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

August 3, 2023

Mr. Eric S. Carr
Senior Vice President and
Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Blvd.
Glen Allen, VA 23060-6711

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS 1 AND 2 - CLOSEOUT OF GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (EPID L-2017-LRC-0000)

Dear Mr. Carr,

The U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02, "*Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"* (Agencywide Documents Access and Management System (ADAMS) Accession No. ML042360586), dated September 13, 2004, requesting that licensees address the issues raised by Generic Safety Issue (GSI)-191, "*Assessment of Debris Accumulation on PWR [Pressurized-Water Reactor] Sump Performance."*

By letter dated May 15, 2013 (ML13141A278), Virginia Electric and Power Company (the licensee) stated that it will pursue Option 2 (deterministic) for the closure of GSI-191 and GL 2004-02 for North Anna Power Station, Unit Nos. 1 and 2 (NAPS).

On July 23, 2019 (Package ML19203A303), GSI-191 was closed. It was determined that the technical issues identified in GSI-191 were now well understood and therefore GSI-191 could be closed. Prior to and in support of closing GSI-191, the NRC staff issued a technical evaluation report on in-vessel downstream effects (ML19178A252 and ML19073A044 (not publicly available, proprietary information)). Following the closure of GSI-191, the NRC staff also issued review guidance for in-vessel downstream effects, "*NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of GL 2004-02 Responses*" (ML19228A011), to support review of the GL 2004-02 responses.

The NRC staff has performed a review of the licensee's responses and supplements to it response to GL 2004-02. Based on the evaluations, the NRC staff finds that the licensee has provided adequate information as requested by GL 2004-02.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) section 50.46. Specifically, GL 2004-02 requested addressees to perform an evaluation of the emergency core cooling system and containment spray system recirculation and, if necessary, take additional action to ensure system function in light of the potential for debris to adversely affect long-term core cooling. The NRC staff finds the information provided by the licensee demonstrates that debris will not inhibit the emergency core cooling system or containment spray system performance following a postulated loss-of-coolant accident. Therefore, the ability of the systems to perform their safety functions, to assure adequate long-term core cooling following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated.

Therefore, the NRC staff finds the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for NAPS.

Enclosed is the summary of the NRC staff's review. If you have any questions, please contact me at (301) 415-2481 or by e-mail at ed.miller@nrc.gov.

Sincerely,

/RA/

G. Edward Miller, Project Manager
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosure:
NRC Staff Review of GL 2004-02
for North Anna Power Station,
Unit Nos. 1 and 2

cc: Listserv

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS 1 AND 2 - CLOSEOUT OF GENERIC LETTER 2004-02, “POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS” (EPID L-2017-LRC-0000) DATED AUGUST 3, 2023

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OFFICE	NRR/DORL/LPL2-1/PM	NRR/DORL/LPL2-1/LA	NRR/DSS/STSB/BC	NRR/DNRL/NCSG/BC
NAME	GEMiller	KGoldstein	VCusumano	SBloom
DATE	7/24/2023	7/21/2023	7/21/2023	7/21/2021
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

U.S. NUCLEAR REGULATORY COMMISSION STAFF REVIEW

OF THE DOCUMENTATION PROVIDED BY

VIRGINIA ELECTRIC AND POWER COMPANY

FOR NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2,

DOCKET NOS. 50-338 AND 50-339

CONCERNING RESOLUTION OF GENERIC LETTER 2004-02

POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING

DESIGN-BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS

1.0 INTRODUCTION

A fundamental function of the Emergency Core Cooling System (ECCS) is to recirculate water that has collected at the bottom of the containment through the reactor core following a break in the reactor coolant system (RCS) piping to ensure long-term removal of decay heat from the reactor fuel. Leaks from the RCS, hypothetical scenarios known as loss-of-coolant accidents (LOCAs), are part of every plant’s design-basis. Hence, nuclear plants are designed and licensed with the expectation that they are able to remove reactor decay heat following a LOCA to prevent core damage. Long-term cooling following a LOCA is a basic safety function for nuclear reactors. The recirculation sump provides a water source to the ECCS in a pressurized-water reactor (PWR) once the primary water source has been depleted.

If a LOCA occurs, piping thermal insulation and other materials may be dislodged by the two-phase coolant jet emanating from the broken RCS pipe. This debris may transport, via flows coming from the RCS break and from the containment spray system (CSS), to the pool of water that collects at the bottom of containment following a LOCA. Once transported to the sump pool, the debris could be drawn toward the ECCS sump strainers, which are designed to prevent debris from entering the ECCS and the reactor core. If this debris were to clog the strainers and prevent coolant from entering the reactor core, containment cooling could be lost and result in core damage and containment failure.

It is also possible that some debris would pass through (termed “bypass”) the sump strainer and lodge in the reactor core. This could result in reduced core cooling and potential core damage. If the ECCS strainer were to remain functional, even with core cooling reduced, containment cooling would be maintained, and the containment function would not be adversely affected.

Findings from research and industry operating experience raised questions concerning the adequacy of PWR sump designs. Research findings demonstrated that, compared to other LOCAs, the quantity of debris generated by a high-energy line break (HELB) could be greater. The debris from a HELB could also be finer (and thus more easily transportable) and could be comprised of certain combinations of debris (i.e., fibrous material plus particulate material) that could result in a substantially greater flow restriction than an equivalent amount of either type of debris alone. These research findings prompted the U.S. Nuclear Regulatory Commission (NRC) to open Generic Safety Issue (GSI) - 191, "*Assessment of Debris Accumulation on PWR Sump Performance*," in 1996. This resulted in new research for PWRs in the late 1990s.

The GSI-191 focuses on reasonable assurance that the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46(b)(5) are met. This deterministic rule requires maintaining long-term core cooling after initiation of the ECCS. The objective of GSI-191 is to ensure that post-accident debris blockage will not impede or prevent the operation of the ECCS and CSS in recirculation mode at PWRs during LOCAs or other HELB accidents for which sump recirculation is required. The NRC completed its review of GSI-191 in 2002 and documented the results in a parametric study that concluded that sump clogging at PWRs was a credible concern.

The GSI-191 concluded that debris clogging of sump strainers could lead to recirculation system ineffectiveness as a result of a loss of net positive suction head (NPSH) for the ECCS and CSS recirculation pumps. Resolution of GSI-191 involves two distinct but related safety concerns: (1) potential clogging of the sump strainers that results in ECCS and/or CSS pump failure; and (2) potential clogging of flow channels within the reactor vessel because of debris bypass of the sump strainer (in-vessel effects). Clogging at either the strainer or in-vessel channels can result in loss of the long-term cooling safety function.

After completing the technical assessment of GSI-191, the NRC issued Bulletin 2003-01, "*Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors*" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML031600259), on June 9, 2003. The Office of Nuclear Reactor Regulation (NRR) requested and obtained the review and endorsement of the bulletin from the Committee to Review Generic Requirements (CRGR) (ML031210035). As a result of the emergent issues discussed in Bulletin 2003-01, the NRC staff requested an expedited response from PWR licensees on the status of their compliance of regulatory requirements concerning the ECCS and CSS recirculation functions based on a mechanistic analysis. The NRC staff asked licensees, who chose not to confirm regulatory compliance, to describe any interim compensatory measures that they had implemented or will implement to reduce risk until the analysis could be completed. All PWR licensees responded to Bulletin 2003-01. The NRC staff reviewed all licensees' Bulletin 2003-01 responses and found them acceptable.

In developing Bulletin 2003-01, the NRC staff recognized that it might be necessary for licensees to undertake complex evaluations to determine whether regulatory compliance exists in light of the concerns identified in the bulletin and that the methodology needed to perform these evaluations was not currently available. As a result, that information was not requested in Bulletin 2003-01, but licensees were informed that the NRC staff was preparing a Generic Letter (GL) that would request this information. GL 2004-02, "*Potential Impact of Debris Blockage on Emergency Recirculation During Design-basis Accidents at Pressurized-Water Reactors*," dated September 13, 2004 (ML042360586), was the follow-on information request referenced in Bulletin 2003-01. This document set the expectations for resolution of PWR sump performance issues identified in GSI-191, to ensure the reliability of the ECCS and CSS at PWRs. NRR

requested and obtained the review and endorsement of the GL from the CRGR (ML040840034).
The GL 2004-02 requested that addressees perform an evaluation of the ECCS and CSS recirculation functions in light of the information provided in the letter and, if appropriate, take additional actions to ensure system function. Additionally, addressees were requested to submit the information specified in GL 2004-02 to the NRC. The request was based on the identified potential susceptibility of PWR recirculation sump screens to debris blockage during design-basis accidents (DBAs) requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects due to debris blockage of flow paths necessary for ECCS and CSS recirculation and containment drainage. GL 2004-02 required addressees to provide the NRC a written response in accordance with 10 CFR 50.54(f).

By letter dated May 28, 2004 (Package ML041550661), the Nuclear Energy Institute (NEI) submitted a report (NEI 04-07), "*Pressurized Water Reactor Sump Performance Evaluation Methodology,*" describing a methodology for use by PWR licensees in the evaluation of containment sump performance. This is also called the Guidance Report (GR). NEI requested that the NRC review the methodology. The methodology was intended to allow licensees to address and resolve GSI-191 issues in an expeditious manner through a process that starts with a conservative baseline evaluation. The baseline evaluation serves to guide the analyst and provide a method for quick identification and evaluation of design features and processes that significantly affect the potential for adverse containment sump blockage for a given plant design. The baseline evaluation also facilitates the evaluation of potential modifications that can enhance the capability of the design to address sump debris blockage concerns and uncertainties and supports resolution of GSI-191. The report offers additional guidance that can be used to modify the conservative baseline evaluation results through revision to analytical methods or through modification to the plant design or operation.

By letter dated December 6, 2004 (Package ML043280641), the NRC issued an evaluation of the NEI methodology. The NRC staff concluded that the methodology, as approved in accordance with the NRC staff safety evaluation (SE), provides an acceptable overall guidance methodology for the plant-specific evaluation of the ECCS or CSS sump performance following postulated DBAs. Taken together NEI 04-07 and the associated NRC staff SE are often referred to as the GR/SE.

In response to the NRC staff SE conclusions on NEI 04-07 "*Pressurized Water Reactor Sump Performance Evaluation Methodology*" (ML050550138 and ML050550156), the Pressurized Water Reactor Owners Group sponsored the development of the following Westinghouse Commercial Atomic Power (WCAP) Topical Reports (TRs):

- TR-WCAP-16406-P-A, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 1 (not publicly available), to address the effects of debris on piping systems and components (NRC Final SE at ML073520295, Non-Public report at ML081000027).

- TR-WCAP-16530-NP-A, "Evaluation of Post-accident Chemical Effects in Containment Sump Fluids to Support GSI-191," issued March 2008 (ML081150379), to provide a consistent approach for plants to evaluate the chemical effects that may occur post-accident in containment sump fluids (NRC Final SE at ML073521072).

- TR-WCAP-16793-NP-A, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," Revision 2 issued July 2013

(ML13239A114), to address the effects of debris on the reactor core (NRC Final SE at ML13084A154).

The NRC staff reviewed the TRs and found them acceptable to use (as qualified by the limitations and conditions stated in the respective SEs). A more detailed evaluation of how the TRs were used by the licensee is contained in the evaluations below.

After the NRC staff evaluated licensee responses to GL 2004-02, the NRC staff found that there was a misunderstanding between the industry and the NRC on the level of detail necessary to respond to GL 2004-02. The NRC staff in concert with stakeholders developed a content guide for responding to requests for additional information (RAIs) concerning GL 2004-02. By letter dated August 15, 2007 (ML071060091), the NRC issued the content guide describing the necessary information to be submitted to allow the NRC staff to verify that each licensee's analyses, testing, and corrective actions associated with GL 2004-02 are adequate to demonstrate that the ECCS and CSS will perform their intended function following any DBA. By letter dated November 21, 2007 (Package ML073110389), the NRC issued a revised content guide (hereafter referred to as the content guide).

The content guide described the following information needed to be submitted to the NRC:

- corrective actions for GL 2004-02,
- break selection,
- debris generation/zone of influence (ZOI) (excluding coatings),
- debris characteristics,
- latent debris,
- debris transport,
- head loss and vortexing,
- NPSH,
- coatings evaluation,
- debris source term,
- screen modification package,
- sump structural analysis,
- upstream effects,
- downstream effects – components and systems,
- downstream effects – fuel and vessel,
- chemical effects, and
- licensing basis.

Based on the interactions with stakeholders and the results of the industry testing, the NRC staff, in 2012, developed three options to resolve GSI-191. These options were documented and proposed to the Commission in SECY-12-0093, "*Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance,*" dated July 9, 2012 (Package ML121320270). The options are summarized as follows:

- Option 1 would require licensees to demonstrate compliance with 10 CFR 50.46, "*Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors,*" through approved models and test methods. These will be low fiber plants with less than 15 grams of fiber per fuel assembly.

- Option 2 requires implementation of additional mitigating measures and allows additional time for licensees to resolve issues through further industry testing or use of a risk-informed approach.
  - Option 2 Deterministic: Industry to perform more testing and analysis and submit the results for NRC review and approval (in-vessel only).
  - Option 2 Risk-Informed: Use the South Texas Project pilot approach.
- Option 3 involves separating the regulatory treatment of the sump strainer and in-vessel effects.

The options allowed industry alternative approaches for resolving GSI-191. The Commission issued a Staff Requirement Memorandum on December 14, 2012 (ML12349A378), approving all three options for closure of GSI-191.

By letter dated May 15, 2013 (ML13141A278), Virginia Electric and Power Company (the licensee) stated that they will pursue Option 2 (deterministic) for the closure of GSI-191 and GL 2004-02 for North Anna Power Station, Units 1 and 2 (North Anna).

On July 23, 2019 (Package ML19203A303), GSI-191 was closed. It was determined that the technical issues identified in GSI-191 were now well understood and therefore GSI-191 could be closed. Prior to and in support of closing the GSI, the NRR staff issued a technical evaluation report on in-vessel downstream effects (IVDEs) (ML19178A252 and ML19073A044 (non-public version)). Following the closure of the GSI, the NRR staff also issued review guidance for IVDEs to support review of the GL 2004-02 responses, "*NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses"* (ML19228A011).

The NRC staff performed an audit of the North Anna GL 2004-02 evaluation in 2007 (refer to the audit report at ML072740400). Some of the licensee responses and staff evaluations are abbreviated and rely on the audit evaluations. Since the licensee's chemical effects evaluation was not available during the 2007 audit, the NRC staff subsequently performed a chemical effects audit in 2008 and the chemical effects audit summary is available in ADAMS (ML090410618).

The following is a list of documentation provided by the licensee in response to GL 2004-02:

Table 1 - GL 2004-02 CORRESPONDENCE

DOCUMENT DATE	**ACCESSION NUMBER**	**DOCUMENT**
March 4, 2005	ML050630559	Millstone, Units 2 and 3, North Anna, Units 1 and 2 and Surry, Units 1 and 2, NRC Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors 90 Day Response.

DOCUMENT DATE	ACCESSION NUMBER	DOCUMENT
September 1, 2005	ML052500378	Kewaunee, Millstone, North Anna, and Surry Stations - Response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors."
February 9, 2006	ML060370463	North Anna, Units 1 and 2, RAI, Re: Re: Response to GL-2004-02, " Potential Impact to Debris Blockage on Emergency Recirculation during Design-Basis Accidents at Pressurized-Water Reactors."
December 19, 2007	ML090860438	Millstone, Units 2 & 3, North Anna & Surry Power Stations Units 1 & 2, NRC Generic Letter (GL) 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors Draft Bench-top Test .....
February 29, 2008	ML080650563	North Anna, Units 1 and 2, Supplemental Response to NRC GL-04-002, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors.
February 27, 2009	ML090641038	North Anna, Units 1 and 2 - Updated Supplemental Response to NRC Generic Letter 2004-02 Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors.
May 28, 2009	ML091350073	North Anna Power Station, Unit Nos. 1 and 2, Request For Additional Information Related To Generic Letter 2004-02 (TAC Nos. MC4696 and MC4697).
April 27, 2011	ML111180686	North Anna, Units 1 and 2 - Updated Supplemental Response to NRC Generic Letter 2004-02 "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors."
May 15, 2013	ML13141A278	North Anna, Units 1 and 2, NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors, Generic Safety Issue (GSI)-191 Closure Option and Tempmat Insulation....

DOCUMENT DATE	ACCESSION NUMBER	DOCUMENT
February 25, 2021	ML21056A557	North Anna Power Station Units 1 And 2 - NRC Generic Letter 2004-02, "Potential Impact Of Debris Blockage On Emergency Recirculation During Design Basis Accidents At Pressurized-Water Reactors" Final Supplemental Response
September 9, 2022	ML22251A129	Millstone Power Station, Units 2 and 3, North Anna Power Station, Units 1 and 2, and Surry Power Station, Units 1 and 2 - Request for Additional Information Related to Response to Generic Letter 2004-04 (EPID L-2017-LRC-0000)
November 7. 2022	ML22312A442	Millstone, Units 1 and 2, North Anna, Units 1 and 2, Surry, Units 1 and 2, NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" Fleet Response to RAI
May 8, 2023	ML23128A162	Millstone, Surry and North Anna Stations - NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors" Fleet Response to Request for Additional Information

The NRC staff reviewed the information provided by the licensee in response to GL 2004-02 and all RAIs. The following is a summary of the NRC staff review.

2.0 GENERAL DESCRIPTION OF CORRECTIVE ACTIONS FOR THE RESOLUTION OF GL-2004-02

GL 2004-02 Requested Information Item 2(b) requested a general description of and implementation schedule for all corrective actions. The following is a list of corrective actions completed by the licensee at North Anna in support of the resolution of GL 2004-02:

- Replaced previous sump screens with surface area of 168 square feet (ft^2) with new containment sump strainers with corrugated, perforated stainless steel fins with a total surface area of over 4,000 ft^2 for the recirculation spray (RS) pumps in each unit, and 2,000 ft^2 for Unit 1 and 1,900 ft^2 for Unit 2 low head safety injection (LHSI) pumps.

- Replaced calcium-silicate (Cal-Sil) insulation within the steam generator (SG) cubicles and pressurizer room with Paroc and TempMat for both units.

- Removed Microtherm insulation installed within the break ZOI from both units.

- Installed a drain in the primary shield wall to the incore sump room in both units to reduce water holdup volume and to increase total volume of water available for strainer submergence and recirculation.

- Modified engineered safety feature circuitry to start the RS pumps on a containment depressurization actuation (CDA) signal coincident with a refueling water storage tank (RWST) low-level signal. The outside RS pumps start immediately, and the inside RS pumps start following a 120-second delay once the coincidence logic is satisfied. This ensures sufficient water is available to meet RS strainer submergence and RS pump NPSH requirements.

- Modified RWST level instrumentation to change the safety injection recirculation mode transfer (RMT) setpoint from 19.4 percent to 16.0 percent RWST wide range level. This allows more energy to be removed from the containment and lowers the sump temperature prior to the LHSI pump suction switching from the RWST to the containment sump. This also provides a higher water level in the containment sump prior to the LHSI pump suction switching to the containment sump. The combination of lower sump temperature and higher water level provides increased NPSH available ($NPSH_a$) to the LHSI pumps and ensures the required volume of water to maintain the strainers submerged.

- Modified the containment sump level transmitters to protect them from clogging due to debris.

    - Modified level transmitters within the sump by drilling holes through stilling wells at various places to prevent the element from clogging.
    - Provided level transmitters located above the containment floor with debris shields to protect them.

- Provided a list of conservatisms used in the GL 2004-02 analysis.

On April 27, 2011, the licensee provided additional information (ML111180686). This was after the NRC staff had completed its review. During a refueling outage, the licensee discovered additional insulation which could become debris. The insulation types were Microtherm, Cal-Sil, and TempMat. The licensee has since removed all the Cal-Sil and Microtherm from locations where it could contribute to the debris source term for the sump strainers. The licensee performed inspections and reviews to ensure that additional previously unidentified insulation was not installed in containment. The licensee evaluated the additional fibrous insulation (TempMat) and determined that the operation of the sump strainer would not be adversely affected. The licensee also stated in the letter that it would take additional corrective actions, as necessary, once industry testing for insulation ZOIs was completed. In its letter dated May 15, 2013 (ML13141A278), the licensee stated that modifications were being developed to remediate the additional TempMat by replacing some fibrous insulation within the ZOI with reflective metal insulation (RMI). During 2016 refueling outages, the licensee replaced SG Thermal-Wrap insulation with RMI to remediate the TempMat insulation concern. The removal of the Thermal-Wrap reduced the fibrous debris source term so that the remaining TempMat term does not challenge the assumed fiber amount.

The licensee also discovered that the strainer area had been calculated incorrectly by the vendor. The LHSI strainer areas were not significantly affected by this issue, but the RS strainers were found to be smaller by about 10 percent (4,000 ft^2 vs. 4,400 ft^2). The licensee evaluated the condition and determined that the strainer testing was not adversely affected by the issue due to the way that test flow rates and debris loads were calculated.

Based on the information provided by the licensee, the NRC staff considers this item closed for GL 2004-02.

3.0 BREAK SELECTION

The objective of the break selection process is to identify the break size and location that present the greatest challenge to post accident sump performance. The term ZOI used in this section refers to the zone representing the volume of space affected by the ruptured piping.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The NRC staff conducted an audit of the North Anna corrective actions to address GL 2004-02 and documented their findings in a November 15, 2007, audit report (Package ML072770236). The audit report contains a detailed description of the break selection evaluation performed for North Anna. The NRC staff reviewed the break selection evaluation and found it to be consistent with the SE approved methodology, and therefore acceptable.

Section 3.3.5 of NEI 04-07 provides guidance that postulated break locations be moved at certain increments along the selected piping. However, North Anna used a more discreet approach driven by the comparisons of debris source term and transport potential for locating the postulated breaks. This method has been accepted by the NRC staff as an alternative to moving the postulated break locations incrementally.

The largest diameter high-energy piping is the RCS cold leg suction (intermediate leg) piping (31-inch (in. or ”) inner diameter (ID)) with the hot-leg piping (29” ID) being somewhat smaller. The largest ZOI would therefore be associated with the intermediate leg piping.

The NRC staff noted that break locations in the feedwater (FW) and main steam (MS) piping systems (secondary breaks) were not considered, as containment sump recirculation is not required for the mitigation of any FW or MS line breaks. Small bore (< 2” diameter) piping breaks were also not evaluated, as allowed in Section 3.3.4.1 of the NRC SE on NEI 04-07. North Anna followed the methodology described in Sections 3.3 and 4.2.1 of the GR/SE, which provides the NRC-approved criteria to be considered in the overall break selection process for identifying the limiting break.

The postulated break locations at North Anna are as follows:

- Break 1 (BK1) - The SG B cold leg suction (intermediate leg) (31”-RC-5-2501 R-Q1) piping at the SG nozzle at El. 257’ [31” ID]

- Break 2 (BK2) - The SG C cold leg suction (intermediate leg) (31”-RC-8-2501 R-Q1) piping at the SG nozzle at El. 257’ [31” ID]

- Break 3 (BK3) - The SG A cold leg suction (intermediate leg) (31”-RC-2-2501 R-Q1) piping at the SG nozzle at El. 257’ [31” ID]

- Break 4 (BK4) - The pressurizer surge line (14”-RC-10-2501 R-Q1) at El. 264’-10” [14” outside diameter (OD)]

Based on the information summarized above, the NRC staff found that the break selection evaluation is consistent with the SE-approved methodology and therefore acceptable.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. The break location analysis completed by the licensee is in accordance with the content guide and the GR/SE while using an acceptable method to determine break locations to analyze for maximum debris generation results. Therefore, the NRC staff concludes that the break selection evaluation for North Anna is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02 for North Anna.

4.0 DEBRIS GENERATION/ZONE OF INFLUENCE (EXCLUDING COATINGS)

The objective of the debris generation/ZOI evaluation is to determine the limiting amounts and combinations of debris that can occur from the postulated breaks in the RCS.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The North Anna debris generation evaluation generally followed approved guidance. The NRC staff audit of North Anna found the debris generation evaluation acceptable (See November 15, 2007, Audit Report (ML072740400)).

The RMI, TempMat, Paroc Mineral Wool, and Thermal-Wrap are predicted to be within the ZOI of the North Anna postulated breaks. The ZOIs selected for the materials were 11.7D for TempMat, 5.4D for mineral wool, 2D for RMI, and 17D for Thermal-Wrap. During the audit, the NRC staff found that the ZOIs were assigned per the applicable guidance or appropriately evaluated to be equivalent to materials that were evaluated in the guidance.

In the debris characteristic section, the NRC staff documented that the TempMat would be generated as 60 percent small fines and 40 percent intact. The licensee, in a supplemental response, stated that the TempMat debris generation size distribution is predicted to be 60 percent small fines and 40 percent intact. The NRC staff guidance is that the 60/40 split is probably a more realistic estimate of the actual debris size distribution for the TempMat. Additionally, TempMat makes up a very small percentage of the fibrous debris created by the postulated breaks. North Anna also assumes 90 percent erosion of fibrous debris. Therefore, the NRC staff concluded that the licensee’s treatment of TempMat was acceptable.

The NRC staff concluded that there are no changes to the audit finding that the North Anna debris generation/ZOI evaluation was conducted appropriately.

As discussed above, the licensee subsequently identified additional potential debris sources within the containments. Cal-Sil and Microtherm were removed from within the ZOIs, but additional TempMat was discovered and evaluated as not affecting the safety function of the strainer. The licensee committed to remove fibrous insulation to return the debris source term to within its analyzed value. The licensee stated that this work was completed in its February 25, 2021, letter.

NRC STAFF CONCLUSION:

For the debris generation/ZOI review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris generation/ZOI evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

5.0 DEBRIS CHARACTERISTICS

The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its contribution to strainer head loss.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The NRC staff conducted an audit review for North Anna and concluded that the debris characteristics area had been adequately addressed (See November 15, 2007, Audit Report (ML072740400)). No open items were identified. The NRC staff compared key assumptions in the supplemental response to those in the audit report and did not identify any discrepancies. No changes to the analysis were noted by the licensee in the supplemental response. Therefore, the NRC staff considered this area to have been acceptably addressed by the licensee.

A detailed description of the licensee approach is provided in Section 3.3 of the North Anna Audit report. In summary, RMI is considered 75 percent small pieces, 25 percent large pieces. Paroc Mineral Wool is 100 percent small fines. Fibrous debris sizing is described in the following table:

Table 1: Licensee's Assumed Debris Size Distribution

Debris Type	Category	Category Percent
Transco Thermal-Wrap Fiber	Small Fines	8%
	Small Pieces	25%
	Large Pieces	32%
	Intact	35%
Paroc	Small Fines	100%
Temp-Mat	Small Fines	60%
	Intact	40%

Assumptions made regarding latent debris and miscellaneous debris characteristics are consistent with the guidance.

Overall, the NRC staff considered the assumptions made to be prototypical or conservative.

NRC STAFF CONCLUSION:

For the debris characteristics review area, the licensee provided information such that the NRC staff has reasonable assurance that the area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris characteristics evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

6.0 LATENT DEBRIS

The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris (e.g., miscellaneous fiber, dust, dirt) existing within the containment and its potential impact on sump screen head loss.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The licensee estimated latent debris mass in containment following the guidance of the GR/SE. The estimation included several conservatisms. Based upon significant conservatisms in the latent debris mass calculation, the NRC staff accepted the latent debris mass estimate, despite an issue raised with mass measurement uncertainty.

The licensee assumed that latent fiber comprises 15 percent (by mass) of the total latent debris in the containment. The licensee assumed that latent fibrous debris is composed of 100 percent small fines. Transco Thermal-Wrap fibers were used for the latent fibrous debris during testing. The NRC staff found that the properties the licensee assumed for latent fibrous debris are consistent with NUREG/CR-6877 (ML052430751) and the NRC SE on NEI 04-07.

The licensee assumed that particulate material comprises 85 percent (by mass) of the total latent debris loading measured in the containment. The licensee assumed that latent particulate debris is composed of 100 percent fine particulate. Walnut shell flour was used as the surrogate for latent particulate debris.

The licensee identified the surface areas within containment that are available for accumulation of latent debris, and eight surface-area categories were defined. After accounting separately for horizontal and vertical surface configurations, a total of twelve area types were defined. The licensee computed the surface area of each of the twelve area types with the aid of plant drawings. The individual area contributions were tabulated in the debris generation calculation.

To estimate the latent debris mass, including dust, particulate and lint, the licensee took samples from each of twelve area types. The sample locations are identified in the latent debris walkdown report. For each of the twelve area types, they measured sample masses for a specific area. The surface areas sampled were used to compute the mean sample mass per unit area, the standard deviation of this quantity, and the 90 percent confidence limit of the quantity. The 90 percent confidence limit was conservatively used as the representative latent debris sample mass per unit area for each specific area type sampled. The total mass of latent debris present in containment in each of the twelve area types was extrapolated from the measured debris masses by multiplying the computed sample mass per unit area by the estimated surface area in containment associated with the specific area type. The masses identified with each area type were summed to provide the total latent debris in containment.

The licensee's analysis of latent debris included the following conservatisms:

1. Inclusion of the glass light bulb debris in the miscellaneous debris estimate is conservative because the glass density is greater than that of the water and macroscopic pieces of glass would likely not be transportable to the containment sump.

2. Conservative estimate of surface areas of the various area types and use of the 90 percent uncertainty bound for latent mass estimation provide adequate margin to compensate for the effect of the mass measurement uncertainty.

3. 5 percent margin for latent debris included in the strainer design specification, bringing the total latent debris mass specified for the strainer design to 118 pounds (lb.).

NRC STAFF CONCLUSION:

For the latent debris review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the latent debris evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

7.0 DEBRIS TRANSPORT

The objective of the debris transport evaluation process is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The NRC staff conducted an audit review for North Anna and concluded that the debris transport area had been adequately addressed (See November 15, 2007, Audit Report (ML072740400)). No open items were identified. The NRC staff compared key assumptions in the supplemental response to those in the audit report and did not identify any discrepancies. No changes to the analysis were noted by the licensee in the supplemental response. Therefore, the NRC staff considered this area to have been acceptably addressed by the licensee. The NRC staff noted that substantial conservatism exists in the transport analysis.

The licensee's transport analysis included modeling of the four main modes of debris transport. However, details of the transport analysis were not discussed in the supplemental response, nor was any attempt made to provide the information requested in the content guide.

The licensee's response indicated that a computational fluid dynamics analysis was not credited to determine the containment pool flows. Rather, the licensee assumed that the flow would exceed the transport threshold for small pieces of all types of debris and essentially only credit the settling of large debris pieces. The NRC staff found this approach conservative.

The overall transport results are shown below:

Table 2: Debris Transport Calculated for Breaks 1-4

Debris Type	Transport Fraction
Transco RMI	0.75
Transco Thermal-Wrap (Within ZOI)	0.65
Transco Thermal-Wrap (Spray Generated)	1.00
Temp-Mat (Within ZOI)	1.00
Temp-Mat (Spray Generated)	1.00
Paroc Mineral Wool	1.00
Fiberglass (Spray Generated)	1.00
Qualified Coatings	1.00
Unqualified Coatings	1.00
Damaged Coatings	1.00
Latent Fiber	1.00
Latent Particulate	1.00
Foreign Material	1.00

A more detailed description of the licensee's transport methodology is available in the audit report.

Following the initial audit, the NRC staff conducted a chemical effects audit to follow-up on the treatment of chemical effects and head loss testing. During the audit, the NRC staff identified that the transport fraction to the LHSI strainer was underestimated at 46 percent while it could actually be 62 percent under some pump alignments. This issue was discussed by senior NRC staff (integrated review team (IRT)) to determine whether it should be transmitted to the licensee. Based on several conservative assumptions in the licensee's debris generation and transport analyses, the NRC staff determined that there is reasonable assurance that there is a 25 percent margin in the debris assumed to reach the LHSI strainer which will more than offset the additional transport that may occur to the strainer. Therefore, the issue was not transmitted to the licensee.

The NRC staff stated that despite the incomplete supplemental response, the licensee's transport analysis is acceptable and conservative based on the audit results. A conservative transport methodology resulted in a bounding debris source term at the strainer for all types of debris.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the debris transport has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris transport evaluation for North Anna is acceptable. Therefore, the NRC staff considers this area closed for GL 2004-02.

8.0 HEAD LOSS AND VORTEXING

The objectives of the head loss and vortexing evaluations are to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 27, 2009.

The NRC staff audit of the North Anna approach to head loss and vortex evaluation was generally favorable. There were only two open items in the head loss and vortexing area found during the audit. The NRC staff followed up the original audit with an additional chemical effects audit (See February 10, 2009, Audit Report at ML090410618). The chemical effects audit was also generally favorable. The NRC staff made two trips to the Atomic Energy of Canada, Limited (AECL) test facility to witness both non-chemical testing and chemical effects testing.

The licensee's approach to reducing strainer head loss was to install two arrays of AECL strainer modules in place of the original sump strainer. One strainer supplies the RS pumps, and one supplies the LHSI pumps. Scaled testing of the strainer modules was conducted at AECL. The results reviewed by the NRC staff are based on fibrous and particulate debris predicted to reach the strainer following a postulated LOCA.

The new strainer modules increased the area of the strainer significantly. The RS strainer area is about 4,000 ft^2 for both units, and the LHSI strainer is about 2,000 ft^2 on Unit 1 and 1,900 ft^2 on Unit 2. The strainers consist of long trains of strainer modules connected via a central plenum. The strainer fins are vertically oriented. The bottom of the RS strainer is about 6.375" off the floor and the LHSI strainer is oriented on top of the RS strainer. The top of the RS strainer is about 21.5" off the floor. The bottom of the LHSI fins are about 23.5" above the floor while the top of the fins are about 50.25" above the floor. This configuration was developed because the RS strainer is placed in service prior to the LHSI strainer, and the pumps have different suction paths. Spray from the RWST continues to add volume to the containment sump after the RS strainer begins recirculation. This allows the LHSI strainer to be fully submerged prior to placing it in service. The maximum design flow for the RS strainer is 12,620 gallons per minute (gpm) with all four RS pumps running. The screen approach velocity for the RS strainer is about 0.0064 ft/sec. The maximum design flow rate for the LHSI strainer is 4,050 gpm, which corresponds to single pump operation. This results in an approach velocity of about 0.0047 ft/sec for the LHSI strainer. Single LHSI pump operation is limiting due to the greater required NPSH ($NPSH_R$) for the additional flow that occurs when only one pump is operating. Minimum submergence of the RS strainer is about 2.625" while the LHSI strainer is reported to have a minimum submergence of 9.75". The design head loss for the RS strainer is 5.0 ft at 180 degrees Fahrenheit (°F) and 12,620 gpm. The design head loss for the LHSI strainer is 8.5 ft at 113°F and 4,050 gpm. The AECL strainer design incorporates internal orifices to force uniform flow through all strainer perforated surfaces.

All large breaks generate significant fibrous debris. The licensee assumed 118 lb. of latent material within containment of which 17.8 lb. would be fine fibers. The licensee assumed 250 ft^2 of sacrificial area for labels, tape, and other miscellaneous debris.

AECL has performed large-scale testing, reduced scale testing (Rig 33), and more recently performed chemical testing (Rig 89). The NRC staff observed both test facilities. In general, the NRC staff found the testing procedures used by AECL for non-chemical debris resulted in prototypical or conservative head loss predictions for the strainer. Testing of AECL strainers found that, in general, thin beds (vs. full loads) present the most challenging head losses.

Based on the audit, the response to the audit open items, and the February 2009 supplemental response, the NRC staff noted that only one item was not fully addressed and was an open item from the full audit. The open item was that the licensee had not adequately addressed the effects of chemicals on the strainer evaluation. The NRC staff performed a separate chemical effects audit at North Anna (Audit Report ML090410618), in which both chemical and non-chemical aspects of the strainer head loss evaluation were evaluated. This later chemical effects audit identified no open items.

The two audit open items identified by the NRC staff during the earlier full audit, but closed as part of the audit follow-up, are summarized as follows:

> <u>Open Item 3.6-1</u> – The licensee scaled test head losses to plant sump conditions based only on temperature-driven viscosity variations. Test phenomena driven by differential pressure (e.g., opening of paths through the bed) should have been considered as well. The licensee stated in its supplemental response, that flow through the debris bed is laminar, the peak head losses were used in the evaluation, no sudden decreases in head loss occurred during testing, and no bore holes were observed during the testing. The licensee also stated that the reduction in head loss occurred before the thin bed was fully formed. The NRC staff did find the licensee's evaluation to be adequate but noted that the statement regarding the timing of the head loss may be used to provide an adequate response to the open item. This evaluation would require a review of the test data to verify that the head loss did not decrease after the thin bed had fully formed.
>
> Because the open item response did not address the issue, the NRC staff proposed an RAI on this topic. The NRC staff (IRT) considered the impact of the proposed RAI holistically in light of conservatisms in other areas of the analyses, such as debris generation, characteristics and transport, latent debris, chemical effects and others. The NRC staff determined that these conservatisms are significant. Regarding the viscosity scaling issue, the staff noted that the impact of the issue would be to lessen the scaling credit considering that pressure-driven (bed degradation) effects scale differently than temperature-driven effects. However, the staff also noted that the minimum head loss margin occurs at a point in time for North Anna when there is a significantly lower benefit from temperature scaling than the maximum. At the time when the pool is much hotter, there is considerably more head loss margin. Additionally, the staff noted that although some pressure-driven bed degradation may have occurred during testing (and also could occur during an accident); there still would be significant viscosity scaling effects as well. Overall, considering margins in head loss results, significant conservatisms in other areas that result in more debris on the strainers during the test than is realistic during a DBA, the staff holistically considered that it was not necessary to pursue the issue of temperature scaling/bed degradation identified in the proposed RAI.

> Open Item 3.6-2 – The licensee assumed that at the beginning of LHSI operation in the recirculation mode there would be no debris accumulation on the LHSI strainer, and that the strainer head loss due to debris would reach the peak thin bed head loss after a period of time. The NRC staff stated that the licensee should provide the basis for these assumptions in its supplemental response. The licensee made an argument that showed that the maximum expected rate of head loss increase starting from a clean strainer value at the time of LHSI pump start, including significant conservatism, would not result in a negative NPSH margin throughout the required operational period for the LHSI pump. The NRC staff accepted this argument and considered this item to be closed.

In its April 27, 2011, letter (ML111180686), the licensee described two issues that could affect the strainer evaluation. First, the licensee discovered additional insulation within the ZOI. The additional insulation was Microtherm, Cal-Sil, and TempMat. The licensee has since removed all the Cal-Sil and Microtherm from locations where it could contribute to the debris source term for the sump strainers. The licensee evaluated the additional fibrous insulation (TempMat) and determined that the operation of the sump strainer would not be adversely affected. In its letter dated May 15, 2013, the licensee stated that modifications were being developed to remediate the additional TempMat by replacing some fibrous insulation within the ZOI with RMI. Therefore, the strainer analysis remains valid.

The licensee also discovered that the strainer area had been calculated incorrectly by the vendor. The LHSI strainer areas were not significantly affected by this issue, but the RS strainers were found to be smaller by about 10 percent (4,000 ft^2 vs. 4,400 ft^2). The licensee evaluated the condition and determined that the strainer testing was not adversely affected by the issue due to the way that test flow rates and debris loads were scaled for testing. Therefore, the NRC staff conclusions regarding the strainer analysis are unchanged.

NRC STAFF CONCLUSION:

The NRC staff conclusions are based on the results of the GL 2004-02 audit and the follow-up chemical effects audit.

For the head loss and vortexing area, the licensee has provided information such that the NRC staff has reasonable assurance that the strainer head loss and potential for air ingestion has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the head loss and vortexing evaluation for North Anna is acceptable. The NRC staff considers this area closed for GL 2004-02.

9.0 NET POSITIVE SUCTION HEAD

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a LOCA considering a spectrum of break sizes.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 27, 2009.

The licensee generally provided the content guide specified information although with brevity in some areas and in large part through reference to the November 15, 2007, audit report (ML072740400) and identified additional/changed information.

The NRC staff found that the methodology used by the licensee is a standard industry practice for calculation of NPSH margin and uses a combination of realistic and conservative assumptions. The GOTHIC computer code was used to determine the $NPSH_a$ for each pump as a function of time, crediting containment atmospheric pressure (the difference between the containment atmosphere pressure and the vapor pressure of the sump water at the pump's suction). This is consistent with the Regulatory Guide 1.82 provision for sub-atmospheric containments. The GOTHIC model did not include recirculation strainer clean or debris laden head loss and the NPSH margin determined by this calculation is available for offsetting strainer head loss.

The North Anna ECCS and containment quench spray (QS) and inside/outside RS (IRS/ORS) system each include two trains of pumps. Each ECCS train consists of one high-head safety injection (HHSI), and one LHSI pump. Each containment spray train has one QS pump discharging to its respective containment spray header and one IRS pump and one ORS pump. On actuation of the safety injection signal (start of the injection phase) the HHSI and LHSI pumps automatically start taking suction from the RWST and discharging into the three RCS cold legs along with the associated three safety injection accumulator tanks. A CDA signal or manual actuation starts the QS pumps flow from the RWST to their respective containment spray headers. When RWST level drops to the 60 percent level, the ORS pumps start. The ORS pumps also receive some suction injection from the casing cooling tank to increase NPSH margin. Discharge from the ORS pumps flows through the respective RS cooler heat exchangers and discharges to the spray headers. The IRS pumps start 120 seconds after the ORS pumps start and take suction from the containment sump. The IRS pumps combine flow with some bleed flow from the QS headers and discharge through their respective RS cooler heat exchangers and spray headers. When the RWST level drops to 16 percent, RMT occurs and the LHSI pump suctions are realigned to the containment recirculation sump and the HHSI suctions to the LHSI pump discharge. The QS pumps stop when the RWST is empty.

The licensee provided the minimum NPSH margins, not factoring in recirculation sump strainer clean and debris laden head losses, as follows:

Summary of GOTHIC NPSH Analysis Results

Pump	Minimum NPSH Available	Time of Minimum NPSH Available	NPSH Required at Maximum Flow	Minimum NPSH Margin (Does Not Include Strainer Head Loss)
LHSI	14.7 feet	3383 seconds – time of transfer to recirculation	13.4 feet at 4,050 gpm	1.3 feet
IRS	14.6 feet	2084 seconds (8 minutes) after pump start	9.6 feet at 3,400 gpm	5.0 feet
ORS	18.0 feet	1524 seconds (8 minutes) after pump start	11.3 feet at 3,750 gpm	6.7 feet

The licensee stated that the NPSH required values were based on the pump vendor supplied curves. The NRC staff position is that it is reasonable to assume that the industry standard practice criterion of 3 percent degradation was used. The licensee indicated that pump flow rates used in estimates of the suction head losses and NPSH required for the LHSI, ORS and IRS pumps were computed using hydraulic models of the flow networks and the pump manufacturer's strongest pump curves. The limiting single-failure resulting in the minimum NPSH margin would occur for the failure of an emergency electrical bus, which would leave only one LHSI pump and one HHSI pump operational. The licensee indicated that single residual heat removal pump flow in recirculation yields a slightly higher flow for the associated strainer and testing to that higher flow would suffice as covering the largest impact single failure scenario. The licensee used the Pipe 2000 hydraulics code to model the flow from the discharge of the LHSI pump to the RCS and to the inlet of the HHSI pump and then subsequently to the reactor vessel cold leg. The flow rates for the ORS and IRS pumps were computed similarly.

The licensee computed the inventory of water in containment using GOTHIC on a transient basis. Sources of water include the accumulators, the RWST, and the casing cooling tank. The water volume released to the containment is computed from the time of the LOCA initiation during the injection phase through the recirculation phase of the event. The water inventory in containment is reduced by estimates of water holdup volumes resulting from condensation films on surfaces within containment, water added to spray system piping, droplets suspended in the containment atmosphere, water absorbed in insulation, and water trapped in the refueling canal and reactor cavity. The sump water level is computed from the volume of liquid in containment, as reduced by the total holdup volume attributable to the various holdup mechanisms. The model contains a table of water level versus volume of water. This table was constructed using a model of the North Anna containment geometry that accounts for the slope of the containment floor and other irregularities in the containment shape. The net volume of water at any time, after subtracting the holdup, is used with this table to predict the containment pool water level at that time.

In its letter dated February 27, 2009, the licensee provided additional results for NPSH in a table, which is reproduced below. In a number of the cases, the minimum margins are very small. However, the NRC staff did not identify any concerns with the NPSH methodology, nor perceive significant uncertainties that would challenge the margins available. The staff noted that the table below was not based upon actual head losses, as explained in footnote g, but based on the allowable head loss specified for the strainer prior to testing. Strainer testing resulted in head losses lower than the values assumed in the table. Using actual tested head loss values would increase the minimum margins.

Summary of RS and LHSI Pump Margins

Pump	Minimum $NPSH_a$ (ft H_2O)[a]	Total Strainer Allowable Head Loss, H_L (ft H_2O)[b]	$NPSH_r$ (ft H_2O) at Maximum Flowrate (gpm)	Minimum Margin (ft H_2O) = $NPSH_a$ – HL - $NPSH_r$
ORS[c] – Short Term[e]	18.1 @ 193.2 °F	5.0 @ 180 °F[d]	11.3 @ 3750	1.8
ORS – Long Term[e]	27.1 @ 104 °F	8.0 @ 104 °F	11.3 @ 3750	7.8
IRS[c] – Short Term[e,f]	14.6 @ 204.3 °F	5.0 @ 180 °F[d]	9.6 @ 3400	0.0[g]
IRS – Short Term[e,h]	15.3 @ 198.4 °F	5.0 @ 180 °F[d]	9.6 @ 3400	0.7
IRS – Long Term[e]	28.0 @ 151.1 °F	8.0 @ 104 °F[d]	9.6 @ 3400	10.4
LHSI – RMT	14.7 @ 168 °F	1.0 @ 113 °F[d]	13.4 @ 4050	0.3
LHSI – Short Term[e]	22.4 @ 139.8 °F	5.0 @ 113 °F[d]	15.21[i] @ 4050	2.19
LHSI – Long Term[e]	26.6 @ 104 °F	8.5 @ 104 °F	16.55[i] @ 4050	1.55

a. This value is from the North Anna GOTHIC containment analysis and does not include strainer head loss.
b. This value includes the debris bed and strainer internals head loss at the strainer flow rates identified in Table 3.f-1.
c. ORS – Outside RS, IRS – Inside RS
d. Conservatively, no temperature correction has been made from NPSHa specified temperature.
e. Short term is defined as the time period from event initiation to the point at which stable containment pressure, sump temperature, and sump water level are achieved (less than 6 hours). Long-term considers contianment conditions from 6 hours to 30 days and includes the maximum efffect of aluminum precipitation in the debris bed.
f. Two RS pumps in operation.
g. Although there is no margin available when compared to the specification for total strainer head loss (5.0 ft H_2O), there is margin available to the test result of 2.21 ft H_2O at 180°F – see Table 3.f-2.
h. Four RS pumps in operation.
i. NPSHr is adjusted by $\beta = 1 + 0.5 \times$ (void fraction), i.e., NPSHr = $13.4 \times \beta$. See Section 3.f for discussion of void fractions predicted.

<u>NRC STAFF CONCLUSION</u>:

For the NPSH area, the licensee has provided information such that the NRC staff has reasonable assurance that it has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the NPSH evaluation for North Anna is acceptable. The NRC staff considers this area closed for GL 2004-02.

10.0 COATINGS EVALUATION

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The licensee used a 10D ZOI, which was based on NRC accepted guidance. All qualified coatings in the ZOI and unqualified coatings in containment failed as fine particulate. For debris transport, 100 percent of the coating debris particulate would transport to the sump and was used in head loss testing. In addition, the licensee added a 10 percent margin to the calculated coatings debris amount used in head loss testing. The licensee observed a bed that fully covered the strainer during testing and treated all the generated coatings debris as fine particulate. The licensee used walnut shell flour as the surrogate material for testing. The licensee's coating assessment program meets NRC staff expectations. For some coatings in the ZOI that were appropriately represented in the WCAP-16568-P, *Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings* (ML061990594, Non-Public), a 10D ZOI was used instead of the WCAP-16568-P ZOI of 5D. The larger 10D ZOI results in approximately seven times as much epoxy debris than the 5D ZOI that the licensee could have justified.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the coatings evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

11.0 DEBRIS SOURCE TERM

The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through April 27, 2011.

The NRC staff audit report for North Anna contains a detailed description of the programmatic controls which were reviewed by the NRC staff and found acceptable. The licensee stated that the existing foreign material exclusion program has been improved because of the corrective actions taken in response to GL 2004-02. The licensee stated that a cover is installed over the strainer at the beginning of refueling outages. The licensee also stated that containment closeout inspections include a visual examination of the recirculation sump, and that the inspection procedure would be re-written to address the design of the replacement strainers.

The licensee stated that the containments are routinely washed down at the end of each refueling outage, the washdowns cover essentially all levels of containment, and procedures instruct plant personnel to cover sensitive floor drains to prevent debris entrained in the drainage water from accumulating and causing blockage. The licensee further stated that Dominion is developing a fleet-wide latent debris program. In addition to containment washdowns, the program tentatively would include periodic walkdowns to collect latent debris samples to ensure that the latent debris analysis bounds the existing plant condition.

The licensee stated that plans exist to create a database for the data obtained from containment debris walkdowns. The licensee plans to designate a site engineer to be responsible for GSI-191 issues, including maintaining the containment debris database.

The licensee stated that Cal-Sil and Microtherm material potentially vulnerable to becoming problematic debris following a LOCA have been removed from the Unit 2 containment and that a similar removal of these materials would be completed in the Unit 1 containment during the upcoming outage in fall 2007. In a letter dated April 27, 2011 (ML111180686), the licensee identified that additional Cal-Sil and Microtherm had been discovered in containment. These materials were subsequently removed. The licensee also reviewed available documents to ensure that the potential debris sources within containment were identified.

The licensee stated that modification to plant insulation would be controlled through insulation change procedures or the work order process. The licensee stated that questions in plant engineering change packages would require an engineering review if an existing insulation material were replaced by a different material. With respect to the work order process, the licensee stated that the outage planning procedure would be revised to require an engineering review of work orders, with approval from the engineering manager. The licensee stated that the engineering manager is also present at daily outage work meetings and would be able to flag any issues associated with insulation modification resulting from emergent work orders.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris source term evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

12.0 SCREEN MODIFICATION PACKAGE

The objective of the screen modification package section is to provide a basic description of the sump screen modification.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 27, 2009.

The licensee provided a description of the major features of the new sump strainers, which are AECL design. The strainers have a surface area of approximately 4,000 ft^2 for the RS pumps in both units, approximately 2,000 ft^2 for the Unit 1 LHSI pumps and approximately 1,900 ft^2 for the Unit 2 LHSI pumps and are fully submerged at the start of recirculation. The difference in surface area between the Unit 1 and Unit 2 LHSI strainers is due to the fin configurations needed to clear interferences. The new strainers are composed of a solid housing which surrounds the ECCS suction pipes, and from which protrude two solid rectangular headers that extend nearly 180 degrees along the containment wall: one header on the bottom for the four RS pump suctions and one header on top for the two LHSI pump suctions. On each side of both headers are fins, the sides of which are perforated corrugated stainless steel. The maximum opening size in the fins is 0.0625 in. Fin spacing is nominally 6 in. (center to center). Debris collects on and between the fins and filtered water passes through the fins and down the headers to the ECCS and spray suction pipes.

Existing suction piping for the ORS and LHSI systems are connected to their associated strainer assemblies by a new strainer header. The OD of the new strainer header is machined to slip-fit into the existing suction openings ensuring that the gaps between the opening and the header piping do not exceed 0.0625 in. For the IRS pump, the strainer header is connected to the pump well by a new well extension housing. The design of the strainers is such that the IRS, ORS, and LHSI pumps no longer take suction directly from the containment sump but take suction from the containment annulus area via the strainers. The RS strainer consists of two legs along the containment wall on either side of the existing/original containment sump. The bottoms of the fins are approximately 6 in. off the containment floor which permits water to flow under the strainer and prevents “large” debris from building up around the fins thus blocking the effective surface area. The LHSI strainer modules are installed along the containment wall on top of the RS strainer modules (RS strainer flow starts before LHSI strainer flow and with less water in containment).

Additional changes needed to provide clearance or otherwise accommodate the new strainers included:

- Reconfiguring the QS bleed lines
- Dike wall interface with new strainer headers
- Dike wall panel and storage rack interferences
- Containment sump level instrument debris shields
- IRS pump test return lines and supports
- Instrumentation and instrumentation rack interferences including tubing, conduit, drains and supports.

Although the maximum opening size in the sump strainer fins is a 0.0625” diameter hole, the licensee determined that the possibility exists for larger ‘gaps’ in the strainer assembly due to fit-up “inconsistencies”. The licensee described the number and size of these gaps as follows: (1) gaps up to 0.125” wide for a total of 1 percent of strainer total flow area; and (2) limited number (4 on the LHSI strainer and 8 on the RS strainer) of 0.1875” wide by 1” long.

The licensee evaluated the following five areas of the downstream effects analysis that could be affected by increased debris resulting from increased gap size:

(1) bypass fraction and debris size,
(2) downstream component wear,
(3) downstream component blockage,
(4) fuels blockage, and
(5) strainer hydraulics.

The evaluation concluded that the presence of 0.125" wide gaps for 1 percent of strainer flow area, and 0.1875" wide by 1" long gaps limited to 4" on the LHSI strainer and 8" on the RS strainer, would have no significant effect on the results of the downstream effects analyses for systems and components or the fuel and vessel.

NRC STAFF CONCLUSION:

For the screen modification package review area, the licensee provided information such that the NRC staff has confidence in the design of the strainer and the evaluation performed for the strainer. Therefore, the NRC staff concludes that the screen modification package information provided for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

13.0 SUMP STRUCTURAL ANALYSIS

The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer including seismic loads and loads due to differential pressure, missiles, and jet forces.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

The NRC staff reviewed Section 3k, Sump Structural Analysis, and the response to RAI 32, in the licensee's submittal dated February 29, 2008, and determined that the licensee adequately addressed the information requested by the content guide for GL 2004-02 Item 2(d)(vii). The licensee stated that the maximum stress induced in the components associated with the replacement sump strainer were within the allowable stress limits of the 1989 Edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Subsection NF requirements. The NRC staff's November 15, 2007, audit report (ML072740400) also confirmed this fact and stated that the sump strainer assembly is structurally adequate to perform its required safety function during a design basis event.

The NRC staff's audit report stated the licensee used computer software to perform a series of static and dynamic finite element analyses to qualify the strainer assembly. The models were subjected to loading combinations associated with dead weight, differential pressure, seismic loads (including hydrodynamic mass), and thermal expansion effects. Each of these loads is consistent with the guidance of NEI 04-07. The induced stress values were then compared to the allowable stress values of the ASME Boiler and Pressure Vessel Code. All resultant stresses were determined to be within the allowable limits.

To address potential dynamic effects associated with a HELB on the replacement sump strainers, the staff's audit report agreed with the licensee's finding that "the piping within the LOCA boundary limit is protected/isolated by missile barriers and provided with whip restraints." Furthermore, the piping that was not isolated by the protective missile barriers was adequately separated to preclude damage, suitably restrained, subject to augmented inspections, or if ruptured would not require the recirculation phase of the ECCS.

The licensee's response to RAI 32 (ML052500378) stated that an active strainer design (i.e., one that incorporates a backflushing strategy) was abandoned in favor of a passive design. For this reason, reverse pressure loadings were not required to be considered on the sump strainers.

The NRC staff stated that the information provided by the licensee shows that the sump structural evaluation contains inherent conservatism by complying with the accepted design codes. A thorough review of pertinent calculations was performed during the staff's audit. The staff's audit report concluded that the stress results of the calculations were acceptable. The staff stated that the licensee provided sufficient information to show that a level of conservatism exists, and the intent of the Revised Content Guide for GL 2004-02 Item 2(d)(vii) has been met.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the sump structural analysis evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

14.0 UPSTREAM EFFECTS

The objective of the upstream effects assessment is to evaluate the flow paths upstream of the containment sump for holdup of inventory, which could reduce flow to the sump.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 29, 2008.

Based upon the information reviewed and summarized in the November 15, 2007, audit report (ML072740400), the NRC staff concluded that water drainage in containment would not be susceptible to being trapped in unanalyzed holdup locations. The staff focused its review of upstream effects on the drainage flow paths through the refueling canal and reactor cavity because of the potential for the drains to these large volumes to act as chokepoints for retaining substantial quantities of water if the drains became blocked by debris.

The licensee assumed that the refueling canal becomes filled with water, which is a conservative assumption. The licensee stated that a small strainer was installed to avoid drain blockage. The licensee also added a large drainage hole to the reactor cavity to ensure that a significant holdup volume would not occur in that location. Therefore, the NRC staff did not identify any issues of significance with respect to the licensee's upstream effects analysis.

The NRC staff found that the GOTHIC analysis for $NPSH_a$ makes the following corrections for holdups in the NPSH analysis: water holdup in the refueling canal, water holdup in the reactor cavity and instrument tunnel, water holdup on condensed films and heat structures, and water holdup and films on platforms and structures. The calculation also accounts for water absorption in insulation. The GOTHIC calculation realistically accounts for the holdups as part of the transient analysis. The staff noted that these holdups appear to be properly accounted for in the calculation.

Based upon the information reviewed and summarized above, the NRC staff concluded that water drainage in containment would not be susceptible to being trapped in unanalyzed hold up locations. The blowout panels in the reactor cavity could potentially block the drain from the refueling canal since it is only a 6" opening. To prevent blowout panels from blocking the opening, a raised steel dome with holes was installed over the refueling canal drain. The remainder of the refueling cavity has numerous drains through the reactor cavity penetrations and incore tunnel openings to drain the water even if some of the openings were blocked.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the upstream effects evaluation for North Anna is acceptable. The NRC staff considers this item closed for GL 2004-02.

15.0 DOWNSTREAM EFFECTS - COMPONENTS AND SYSTEMS

The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through February 21, 2021.

The licensee provided a detailed description of the evaluations performed to assess the effects of recirculated sump fluid on the components and systems located downstream of the ECCS sump strainer. The licensee stated that the evaluation was performed following the guidelines of WCAP-16406-P, Revision 1, *Evaluation of Downstream Sump Debris Effects in Support of GSI-191* (ML081000027), and the NRC SE for that document (ML073520295), without exception. The licensee also stated that there were no modifications required as a result of the evaluations.

In its February 27, 2009, response, the licensee described a downstream effects evaluation performed to address some minor fit-up gaps in the strainer assemblies. The licensee stated that the Downstream Effects – Components and Systems evaluation included the effects of additional bypass that could occur due to the fit-up issues. The licensee stated, in section 3.j (Screen Modification) of the response that the gaps would have no significant effect on the results of the downstream analysis. In its February 21, 2021, submittal, the licensee stated that the effects of the gaps were evaluated by assuming that additional particles of debris could penetrate the strainer. The licensee evaluated the additional debris source term and found it to have no adverse effects on the downstream evaluations.

The licensee stated that the downstream effects analysis addressed:

1. Extent of wear of the HHSI pumps (Charging pumps), ORS pumps, IRS pumps, LHSI pumps, manually throttled valves, motor operated valves, orifices, flow venturis, RS nozzles, and heat exchangers,
2. Effects of wear on the performance of the component listed in (1) above,
3. Effects of debris on pressure relief valves which could potentially open during recirculation and piston check valves which open during recirculation, and
4. Potential for blockage of downstream components, including instrumentation, by debris.

The licensee stated that wear models were developed in accordance with the methodology in WCAP-16406-P, Rev. 1, to assess the amount of wear expected to occur in ECCS and recirculation spray system (RSS) components. The analysis considered the initial debris concentration in the pumped fluid, the debris depletion rate due to settling and filtration, the hardness of the wear surfaces, and the component mission time. The licensee stated that the evaluation results show that all downstream components are acceptable per the criteria set forth in WCAP-16406-P, Rev. 1.

Pump Evaluations

The licensee stated that the evaluation of pump hydraulic performance and mechanical dynamic performance was based on pump design performance characteristics supported by approximately ten years of in-service testing that demonstrated that there had been no statistically significant degradation of the performance of the North Anna HHSI, LHSI, IRS, and ORS pumps over that period.

The licensee stated that abrasive wear of the ECCS and RSS pumps was conservatively calculated, and the worn-condition pump hydraulic performance was evaluated for its effect on system minimum performance requirements. This overall system performance evaluation also included a review of cumulative system resistance changes due to wear in system piping and components to determine the impact on system maximum flow to assess pump run-out potential. The review of component wear concluded that all system components pass the WCAP-16406-P, Rev. 1, criteria. In addition, the system performance evaluation concluded that there would not be a significant effect on system resistance or flow rate. The licensee's overall system performance evaluation concluded that the ECCS and RSS pumps would meet their hydraulic performance requirements at the end of their 30-day mission time.

The impact of abrasive debris on the performance of pump mechanical shaft seals was evaluated for the LHSI, HHSI, and ORS pumps (IRS pumps do not use a mechanical seal). The licensee concluded that the debris-laden recirculation fluid would not adversely impact the performance of the mechanical seals during the mission time.

The licensee stated that it performed an evaluation of the effect of the increased flow clearances resulting from the abrasive and erosive wear of pump components to determine if ECCS and RSS pumps would be capable of operating satisfactorily, without excessive vibrations, over the required post-LOCA mission time.

The licensee stated that the heat exchangers in the recirculation flowpaths were evaluated for wear effects due to debris-laden fluid flow. The evaluation concluded that the actual wall thickness of the heat exchangers tubes minus the tube wall thickness lost due to erosion during a 30-day period is greater than the minimum wall thickness required to withstand both the internal tube design pressure and the external shell design pressure. Therefore, the heat exchanger tubes were determined to have sufficient wall thickness to withstand the erosive effect of the debris-laden post-LOCA recirculated sump water for a period of 30 days. Further, tube blockage is not expected to occur because the tube internal diameter is greater than the maximum debris size and the flow velocity is greater than the debris settling velocity.

The licensee stated that the manually throttled valves, motor operated valves, flow venturis, orifices, and RS nozzles in the ECCS/RSS recirculation flow path were evaluated for the effects of wear due to the debris-laden fluid flow. These components were evaluated individually and, with the exception of the plate orifices in the safety injection system, were found to meet the criteria set forth in WCAP-16406-P, Rev. 1. A system evaluation was also performed to determine the cumulative effect of wear on system flow rates and the hydraulic performance requirements were determined to be met. The wear of the plate orifices in the safety injection system flow path was included in the evaluation of system flow effects and found to have an insignificant effect. Relief valves in the recirculation flow path were evaluated for the ability to reseat in the event of opening considering the debris-laden fluid. None of the relief valves have the potential to lift during the recirculation phase; therefore, the potential for debris blockage in the open position does not exist. Piston check valves were evaluated for the potential to malfunction due to debris and determined that failure of the piston check valves to close would have no effect on system functions required for the recirculation phase.

The licensee stated that instrumentation, except for the reactor vessel level instrumentation system (RVLIS), in the recirculation flow path that would be required to function after a LOCA was verified to be mounted either horizontally or vertically on top of the recirculation piping and the associated instrument sensing lines are oriented horizontally or vertically up from the pipe taps, so that the entry of debris is unlikely. The RVLIS measures reactor vessel water level with a differential pressure transmitter connected through instrument tubing to the top and bottom of the reactor vessel. There is no flow through the RVLIS tubing so debris would not be drawn into the RVLIS connections. Additionally, no debris is expected to accumulate in the reactor vessel upper head near the RVLIS connection. The flow velocity in the reactor vessel lower plenum during recirculation would be minimal, so debris is expected to collect around the instrument nozzle penetrations, one of which is used for the RVLIS connection. However, since the instrument nozzle extends above the inside surface of the reactor vessel lower head, and there is no flow through the RVLIS sensing tubing, debris would not collect near the tubing open end in sufficient quantity to prevent the RVLIS from sensing lower head static pressure. The debris collecting in the lower plenum would not affect RVLIS water level measurements. Therefore, instrumentation will not be adversely affected by debris in the recirculation flow path.

NRC STAFF CONCLUSION:

For the ex-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

16.0 DOWNSTREAM EFFECTS - FUEL AND VESSEL

The objective of the downstream effects, fuel and vessel section, is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on long-term core cooling.

NRC STAFF REVIEW:

The NRC staff review is based on documentation provided by the licensee through May 8, 2023.

In its supplemental response dated February 27, 2009 (ML090641038), the licensee stated that the evaluations completed to date followed the guidance in WCAP-16793-NP, Rev 0 (ML071580139). Because later strainer penetration evaluations found that the fiber limits associated with WCAP-16793-NP could be exceeded, the licensee reperformed its in-vessel evaluation based on WCAP-17788 (ML15210A667, Package) and associated NRC staff guidance.

In a May 15, 2013, letter, the licensee stated that testing had been conducted to determine the amount of fiber that could penetrate the strainer. Testing was conducted for North Anna, Surry, and Millstone 2. The licensee stated that 99.9 percent of the fiber is captured by the strainer on its first pass. The testing used grab samples to determine the penetration amounts. The staff has recommended that penetration testing use full flow filtering to capture fiber that bypasses the strainer.

By letter dated August 13, 2015 (ML15232A026) the licensee informed the NRC that North Anna would demonstrate compliance with the WCAP-17788-P reactor vessel debris acceptance criteria, instead of relying on WCAP-16793-NP to evaluate reactor vessel debris.

The licensee initially calculated the total fibrous debris quantity from Thermal-Wrap, TempMat, Paroc Mineral Wool, fiberglass, and latent fiber that could potentially reach the sump strainer to be 2,289 pound-mass (lbm). However, after the licensee removed Thermal-Wrap on the SGs and replaced it with RMI, the maximum amount of fiber that could potentially reach the strainers is bounded by the AECL tested limit of 1,818.7 lbm. Because the plant has separate strainers for RSS and LHSI, the amount of fiber predicted to reach the LHSI strainer was calculated to be 909 lbm.

The licensee stated that because the strainer fiber bypass testing performed by AECL for the strainer design installed at North Anna used a “grab sample” method, there is no data for the quantity of bypassed fiber as the debris bed is forming and therefore, cumulative fiber bypass fractions could not be determined. In addition, the mix of fibrous insulation types significantly changed, which impacts the theoretical debris bed thickness for determination of fiber fraction. The licensee stated it used fiber bypass data from other plants to apply to the AECL strainer at North Anna. The licensee noted that it has two hydraulically independent strainers that serve the LHSI system and RS system pumps and since only the LHSI strainer delivers sump water to the reactor vessel, the bypass fraction was only determined for the LHSI strainer.

The licensee applied Point Beach test results to the North Anna strainer. The licensee stated that because North Anna has a higher strainer approach velocity than Point Beach, it was necessary to apply a correction factor to scale the Point Beach data to the higher velocity. The licensee derived the correction factor from the Vogtle plant tests that recorded bypass fractions at various velocities. The licensee determined that bypass mass, normalized by flow rate, was linearly related to approach velocity, which supported the calculation of cumulative bypass fractions for the Vogtle strainer at flow rates comparable to North Anna and Point Beach. The licensee then was able to determine a cumulative bypass correction factor at a given debris bed thickness by scaling the Vogtle data at the North Anna velocity to the Point Beach test velocity.

The geometry of the Point Beach disk strainer was compared to the North Anna strainer and assessed to be equivalent in its hydraulic performance characteristics. The licensee stated that the design of the strainer ensures uniform debris disposition. The licensee assumed that all the sacrificial area would be available for formation of the fibrous debris bed to minimize the thickness of the calculated theoretical debris bed, which would result in larger cumulative bypass fractions for the maximum debris load. The licensee compared the slightly larger strainer perforation size for Point Beach (0.066”) to North Anna (0.0625”) and determined it has a conservative influence on cumulative bypass fractions when applying the Point Beach test results to North Anna.

The licensee discussed conservatisms applied when determining the cumulative bypass fraction for the North Anna strainer and provided a table listing the critical parameter comparison for sump strainer bypass testing. The cumulative bypass fraction at the theoretical debris bed thickness of 1.066" was calculated as 3.8 percent and was corrected with a velocity factor of 1.948, resulting in a cumulative fiber bypass fraction of 7.4 percent. The NRC staff drafted a question regarding the methodology used to calculate the fiber amount that would penetrate the strainer. The NRC staff did not understand how the bed thickness correction factor was implemented to scale Point Beach test results to the North Anna plant conditions. The licensee provided an RAI response on November 7, 2022 (ML22312A443). Based on the response, the NRC asked a follow-up RAI that requested the licensee to justify the method used. The licensee responded in letter dated May 8, 2023 (ML23128A162). The response recalculated the amount of debris penetrating the strainer and the amount of debris that can arrive at the core. The response also revised the assumptions and methods used to evaluate the in-vessel debris load acceptability because the in-vessel debris amounts increased. The following discussion reflects the final debris values.

North Anna is a Westinghouse 3-loop design that uses Westinghouse 17x17 Robust Fuel Assembly 2 (RFA-2) fuel. The licensee stated that the proprietary total in-vessel (core inlet and heated core) fibrous debris limit contained in Section 6.5 of WCAP-17788-P, Volume 1, Revision 1, "*Comprehensive Analysis and Test Program for GSI-191 Closure*" (Package - ML20010F181), applies to North Anna.

The licensee calculated the fibrous debris amounts using the methodology from WCAP-17788-P. The licensee calculated that the maximum amount of fibrous debris to potentially reach the reactor vessel is 23.19 grams per fuel assembly (g/FA), which is less than the proprietary in-vessel fibrous debris limit in Section 6.5 of WCAP-17788, Volume 1. Based on the NRC staff questions (cited above) regarding the bed thickness correction factor the licensee recalculated the amount of debris reaching the vessel to be 98.1 g/FA. This is greater than the core inlet debris limit, but less than the total core debris limit.

The licensee stated that the earliest sump switchover (SSO) time for North Anna is 33.3 minutes and chemical effects timing (t_{chem}) is 24 hours. The licensee stated that hot-leg switchover (HLSO) occurs no later than five hours after event initiation to mitigate the potential for boric acid precipitation, which is also less than 24 hours. The licensee stated that complete core inlet blockage time (t_{block}) for North Anna is 143 minutes (WCAP-17788, Volume 1, Table 6-1), which is the earliest time that complete fuel inlet blockage can occur while not compromising long-term core cooling (LTCC) (WCAP-17788-P) nor inhibiting LTCC. The license confirmed that t_{chem} of 24 hours is greater than t_{block} of 143 minutes. The t_{chem} timing is based on Test Groups 5 and 15 from WCAP-17788-P which were stated to be representative of the North Anna plant conditions. The NRC staff reviewed the autoclave test conditions for the aforementioned autoclave test groups in Volume 5 of WCAP-17788-P and verified that they are representative of the projected post-LOCA environments for North Anna Units 1 and 2.

The licensee stated that North Anna rated thermal power (2,940 megawatts thermal (MWt)) is less than the applicable analyzed thermal power in the WCAP (3,658 MWt) and is therefore bounded by the WCAP alternate flow path (AFP) analysis.

The licensee stated that the North Anna specific AFP resistance (WCAP-17788, Volume 4, RAI Table 4.2-24), is less than the proprietary analyzed AFP resistance (Table 6-1 of WCAP-17788, Volume 4) and is therefore bounded by the resistance applied to the AFP analysis.

The licensee stated that the minimum plant-specific ECCS recirculation flow rate is 22.56 gpm/FA and that the ECCS recirculation flow rate corresponding to the most limiting fiber injection hot-leg break scenario is 35.73 gpm/FA. The licensee stated that these flow rates are within the range of ECCS recirculation flow rates considered in the AFP analysis.

Because the updated debris amount for the core increased to a value greater than the core inlet debris limit, the licensee cited NRC staff guidance that the debris bed is realistically expected to collect non-uniformly. As a result, the licensee concluded that the amount of debris required to completely block the core inlet would be greater than that assumed in the analyses and the updated amount of debris would not result in blockage at the core inlet, and the current LTCC analyses remain applicable.

The NRC staff reviewed the licensee's information and found that it had generally followed staff guidance in the in-vessel evaluation. All the key parameters were bounded by the WCAP-17788-P analyses except for the core debris inlet limit.

For chemical effects the licensee demonstrated that precipitation would not occur before 24 hours and stated that this is longer than the analyzed t_{block} time for the plant and longer than the HLSO time for the plant. Therefore, AFPs are available for coolant to reach the core should the core inlet be blocked by chemical precipitates combined with other debris.

During its review of the February 25, 2021, submittal, the NRC staff identified additional information required to ensure that the in-vessel evaluation was performed acceptably. In letter dated September 9, 2022, the NRC staff requested additional information regarding the licensee's method for correcting the penetration values for fiber bed thickness, clarifications on the references used, and confirmation that the RSS would start and run at the flow rate assumed for the period during which penetration is calculated. The licensee responded to the NRC staff questions in letter dated November 7, 2022. The response adequately addressed the staff concerns except for the methodology for correcting the penetration amounts. The NRC staff found that the responses are consistent with staff guidance and the licensee's evaluation. The issues regarding the fiber penetration methodology are discussed above.

The NRC staff recognizes that the licensee is citing NRC staff guidance that allows crediting non-uniform debris bed distribution at the core inlet combined with maintaining the total debris amount reaching the reactor less than the total core fiber limit as the primary criteria for maintaining adequate LTCC. The licensee also provided information that indicates that the AFPs will be available to provide cooling to the core should the core inlet become blocked. This is an acceptable evaluation methodology to ensure LTCC will not be compromised by debris entering the core.

<u>NRC STAFF CONCLUSIONS</u>:

For the in-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has overall been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

17.0 CHEMICAL EFFECTS:

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling. The evaluation of chemical effects on the reactor vessel core is discussed in Section 16.0, "Downstream Effects - Fuel and Vessel."

INITIAL NRC STAFF REVIEW:

The NRC staff review is based on the following documentation provided by the licensee (ML090641038, ML090400742, and ML111180686), NRC audit report on chemical effects-related actions to address GL 2004-02 (ML090410626) as well as a May 15, 2013, updated plant-specific path and schedule for resolution of GL 2004-02 (ML13141A278). The reference documents used for this review include the March 31, 2008, NRC staff SE of WCAP-16530-NP-A, "WCAP-16530-NP-A, Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" (ML081150379) and the March 28, 2008 "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Plant-Specific Chemical Effects Evaluations" (ML080380214).

The licensee uses sodium hydroxide for post-LOCA pool pH control for North Anna. The licensee calculated a range of post-LOCA pool pH values using a Monte Carlo analysis methodology. The licensee's plant-specific debris sources for North Anna included Transco RMI, Thermal-Wrap, TempMat, Paroc Mineral Wool, fiberglass, Microtherm, and Cal-Sil. The new containment sump strainer consists of a finned strainer manufactured by AECL. The strainer surface area is approximately 4,000 ft^2 for the RS pumps in both units, approximately 2,000 ft^2 for Unit 1 LHSI pumps and approximately 1,900 ft^2 for Unit 2 LHSI pumps and is fully submerged at the start of recirculation.

The licensee also used AECL to perform the chemical effects head loss testing and evaluation for North Anna. Chemical effects testing consisted of bench-top testing and a reduced scale test (Test Rig 89).

Background:

The NRC staff asked RAIs in the chemical effects area. The initial NRC staff RAIs are not discussed in this review since at the time, the licensee was still performing testing for their chemical effects evaluation. The licensee submitted a draft test plan on December 19, 2007. On February 29, 2008, the licensee provided a supplemental response. At the time, testing (Bench Top Testing) to determine potential precipitates was still in progress.

The NRC staff visited AECL's Chalk River Facility from May 5-9, 2008, to observe integrated chemical effects head loss testing for the Dominion plants. The purpose of the NRC staff trip was to observe chemical effects head loss testing in the recently constructed multi-loop test rig and to discuss the bench-top testing results used to justify the chemical effects testing procedure. Details of the visit are documented in the February 9, 2009, NRC trip report (ML090400786). The licensee's testing program for chemical effects consisted of protocols developed by AECL. The AECL protocol differed from the approaches used by many other test vendors (testing approaches were typically based on the WCAP-16530-NP-A-methodology). Following the NRC visit, the NRC staff held follow on phone calls with the licensee and AECL (June 25, 2008, and August 8, 2008) to discuss results of the multi-loop test rig and critical aspects of the testing program, such as the behavior of the measured head loss when significant quantities of chemicals were added to the test loops.

In addition to observing testing at AECL, the NRC staff also visited Dominion's Innsbrook facility from November 12-14, 2008, to perform a chemical effects audit for North Anna. The main purpose of the audit was to allow the NRC staff to perform a detailed review of the chemical effects evaluation. The NRC staff's review for the chemical effects audit focused primarily on systematic differences in head loss that had been observed for similar non-chemical debris loadings in two different AECL test rigs (Rigs 33 and 89) used for testing issues. Prior to the on-site portion of the audit, the NRC staff reviewed relevant documents related to chemical effects bench-top testing and integrated head loss test results. During the audit, the NRC staff reviewed the overall chemical effects approach, including the AECL test facilities, North Anna safety systems drawings of the sumps, observed systematic non-chemical head loss differences, chemical effects head loss test results, and analytical conservatisms. The February 9, 2009, audit report (ML090400797), includes detailed descriptions and evaluations of the head loss testing facilities. The report also includes a detailed review of head loss testing results, review of conservative assumptions incorporated into the sump strainer performance analysis, and an assessment of the post-LOCA NPSH margins. The NRC staff also evaluated the primary issues (discrepancy between Rigs 33 and 89 head loss results for similar debris loadings and the anomalous behavior in some of the reduced-scale tank tests) identified during the NRC staff trip to AECL's Chalk River Facility from May 5-9, 2008 (ML090400786). Based on the evaluation of these issues during the chemical effects audit, the NRC staff considers these issues resolved for North Anna. Details about the audit and how these issues were resolved, are documented in the February 9, 2009, audit report (ML090400797). The licensee superseded its February 29, 2008, revised supplemental response with a February 27, 2009, revised supplemental response); which included the chemical effects evaluation (incorporating AECL testing program using Test Rig 89).

Assessment of Potential Chemical Precipitates:

The chemical effects testing methodology developed by AECL was different from the approaches used by other vendors, which were based on the methodology described in WCAP-16530-NP-A. The WCAP methodology involves determining the chemical precipitate load, preparing the calculated amount of precipitates, and adding the pre-mixed precipitates to the test loop after a debris bed is formed on the test strainer.

The AECL methodology used a similar approach as outlined in WCAP-16530-NP-A to calculate the mass of aluminum released. However, rather than using the WCAP-16530-NP-A release equation, AECL used the data from WCAP-16530-NP-A and other sources (e.g., available experimental data including integrated chemical effects tests and data from scientific literature) to develop a semi-empirical release equation. In order to model the aluminum release rate, the pH and temperature dependencies of the corrosion rates were evaluated separately.

The licensee compared the results of the application of the AECL release rate model to the WCAP-16530-NP-A model results using North Anna aluminum inventories and found they predicted a greater 30-day release of aluminum. The total aluminum mass released to the sump water (plant-specific dissolved aluminum concentration) was calculated using the AECL aluminum release rate equation along with North Anna aluminum inventories based on exposure category, sump and spray water pH, and sump and spray water temperatures for specific time intervals following a LOCA.

The licensee used different assumptions in the calculation of aluminum release in support of chemical effects testing. For more details on these assumptions, refer to the revised supplemental response letter dated February 27, 2009.

Testing:

The AECL methodology for the chemical effects on sump strainer performance consisted of three elements:

1. An assessment of potential chemical precipitates, including determination of reactive material amounts present in the containment sump pool, pH and temperature profiles in containment, and a review of existing test and scientific literature data.

The North Anna chemical precipitates of concern were aluminum oxyhydroxide and calcium phosphate. Since the license determined that North Anna does not use tri-sodium phosphate as a pH buffer for the sump water, only the formation of aluminum oxyhydroxide needed further evaluation.

2. Bench-top testing to demonstrate that the solubility behavior of potential precipitates determined from literature is reproducible under plant conditions and to confirm that precipitates can be produced, if required, for reduced scale testing.

3. Reduced-scale testing to determine that any chemical products formed in the post-LOCA containment sump pool would not produce unacceptable head loss across the ECCS strainer debris bed. These tests verified that adequate NPSH was available to support the operation of the LHSI and RS pumps during the post-LOCA recirculation mode.

The initial goal of the bench-top test program was to show that no precipitation would occur in the projected plant-specific post-LOCA environment. Since the bench-top test results indicated precipitation could occur, the licensee concluded that additional chemical effects testing was needed. Therefore, the licensee performed integrated chemical effects head loss testing at the AECL Chalk River facility.

In particular, a multi-loop test facility identified as Rig 89 was fabricated to perform these tests. Rig 89 integrated chemical effects tests were performed in a simulated post-LOCA pool environment containing representative amounts of boron and scaled amounts of plant-specific debris. Test loop pH was adjusted to a representative value using sodium hydroxide. The test loop temperature was held constant at 104 °F (40 degrees Celsius). Plant-specific particulate debris quantities and the quantity of fiber needed to develop a thin bed were added in increments to the test loop. After a stable baseline head loss was established across the test strainer section, sodium aluminate was added in small batches with the objective of having the dissolved aluminum concentration in the Rig 89 test loop equal to the predicted plant-specific calculated dissolved aluminum concentration.

Since the Rig 89 test loop aluminum addition was scaled according to the post-LOCA pool concentration (instead of scaling the aluminum precipitate mass to the strainer area), precipitation of an aluminum compound during the test could result in a non-conservative dissolved aluminum concentration in the test loop. Therefore, if dissolved aluminum measurements indicated precipitation of an aluminum containing compound had occurred during the test, more sodium aluminate was added to the test loop to reach the target aluminum concentration, up to an amount that would represent the maximum amount of aluminum precipitate mass per strainer area for the plant. The total head loss measured in the Rig 89 test loop represents the plant-specific, integrated head loss across the sump strainer for plant debris and chemical effects. Over the course of the test, 19 sodium aluminate additions were made to the LHSI strainer test loop, for a total of 52.77 grams of sodium aluminate, and 24 sodium aluminate additions were made to the RS strainer test loop, for a total of 69.37 grams of sodium aluminate.

The NRC staff has reviewed all documentation submitted from the licensee with regards to chemical effects. The plant-specific aluminum release was calculated at a pH of 8.5, and the Rig 89 multi-loop rig tests were performed at a pH of 7. These values provide for a conservative amount of aluminum release and a conservative amount of aluminum precipitation in the test loop, relative to that projected for the plant-specific environment. The licensee also added margin into their calculations for plant-specific aluminum. After considering the significant conservatisms incorporated into the licensee's sump performance analysis, the NRC staff concludes that the uncertainties associated with the formation of debris beds in the multi-loop test rig were bounded.

FINAL NRC STAFF REVIEW:

Based on the information the licensee provided to the NRC staff in their previous submittals (February 29, 2008, and February 27, 2009, supplemental responses), the NRC staff had no further questions regarding the performance of North Anna ECCS strainers. Therefore, on May 28, 2009, the NRC staff issued a partial closure letter.

On April 27, 2011, the licensee submitted an updated supplemental response; wherein, the licensee identified additional insulation in the North Anna units. More specifically, the licensee identified three types of insulations: Microtherm (located in the ZOI associated with containment sump recirculation), Cal-Sil (located within the SG cubicles and pressurizer room), and TempMat (located in piping penetrations in the reactor vessel primary shield wall). The licensee stated that the insulation discrepancies were discovered as a result of detailed inspections, drawings, and design document reviews. The licensee completed a formal review of the plant design documents to identify other design or testing information/data or a plant configuration that may have changed since the February 29, 2008, and February 27, 2009, submittals. The licensee identified that the previous chemical effects testing and analysis performed as part of the licensee's response to GL 2004-02 did not include Microtherm and Cal-Sil insulation types. Therefore, the new plant-specific total debris loading of fibrous insulation exceeded the debris loading previously used during their testing.

Therefore, the licensee removed Microtherm and Cal-Sil insulation from the ZOI region of North Anna Units during the fall 2010 outage. The remaining Microtherm and Cal-Sil insulation within the containments were not located within the ZOIs associated with containment sump recirculation. Also, according to the licensee's assessment, the remaining Microtherm and Cal-Sil insulation is adequately protected or located in areas that preclude transport to the strainer due to containment spray or submergence. The inspections and remediation of the Microtherm and Cal-Sil insulation in the North Anna containments were the subject of an NRC special inspection documented in Inspection Report Nos. 05000338/2010006 and 05000339/2010006 dated December 10, 2010 (ML103440476).

The licensee also performed an assessment of the fibrous insulation inventories in North Anna containments to provide assurance that the current inventories had been properly accounted for. This assessment confirmed that while the fibrous debris generation inventories for North

Anna exceeded the tested fibrous debris inventories assumed in Test Rigs 33 and 89, the containment sump system would continue to perform its intended safety function.

The licensee also identified that the strainer vendor (AECL) had incorrectly calculated the strainer surface areas used during the strainer tests. This was identified while the test data was being re-evaluated by the vendor and after the testing was completed. AECL originally calculated the corrugated RS and LHSI strainers' surface areas using a simplified formula whereby the strainer surface area was equal to the projected area multiplied by a factor of 1.8. For the large LHSI strainer fins, the formula provides a reasonably accurate result. However, for the substantially smaller RS fins, the formula will non-conservatively over-predict the available surface area since the uncorrugated upper and lower parts of the fin represent a larger fraction of the total screen area. The licensee recalculated surface area of the LHSI and determined that it was relatively unaffected, although the corrected size decreased by 38 ft^2 for Unit 1 and 35 ft^2 for Unit 2.

Regarding the chemical effects test results using Test Rig 89, the licensee determined that these reductions in surface areas for the strainers have an overall conservative impact on head loss test results due to the original test conditions overestimating the debris loading (lower scaling factors) and velocity of the sump fluid at the strainer. The licensee performed a detailed review that showed the modeled surface areas (testing scaling factor multiplied by the actual test module area) for the RS and LHSI strainers were less than the effective surface areas (corrected total installed surface area minus the required sacrificial area of 150 ft^2). For more details on the licensee's assessment, refer to Table 6 of the April 27, 2011, supplemental response update.

The NRC staff has reviewed the licensees' assessment and considers the existing Test Rig 89 head loss test results are still bounding. The licensee's evaluation demonstrated that the Test Rig 89 modeled strainer area is conservative to the plant's strainer effective surface area. The licensee's previous head loss test results from Test Rig 89 remain valid for North Anna as they overestimated debris loading values during their initial test conditions. Therefore, the NRC staff concludes that the licensee has adequately demonstrated that the existing chemical effects evaluation remains valid with respect to the remaining amounts of insulation materials (Microtherm, Cal-Sil, and TempMat) in containment at North Anna.

NRC STAFF CONCLUSION:

For the chemical effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that chemical effects have been addressed conservatively or prototypically for North Anna. Therefore, the NRC staff concludes that the chemical effects evaluation for North Anna is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

18.0 LICENSING BASIS

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the changes associated with GL 2004-02.

The licensee provided sufficient information such that there is reasonable assurance that changes to the North Anna Units 1 and 2 licensing basis are being adequately addressed. Several licensing basis changes associated with resolution of the sump issues considered in GSI-191 and GL 2004-02 have been implemented for North Anna Units 1 and 2 in the form of updated final safety analysis report (UFSAR) revisions, a containment analysis methodology change, and license amendment requests, which have been approved.

The licensee stated their intention to further update their licensing and design basis documentation upon completion of all activities underway to address GL 2004-02.

UFSAR

The UFSAR was revised to reflect the installation of the new containment strainers for the RS and LHSI pumps, as well as the adoption and application of the GOTHIC code for containment analysis rather than the previous LOCTIC code. However, the current licensing basis for debris loading is being maintained until the downstream effects evaluation has been completed, as well as any accompanying modifications, if required. Upon completion of these activities, the UFSAR will be revised to reflect the updated licensing basis.

License Amendment Request

On October 3, 2006, the licensee submitted a license amendment request (Serial No. 06-849) (ML062850195) for NRC review and approval in support of the installation of the new strainers and resolution of GSI-191 and GL 2004-02. On March 13, 2007, the NRC approved the license amendment request (ML070720043), and the licensee implemented the approved license amendment for North Anna Units 1 and 2.

A UFSAR change and Technical Specifications Bases change were made to establish the limit for the long-term containment sump pH from 9.5 to 8.5 to be consistent with the calculation of sump aluminum load discussed in Section 3.0.

NRC STAFF CONCLUSION:

For this review area the licensee has provided information, such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff considers this item closed for GL 2004-02.

19.0 CONCLUSION

The NRC staff performed a thorough review of the licensee's responses and RAI supplements to GL 2004-02. The NRC staff conclusions are documented above. Based on the above evaluations the NRC staff finds that the licensee has provided adequate information as requested by GL 2004-02.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with 10 CFR 50.46. Specifically, the GL requested addressees to perform an evaluation of the ECCS and CSS recirculation and, if necessary, take additional action to ensure system function in light of the potential for debris to adversely affect long-term core cooling. The NRC staff finds that the information provided by the licensee demonstrates that debris will not adversely inhibit the ECCS or CSS performance following a postulated LOCA. Therefore, the ability of the systems to perform their safety functions, to assure adequate LTCC following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated.

Therefore, the NRC staff finds that the licensee’s responses to GL 2004-02 are adequate and considers GL 2004-02 closed for North Anna Power Station, Unit Nos. 1 and 2.

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