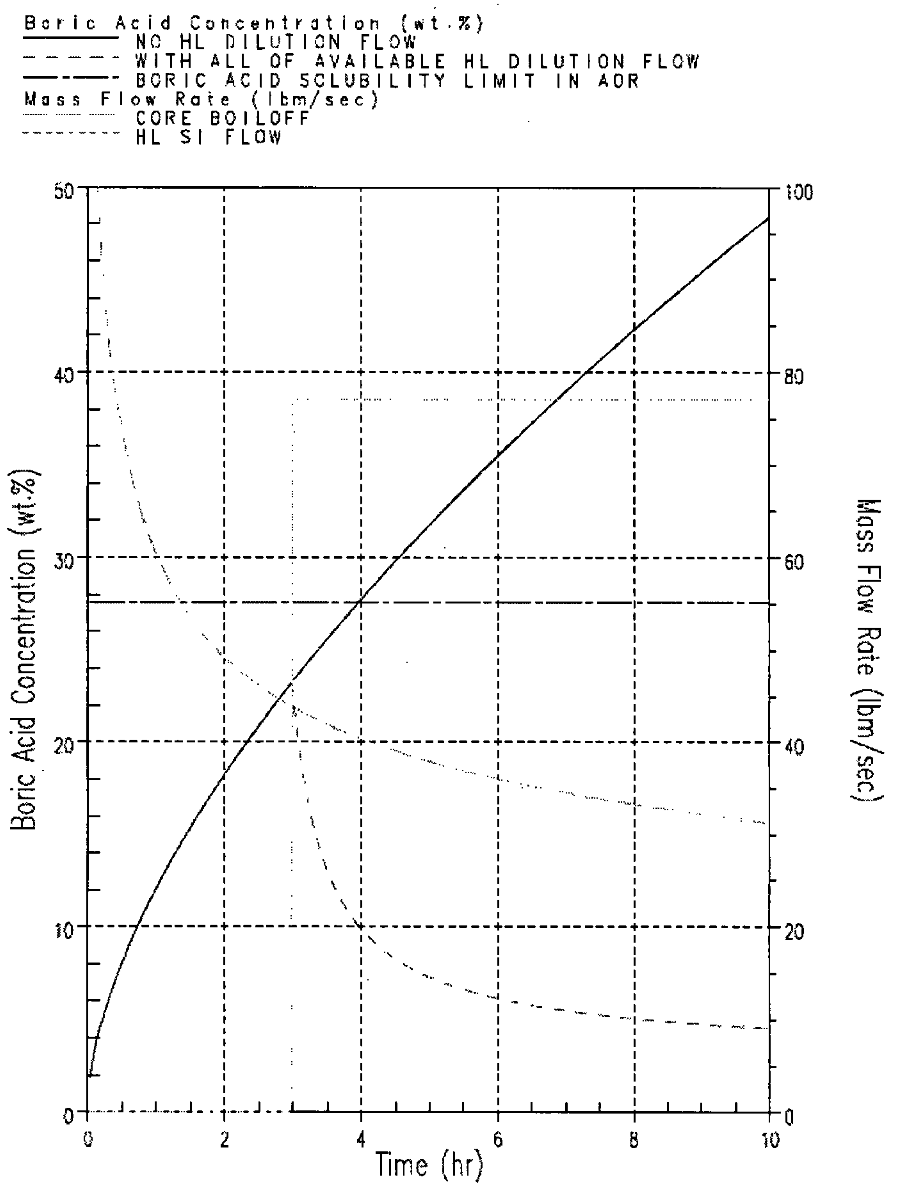


Figure 3 –Boric Acid Buildup and Core Dilution Assuming 0% Containment Condensation and RWST as the Exclusive Source for Core Boiloff Make-up

Enclosure 7
TVA Letter Dated July 18, 2011

New Regulatory Commitments

1) Provide a peaking factor uncertainty analysis and incorporate the results in the WBN Unit 2 COLR.