Non-Proprietary Version

Attachment 2

W3F1-2008-0018

Supplemental Response to NRC Generic Letter 2004-02 "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors"

Table of Contents

Acronyms

AJIT	Air Jet Impact Test
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CFD	Computational Fluid Dynamics
CFR	Code Federal Regulation
CS	Containment Spray
CSS	Containment Spray System
DBA	Design Basis Accident
DIR	Design Input Record
ECCS	Emergency Core Cooling System
GE	General Electric
GL	Generic Letter
GR	Guidance Report
HELB	High Energy Line Break
HPSI	High Pressure Safety Injection
ID	Internal Diameter
IOZ	Inorganic Zinc
LB LOCA	Large Break Loss of Coolant Accident
LOCA	Loss of Coolant Accident
LPSI	Low Pressure Safety Injection
MEI	Metal Encapsulated Insulation
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NPSH	Net Positive Suction Head
OPG	Ontario Power Generation
PWR	Pressurized Water Reactor
PZR	Presurizer
RAS	Recirculation Actuation Signal
RC	Reactor Coolant
RCP	Reactor Coolant Pump
RF15	Refuel 15
RMI	Reflective Metal Insulation
RPV	Reactor Pressure Vessel
RCB	Reactor Containment Building
RWSP	Refueling Water Storage Pool
SB LOCA	Small Break Loss of Coolant Accident
SDC	Shut-down Cooling
SE	Safety Evaluation
SER	Safety Evaluation Report
SG	Steam Generator
SI	Safety Injection
SIS	Safety Injection System
SIT	Safety Injection Tank
SS	Stainless Steel
SSC	System, Structure, or Component
TSP	Tri-Sodium Phosphate
UFSAR	Updated Final Safety Analysis Report
WF3	Waterford 3
ZOI	Zone of Influence

1.0 Overall Compliance

<u>NRC Issue 1:</u>
Provide information requested in GL 2004-02, "Requested Information." Item 2(a) regarding compliance with regulations. That is, provide confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis was updated to reflect the results of the analysis described above.

<u>WF3 Response 1:</u>
The recirculation functions for the SIS and the CSS for WF3 will be in compliance with the regulatory requirements listed in the applicable Regulatory Requirements section of the subject generic letter under debris loading conditions by the completion of Refuel 15 (RF15), the spring 2008 outage for WF3. WF3 has received an extension from the NRC for the completion date of this project as documented in Reference 44.

Listed below are some of the conservatisms, detailed throughout this response, which WF3 is incorporating into the methodology for meeting GL 2004-02.

1. WF3 utilizes a bounded loading strategy for testing inputs. The load utilized is a combination of the bounding fiber and particulate loads from the various breaks that were considered. (Response Sections 3.a)
2. WF3 utilizes a 7D ZOI on jacketed Nukon insulation for the sump design calculations. WCAP-16710-P (Reference 38) testing confirmed ZOI could be reduced further to 5D. (Response Section 3.b)
3. WF3 assumed a failure of 50% of the coatings on the containment liner plate on the containment dome and on the areas above the Polar Crane Rails, (Response Section 3.h)
4. WF3 used the largest specified mil thickness for all coatings on a specific material (Reference 28). For instance, for structural steel, WF3 used a thickness of 29 mils for all structural steel coatings, even though some specified thicknesses could be less. (Response Section 3.h)
5. WF3 assumes ECCS and CS pumps operate at run-out capacity for NPSH and strainer head loss analysis. (Response section 3.g.2)

2.0 General Description of and Schedule for Corrective Actions

<u>NRC Issue 2:</u>
Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per "Requested Information" Item 2(b). That is provide a general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this generic letter. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1,

2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

WF3 Response 2:
Based on the results of debris generation and transport analyses, modifications to the existing SI Sump screens were required to meet the applicable Regulatory Requirements discussed in the generic letter (Reference 1). The physical changes were performed during the WF3 refueling outage RF14, in the fall of 2006. The changes are listed below:

1. The original box-like SI Sump screen that surrounded the sump itself was removed and replaced with General Electric Energy, Nuclear (GE) Modularized Stacked Disk Strainers. Due to the amount of screen area required to be installed to meet the requirements of Reference 1, a strainer plenum with strainer modules on top was constructed over the SI Sump and over the concrete floor. The total surface area of the new SI Sump strainers is approximately 3699 $ft.^2$ as compared to the original screen with a surface area of approximately 200 $ft.^2$.
2. The screen partition that separated the two trains of the SI inlets was replaced with stainless steel grating.
3. The low level switch inside the SI Sump was relocated to mount on top of the new screen plenum.
4. The tubing for two level transmitters inside the SI Sump was rerouted to penetrate through the plenum in a designed location in order to prevent debris from passing through the penetration opening.
5. Nineteen TSP baskets were relocated to allow easier installation of the new plenum and strainers, or to eliminate interferences with the baskets.

Along with the physical changes described above, the following documents were generated are in the process of being generated to support the GL 2004-02 actions.

- Debris Generation Calculation (Reference 28)
- Debris Transport Calculation (including CFD modeling) (Reference 29)
- Downstream Effects Calculations (References 31 and 32)
- Hydraulic Sizing Report (Reference 36)
- Water Level Inside Containment Calculation (Reference 37)
- ECCS and CS Pump NPSH Analysis (Reference 51)

Not all of these documents have been finalized as of the date of this supplemental report. However, as documented in Reference 44, WF3 has received an extension to complete these activities by the end of RF15, the Spring 2008 refueling outage.

3.0 Specific Information Regarding Methodology for Determining Compliance

3.a Break Selection

NRC Issue 3.a:
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.

1. *Describe and provide the basis for the break selection criteria used in the evaluation.*
2. *State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines) and briefly explain why or why not.*
3. *Discuss the basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance.*

WF3 Response 3.a.1:
Background Information:

WF3 is a Combustion Engineering PWR with a large volume dry containment. Each of the two loops contains two Reactor Coolant Pumps (RCP), one Steam Generator (SG), and associated piping, located with a concrete wall enclosure commonly referred to as a D-ring. The two RCS piping loops are nearly identical with the exception that one loop includes the Presurizer (PZR) and associated piping. The area inside each D-ring is open directly above it. The two D-rings are also open on the bottom to a common open area on the basemat of the plant. The two loops are separated by the refueling cavity along with concrete walls. The PZR is contained within a separate concrete enclosure.

Baseline Break Selection:

A number of breaks were selected in order to provide conservative input for the transport calculations. The breaks that were selected are:

1. Break S1 – Hot Leg Piping at SG 1 Nozzle
2. Break S2 – SG 1 Hot Leg Piping at RPV Connection
3. Break S3 – Hot Leg Piping at SG 2 Nozzle
4. Break S4 – Tee between SG 1 Hot Leg and PZR Surge Line (Alternate Break)
5. Break S5 – Cold Leg Piping at RCP 1A Inlet Nozzle
6. Break S6 – Cold Leg Piping at RCP 2B Inlet Nozzle
7. Break S7 – PZR Surge Line at PZR Nozzle
8. Break S8 – Cold Leg Piping at RCP 1B Inlet Nozzle
9. Break S9 – Cold Leg Piping at RCP 2A Inlet Nozzle

Breaks S1, S2 and S3 are located on the hot leg of the primary piping, which has the largest diameter of the primary piping with a 42-inch diameter, obviously producing the largest ZOI.

Breaks S1 and S3 are placed at the steam generator nozzles in order to capture the most debris. Break S2 is located at the RPV.

Breaks S5 and S6 are located at the RCP inlet nozzles on the cold leg piping, which has the next largest diameter of the primary piping with a 30-inch diameter. For conservatism, the ZOI for the cold leg piping was based on the 42-inch diameter of the hot leg. These breaks are located closer to the SI Sump, thus providing conservative input for the debris transport and head loss calculations.

Break S4 is located on the PZR surge line at the connection to the SG 1 Hot Leg. In accordance with the alternate break methodology, it is considered to have a 12-inch inner diameter, although the actual ID is 10.126 inches. The debris load from the alternate break was determined; however, the deterministic methodology described in Sections 3, 4 and 5 of the NEI guidance document (Reference 2) was used to determine bounding debris generation and transport volumes.

Break S7 is located where the PZR surge line connects to the PZR inlet nozzle on the bottom of the PZR. This break is located outside the D-ring walls, and nearer the SI Sump location than any of the other breaks. This break does not produce a significant amount of debris; however it was selected due to the proximity and clear debris path to the SI Sump.

Break S8 is located at the RCP 1B inlet nozzle on the cold leg piping. This break will have the same debris generation as for the S5 break. This break was only analyzed for flow distribution in containment. This was to determine the worst case flow for debris transport. The S8 break did not result in higher debris transport than the other breaks already analyzed.

Break S9 is located at the RCP 2A inlet nozzle on the cold leg piping. This break will have the same debris generation as for the S6 break. This break was only analyzed for flow distribution in containment. This was to determine the worst case flow for debris transport. The S9 break did not result in higher debris transport than the other breaks already analyzed.

<u>WF3 Response 3.a.2:</u>
Secondary pipe breaks were not considered for this analysis. Based upon a review of the plant UFSAR, and as discussed in the Debris Generation calculation (Reference 28), containment spray and recirculation are not required for a Main Steam Line Break or a Feedwater Line Break. Additionally, breaks of small lines were not investigated, because the debris load would not be bounding due to the smaller areas covered by the break zone.

<u>WF3 Response 3.a.3:</u>
The locations of the analyzed breaks are chosen in order to maximize the amount and types of debris generated. To this end, breaks are placed near large insulated equipment, specifically the SGs, RCPs, and PZR. The breaks are also placed near walls and the floor since concrete surfaces have very thick coatings compared to steel surfaces. Finally, breaks were located in areas expected to maximize the transport of debris to the sump strainer.

3.b Debris Generation/Zone of Influence (ZOI) (excluding coatings)

NRC Issue 3.b:
The objective of the debris generation/ZOI process is to determine, for each postulated break location: (1) the zone within which the break jet forces would be sufficient to damage materials and create debris; and (2) the amount of debris generated by the break jet forces.

1. *Describe the methodology used to determine the ZOIs for generating debris. Identify which debris analyses used approved methodology default values. For debris with ZOIs not defined in the guidance report (GR)/safety evaluation (SE), or if using other than default values, discuss method(s) used to determine ZOI and the basis for each.*
2. *Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent.*
3. *Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the NRC for review or information, describe the test procedure and results with reference to the test report(s).*
4. *Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data only for the four most limiting locations.*
5. *Provide total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment.*

WF3 Response 3.b.1:
In order to perform the calculation of debris generation within the ZOI, a representative model of the insulation location and volume is utilized (Reference 28). The model is a Microsoft Excel® spreadsheet created from piping isometric drawings and insulation drawings. These drawings were used to develop a 3-dimentional computer model, which was then converted to the Excel® spreadsheet model. The spreadsheet determines the amount of insulation within a ZOI centered at coordinates that are input by the user. In this way multiple break locations are able to be evaluated relatively quickly and the user can ensure that conservative and limiting breaks are chosen.

The insulation in containment at WF3 consists of Nukon (canvas encapsulated (unjacketed) or stainless steel jacketed), MEI (stainless steel jacketed), Min-K, Microtherm, and Transco RMI. The amount of insulation debris generated is dependent on the proximity of each insulated target to the postulated break.

The SER (Reference 3) recommends a ZOI radius of 17.0D ("D" being the inside diameter of the pipe break) for both jacketed and unjacketed Nukon Fiber. The SER recommended ZOI radius of 17D is used for unjacketed Nukon Fiber debris generation analysis. Based on testing contained in Westinghouse report WCAP-16710-P (Reference 38), a reduced ZOI of 7.0D is used for the SS Jacketed Nukon debris generation analysis. The NEI and SER documents (References 2 and 3) do not address MEI insulation. Based on industry testing documented in Alion report ALION-REP-ENTG-4771-02 (Reference 39), a ZOI of 4.0D is used for the SS Jacketed MEI debris generation analysis. The SER recommended ZOI radius of 28.6D is used for Min-K insulation. The NEI and SER documents do not address the ZOI for Microtherm insulation. Therefore, a ZOI radius of 28.6D is used for Microtherm based on its similarity to Min-K insulation and because the ZOI radius for Min-K is the largest of all the tested materials described in the NEI and SER documents. The SER recommended ZOI radius of 2D is used for RMI debris generation analysis.

As discussed in Section 3d of this response submittal, latent debris and miscellaneous (foreign) materials are also included in the debris generation analysis. The amounts of these types of debris are determined from plant walkdown reports and are presented in their respective section of this response.

WF3 Response 3.b.2:

Table 3.b.2-1: Destruction ZOIs

Debris Type	ZOI	Basis
Jacketed Nukon Fiber Blankets	7	Reference 38
Unjacketed Nukon Fiber Blankets	17	Reference 3
MEI	4	Reference 39
Min-K	28.6	Reference 3
Microtherm	28.6	Reference 28
Transco RMI	2	Reference 3

WF3 Response 3.b.3:

Westinghouse report WCAP-16710-P (Reference 38) documents testing performed on jacketed Nukon insulation blankets to determine the proper ZOI. From Section 4 of Reference 38, "The approach taken to develop this experimental program was to subject the encapsulated ...stainless steel jacketed NUKON fiberglass insulation materials to phenomena and processes that accurately simulate those experienced during a postulated LOCA blowdown for a PWR. The conditions of interest are exposure to elevated temperature, pressure and high mass flux. Data collected from and observations from the tests were used as follows:

- For the jacketed NUKON fiberglass insulation system, determine an appropriate, technically defensible, realistic material-specific ZOI at which the fiberglass insulation will not experience damage that would require it to be treated as debris."

The objective of the test was to determine the generation of debris of the insulation material that should be considered in post-accident sump performance. The testing consisted of subjecting the jacketed NUKON insulation to a two phase jet originating from a subcooled, high pressure, high temperature reservoir. For the purposes of this testing, debris generation was defined as the "observable release or extrusion of fiberglass insulation material from the fiberglass from the woven fiberglass cloth covered blanket." The results of this testing showed that the ZOI for the SS jacketed NUKON insulation could be reduced to as low as 5D. However, for conservatism, a ZOI of 7D was used for Waterford 3.

WF3 Response 3.b.4:
The insulation totals for the four most limiting breaks evaluated are presented in the table below.

Table 3.b.4-1: Summary of LOCA Generated Debris Inside the ZOI (Reference 28)

Debris Type	Units	S1/S5	S2	S3/S6	S4
Jacketed Nukon Fiber Blankets	[ft^3]	81.4	177	25.4	0
Unjacketed Nukon Fiber Blankets	[ft^3]	351.1	113	501.8	331
MEI	[ft^3]	405.0	3	558.4	40.8
Min-K	[ft^3]	0.4	0.4	0.4	0.4
Microtherm	[ft^3]	4.2	4.2	4.2	4.2
Transco RMI	[ft^2]	0	8750	0	0

WF3 Response 3.b.5:
As discussed in Section 3d of this response submittal, latent debris and miscellaneous (foreign) materials are also included in the debris generation analysis. An analysis in the Debris Generation calculation 2004-07780 (Reference 28), shows that the debris loading to be used is 250 lb_m.

Labels, tags, stickers, placards and other miscellaneous or foreign materials were evaluated via walkdown. The walkdown results are included in Debris Generation calculation 2004-07780 (Reference 28). Based on this calculation, a sacrificial area of 151 ft^2 of the strainer surface is used for stickers, index cards, placards, tape, glass and other miscellaneous or foreign materials. This total includes only those materials which are not Design Basis Accident (DBA) qualified.

3.c Debris Characteristics

NRC Issue 3.c:
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 head loss. Provide the assumed size distribution for each type of debris.

1. *Provide the assumed size distribution for each type of debris.*
2. *Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.*
3. *Provide assumed specific surface areas for fibrous and particulate debris.*
4. *Provide the technical basis for any debris characterization assumptions that deviate from NRC-approved guidance.*

WF3 Response 3.c:
The debris sources at WF3 include insulation, coatings, foreign material and latent debris. The characteristics of the insulation debris material are discussed in this section. The characteristics

of the other debris types (e.g. coatings, foreign and latent) are included in their respective sections of this response submittal (Sections 3h and 3d).

WF3 Response 3.c.1:

Unjacketed Nukon Insulation Size Distribution:
For unjacketed Nukon insulation with a ZOI of 17D a size distribution of 8% fines, 25% small pieces, 32% large pieces and 35% intact pieces is used. This distribution is determined based on an analysis of the results of the BWR Owners' Group (BWROG) air-jet impact tests (AJIT) and the Ontario Power Generation (OPG) debris generation tests as described in NUREG/CR-6808 (Reference 18). Based on the results of the AJIT and OPG debris generation tests as presented in Appendix VI of Reference 3 and Volume 3 of NUREG/CR-6762 (Reference 14), 33% of all fibrous insulation within the ZOI is modeled as becoming fines or small debris. This fraction of fines or small debris is conservatively increased from the value (22%) suggested in Appendix II of the SER based on the OPG debris generation test. Implicit in these values is the assumption that the insulation is uniformly distributed within the ZOI. Due to the fact that the unjacketed Nukon insulation for the applicable breaks is distributed in several locations within each ZOI, uniformity is considered a reasonable approximation. Thus, 67% of all fibrous insulation within the ZOI is modeled as becoming either large debris or remaining intact. To determine the appropriate split between fine and small debris, the results of the AJIT are used. The AJIT indicated that, when insulation was completely destroyed, a maximum of 25% of the insulation was too fine to collect by hand. Thus 25% of the 33% small debris fraction is modeled as becoming fines; i.e. 8% [0.25*0.33] of the fibrous insulation within the ZOI becomes fine debris when destroyed. This implies that 25% [(1-0.25)*0.33] of the fibrous insulation within the ZOI becomes small debris when destroyed. To determine the appropriate split between large and intact debris, the results of the AJIT are also used. Per the SER guidance provided in Appendix VI of Reference 3, 35% of the fibrous insulation within the ZOI is modeled as intact debris, leaving 32% as large piece debris. Fines that enter the active recirculation pool are considered 100% transportable. Small, large and intact pieces are transported based on velocity data found in various references. Specifics of debris transport are discussed in Section 3e.

SS Jacketed Nukon Insulation Size Distribution:
For stainless steel jacketed Nukon insulation with a ZOI of 7D a size distribution of 25% fines and 75% small pieces is used. For a ZOI of 7D, the suggested Nukon size distribution contained in Table 3-3 of the SER (Reference 3) is not applicable. Instead the size distribution is determined from Figure II-1 of the SER, which relates jet pressure to ZOI radii, and Figure II-2 of the SER, which relates jet pressure to the fraction of small debris generated. The data presented in Figure II-2 comes from the Air Jet Impact tests, which are discussed in many documents related to GSI-191 including NUREG/CR-6808 (Reference 18).

SS Jacketed MEI Insulation Size Distribution:
For stainless steel jacketed MEI insulation with a ZOI of 4D a conservative size distribution of 100% fines is used. Fines are the constituent part of the insulation and are considered 100% transportable.

Min-K Insulation Size Distribution:

For Min-K insulation a conservative size distribution of 100% fines is used as documented in Table 3-3 of the SER (Reference 3). Fines are the constituent part of the insulation and are considered 100% transportable.

Microtherm Insulation Size Distribution:
For Microtherm insulation a conservative size distribution of 100% fines is used as documented in Table 3-3 of the SER (Reference 3). Fines are the constituent part of the insulation and are considered 100% transportable.

Transco RMI Insulation Size Distribution:
For Transco RMI insulation with a ZOI of 2D, a size distribution of 75% small fines and 25% large pieces is used. This size distribution is confirmed by Table 3-3 of the SER (Reference 3).

WF3 Response 3.c.2:
Nukon Insulation Density:
Per Table 3-2 of the NEI Guidance (Reference 2) the bulk density of Nukon insulation is 2.4 lbm/ft^3. The bulk density of the Nukon insulation installed at WF3 and used in the sump strainer performance testing is also 2.4 lbm/ft^3.

MEI Insulation Density:
The metal encapsulated insulation (MEI) is Owens-Corning TIW Type II. Based on manufacturer data for this insulation the bulk density is 2.4 lbm/ft^3. The bulk density of the MEI insulation installed at WF3 and used in the sump strainer performance testing is also 2.4 lbm/ft^3.

Min-K Insulation Density:
Per Table 3-2 of the NEI Guidance (Reference 2) the bulk density of Min-K insulation is 8 to 16 lbm/ft^3. The bulk density of the Min-K insulation installed at WF3 is 13 lbm/ft^3 (Reference 40). This compares to a bulk density of 14.5 lbm/ft^3 for the insulation used in the sump strainer performance testing.

Microtherm Insulation Density:
Per Table 3-2 of the NEI Guidance (Reference 2) the bulk density of Microtherm insulation is 5 to 12 lbm/ft^3. This compares to a bulk density of 14.5 lbm/ft^3 of the insulation used in the sump strainer performance testing.

Reflective Metal Insulation Density:
Transco and Mirror RMI are comprised of thin layers of stainless steel foil. Stainless steel has a density of 490 lbm/ft^3.

WF3 Response 3.c.3:
The Material density and specific surface area (S_v) were only used for preliminary analytically determined head loss values across a debris laden sump screen using the correlation given in NUREG/CR-6224 (Reference 8). Since the head loss across the installed sump screen is determined via testing, these values are not used in the design basis for WF3. Therefore, these values are not provided as part of this response.

WF3 Response 3.c.4:
WF3 debris generation, transport, and head loss testing have used the debris characterization assumptions provided in the SER (Reference 3).

3.d Latent Debris

NRC Issue 3.d:
The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris existing within the containment and its potential impact on sump screen head loss.

1. *Provide the methodology used to estimate quantity and composition of latent debris.*
2. *Provide the basis for assumptions used in the evaluation.*
3. *Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under c. above.*
4. *Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.*

WF3 Response 3.d.1:
Latent debris has been evaluated by containment walkdown as recommended by Section 3.5.2 of the NEI Guidance (Reference 2) and confirmed by the NRC SER (Reference 3). The walkdown of the WF3 containment was conducted in accordance with the guidance provided by NEI documents 04-07 (Reference 2) and 02-01 (Reference 20) and the SER of NEI document 04-07 (Reference 3). As shown below, four (4) or more samples were collected for all surface types except grating. The additional samples collected for certain surface types increase the statistical accuracy of the evaluation. A listing of the number of each sample type follows.

Number of Samples Collected

- Containment Liner 4
- Equipment (Horizontal) 4
- Equipment (Vertical) 4
- Floor 4
- Wall 5
- HVAC Duct (Horizontal) 4
- HVAC Duct (Vertical) 4
- Pipe (Horizontal) 4
- Pipe (Vertical) 4
- Cable Tray (Horizontal) 4
- Cable Tray (Vertical) 4
- Gratings 0

The weights of the samples collected are used to determine the latent debris mass distribution (g/ft^2). Measurements taken are accurate to 0.01 grams. A statistical analysis of the samples is performed in the post-processing of the latent debris walkdown results, which is Attachment 8.8 of the WF3 Debris Generation calculation (Reference 28). The analysis determined a 90% confidence limit of the mean value for each type of surface based on a normal distribution. The upper limit of the mean value for each surface type is then applied over the entire surface area of that type throughout containment. This analysis lends further confidence and conservatism to the latent debris mass determination.

Labels, tags, stickers, placards and other miscellaneous or foreign materials (including glass) were also evaluated via walkdown. The walkdown results are included as attachment 8.9 of the

WF3 Debris Generation calculation (Reference 28) and are summarized in section 5.5 of the calculation.

WF3 Response 3.d.2:
No samples were available for grating; therefore, grating is conservatively assumed to have the same latent debris loading as the floor.

WF3 Response 3.d.3:
Consistent with the NRC SER of the NEI Guidance (Reference 3), 15% of the latent debris load (by mass) is assumed to be fibrous debris and the other 85% (by mass) is treated as particulate debris. Likewise, consistent with the SER (Reference 3), a density of 2.7 g/cm^3 for particulate debris is used. For latent fibrous debris, a density of 2.4 lb_m/ft^3 (bulk density of Nukon per NEI, Reference 2) is used in order to conservatively maximize the volume of latent fibrous debris. As the specific surface area of debris is only relevant for head-loss calculations per NUREG/CR-6224 (Reference 8) and head-loss evaluations are being conducted experimentally, the specific surface area of latent debris is not determined.

The results of the latent debris calculation conservatively determined the debris loading to be 250 lb_m.

Miscellaneous latent debris is also discussed in more detail in the following debris transport section 3.e.

Table 3.d.3-1: Latent and Foreign Material Debris

Latent and Foreign Material Debris	Quantity
Latent Debris (lb_m)	250
Fiber (lb_m)	37.5
Particulate (lb_m)	212.5
Foreign Material Debris (ft^2)	151
Stickers, index cards, placards and tape (ft^2)	81
Glass (light bulbs) (ft^2)	70

WF3 Response 3.d.4:
A sacrificial area of 151 ft^2 of the strainer surface is retained for stickers, index cards, placards, tape, glass and other miscellaneous or foreign materials. This total includes only those materials which are not Design Basis Accident (DBA) qualified.

3.e Debris Transport

NRC Issue 3.e
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.

1. *Describe the methodology used to analyze debris transport during the blowdown, washdown, pool-fill-up, and recirculation phases of an accident.*
2. *Provide the technical basis for assumptions and methods used in the analysis that deviate from the approved guidance.*
3. *Identify any computational fluid dynamics codes used to compute debris transport fractions during recirculation and summarize the methodology, modeling assumptions, and results.*
4. *Provide a summary of, and supporting basis for, any credit taken for debris interceptors.*
5. *State whether fine debris was assumed to settle and provide basis for any settling credited.*
6. *Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the strainers.*

WF3 Response 3.e.1:
Debris transport determines the fraction of debris generated that is transported from debris sources (break location) to the sump screen. The debris transport analysis for WF3 is conducted in accordance with both the NEI Guidance provided in Reference 2 and the NRC Safety Evaluation of the NEI Guidance provided in Reference 3. As such, each phase of post-LOCA transport is considered: blowdown, washdown, pool fill-up and recirculation. A detailed discussion of each transport phase, including information on their effect on overall transport for WF3 follows.

Blowdown and Washdown:
For mostly uncompartmentalized containments such as at WF3, Section 3.6.3.2 of Reference 2 states that all RMI debris (small and large) is conservatively postulated to fall to the containment floor; i.e. no RMI debris is ejected into the dome. Although NEI 04-07 does not specifically state that all fiber debris is assumed to fall to the containment floor, it is conservatively modeled as such (see Table 3-4 of the SER, Reference 3). Similarly, all Min-K, Microtherm, and coating debris is also conservatively modeled as falling to the containment floor. Thus, all LOCA generated debris is conservatively modeled as falling to the floor in the post-accident environment. This is reasonable as large debris should be modeled as falling to the containment floor per Section 3.6.3.2 of Reference 2 and small debris that could reach the dome would eventually wash down to the active pool. Therefore, since all insulation debris eventually lands on the floor, a detailed blowdown and washdown analysis is not conducted. Rather all insulation debris generated is conservatively placed on the floor immediately and is further transported by pool fill-up and recirculation as discussed in the following sections. Conservatively, qualified coatings are also considered to fall directly to the floor. All other debris types, including unqualified coatings, latent and foreign material debris that are generated from outside the break ZOI are therefore considered to fall directly to the floor.

Pool Fill-up
Conservatively, no inactive pools are credited. All debris on the floor prior to pool fill-up remains on the floor in the active pool after pool fill-up. During pool fill-up debris is transported away from the break area and toward the perimeter of containment by the water spilling onto the floor. Debris is then further transported by recirculation, as discussed in the following section.

Recirculation

Debris that reaches the containment pool is subject to transport by the pool flow present during recirculation. In accordance with the NEI and SER Guidance documents (References 2 and 3) all fine debris that lands in the pool is considered to transport entirely to the sump strainer. The transport of small, large and intact pieces of debris during recirculation is dependent on the velocities present in the containment pool.

Nukon debris transport is investigated and reported in NUREG/CR-6772 (Reference 16). Transport velocities pertinent to Nukon debris transport at WF3 are taken from this document. The document reports values at which some debris begins to move and at which a majority begins to move. These are referred to herein as the "incipient tumbling" and "bulk transport" velocities. Conservatively, the incipient tumbling velocity is used to determine transport potential. Accordingly, for breaks corresponding to Configuration A in Reference 16, non-fines Nukon pieces are considered to transport at velocities of 0.12 ft/s or greater and small and large Nukon pieces are considered to transport over an 6-inch curb at 0.34 ft/s. For breaks corresponding to Configuration B in Reference 16, non-fines Nukon pieces are considered to transport at velocities of 0.07 ft/s or greater and small and large Nukon pieces are considered to transport over a 6-inch curb at 0.25 ft/s. For breaks corresponding to Configuration C in Reference 16, non-fines Nukon pieces are considered to transport at velocities of 0.06 ft/s or greater and small and large Nukon pieces are considered to transport over a 6-inch curb at 0.28 ft/s. Intact Nukon fiber blankets and Nukon jacketing are not considered to lift over the curb due to their size.

RMI debris transport is investigated in NUREG/CR-3616 (Reference 7) and NUREG/CR-6772 (Reference 16). Transport velocities pertinent to RMI debris transport at WF3 are taken from these documents. Both documents report values at which some debris begins to move and at which a majority begins to move. These are referred to herein as the "incipient tumbling" and "bulk transport" velocities. Conservatively, the incipient tumbling velocity is used to determine transport potential. Accordingly, for breaks corresponding to Configuration A in Reference 16, non-fines RMI pieces are considered to transport at velocities of 0.28 ft/s or greater and are considered to transport over an 6-inch curb at 0.84 ft/s. For breaks corresponding to Configuration B in Reference 16, non-fines RMI pieces are considered to transport at velocities of 0.41 ft/s or greater and are considered to transport over an 8-inch curb at 0.30 ft/s. For breaks corresponding to Configuration C in Reference 16, non-fines RMI pieces are considered to transport at velocities of 0.20 ft/s or greater and are considered to transport over an 6-inch curb at 1.0 ft/s.

As noted in NUREG/CR-6773 (Reference 17) low density fiberglass debris (such as Nukon and MEI debris) is subject to erosion during Recirculation. The erosion rate used for the small and large Nukon debris pieces is 10% over the 30-day Recirculation mission time (Reference 41). The erosion rate used for the MEI debris pieces is 90% over the 30-day Recirculation mission time, as described in Appendix III of Reference 3).

<u>WF3 Response 3.e.2:</u>
There are no assumptions or methods that deviate from the approved guidance (Reference 3) in the areas of debris transport, except for the erosion rate of the Nukon insulation. This is justified in an analysis / test documented in Reference 41.

WF3 Response 3.e.3:
To assist in the determination of recirculation transport fractions, several Computational Fluid Dynamics (CFD) simulations were performed using Fluent™, a commercially available software package. Multiple break locations were investigated by the CFD simulations to determine which scenario would maximize debris transport. Four of the eight simulations conducted were based on the final strainer system design. The simulation results include a series of contour plots of velocity and turbulent kinetic energy (TKE), plots of flow path lines originating at the break locations and animations of the flow velocities. These results have been combined with information in the GSI-191 literature and plant specific erosion test results to determine the overall transport fractions for small, large and intact pieces of fibrous debris and large pieces of RMI debris (fines are 100% transportable).

WF3 Response 3.e.4:
No debris interceptors were installed at WF3 as part of the GL 2004-02 resolution.

WF3 Response 3.e.5:
Credit is taken for the plenum that the strainers sit on. From the CFD results it is determined how much of the plenum perimeter is in areas with flow velocities in excess of the velocity required to lift the debris over a 6-inch obstacle. Since the plenum is approximately 8-inches tall, using the lift-over curb velocity for a 6-inch curb is conservative. The fraction of the curb perimeter in excess of the lift-over curb velocity is applied to the debris pile in the vicinity of the strainer to determine the debris load on the strainer. In all but one of the CFD scenarios the approach velocity does not exceed the lift over curb velocity at any location along the plenum perimeter. In the remaining scenario, less than 25% of the perimeter has velocities in excess of those necessary to lift over a 6-inch curb; however for conservatism, 25% of the small debris is treated as lifting onto the sump strainer.

No credit was taken for settling of fine debris.

WF3 Response 3.e.6:
The amount of debris determined to transport to the sump strainer for the limiting breaks is provided in the following tables.

Insulation:

Table 3.e.6-1: Debris Generated and Transported to Strainer – Break S1

Debris Transport by Type	Units	Debris Generated	Transport Fraction	Debris at Strainer
SS Jacketed Nukon	[ft^3]	81.4	0.325	26.46
Unjacketed Nukon	[ft^3]	351.1	0.137	48.1
SS MEI (Fiberglass)	[ft^3]	405.0	0.92	372.6
Min-K	[ft^3]	0.4	1.00	0.4
Microtherm	[ft^3]	4.2	1.00	4.2
Transco RMI	[ft^2]	0	0.75	0
Qualified Coatings	[ft^3]	13.5	1.00	13.5

Unqualified Coatings	[ft^3]	31.02	*	21.70
Latent Debris	[lb_m]	250	1.00	250
Foreign Materials:	[ft^2]	151	1.00	151

Table 3.e.6-2: Debris Generated and Transported to Strainer – Break S3

Debris Transport by Type	Units	Debris Generated	Transport Fraction	Debris at Strainer
SS Jacketed Nukon	[ft^3]	25.4	0.325	8.26
Unjacketed Nukon	[ft^3]	501.8	0.137	68.75
SS MEI (Fiberglass)	[ft^3]	558.4	0.92	513.73
Min-K	[ft^3]	0.4	1.00	0.4
Microtherm	[ft^3]	4.2	1.00	4.2
Transco RMI	[ft^2]	0	0.75	0
Qualified Coatings	[ft^3]	21.2	1.00	21.2
Unqualified Coatings	[ft^3]	31.02	*	21.70
Latent Debris	[lb_m]	250	1.00	250
Foreign Materials:	[ft^2]	151	1.00	151

Table 3.e.6-3: Debris Generated and Transported to Strainer – Break S4

Debris Transport by Type	Units	Debris Generated	Transport Fraction	Debris at Strainer
SS Jacketed Nukon	[ft^3]	0	0.325	0
Unjacketed Nukon	[ft^3]	331	0.137	45.35
SS MEI (Fiberglass)	[ft^3]	40.8	0.92	37.54
Min-K	[ft^3]	0.4	1.00	0.4
Microtherm	[ft^3]	4.2	1.00	4.2
Transco RMI	[ft^2]	0	0.75	0
Qualified Coatings	[ft^3]	13.5	1.00	13.5
Unqualified Coatings	[ft^3]	31.02	*	21.70
Latent Debris	[lb_m]	250	1.00	250
Foreign Materials:	[ft^2]	151	1.00	151

Table 3.e.6-4: Debris Generated and Transported to Strainer – Break S5

Debris Transport by Type	Units	Debris Generated	Transport Fraction	Debris at Strainer
SS Jacketed Nukon	[ft^3]	81.4	0.325	26.46
Unjacketed Nukon	[ft^3]	351.1	0.137	48.1
SS MEI (Fiberglass)	[ft^3]	405.0	0.92	372.6
Min-K	[ft^3]	0.4	1.00	0.4
Microtherm	[ft^3]	4.2	1.00	4.2
Transco RMI	[ft^2]	0	0.75	0
Qualified Coatings	[ft^3]	13.5	1.00	13.5
Unqualified Coatings	[ft^3]	31.02	*	21.7
Latent Debris	[lb_m]	250	1.00	250

Foreign Materials:	[ft^2]	151	1.00	151

Table 3.e.6-5: Total Debris Generated and Transported to Strainer – Break S7

Debris Transport by Type	Units	Debris Generated	Transport Fraction	Debris at Strainer
SS Jacketed Nukon	[ft^3]	30	0.3925	11.78
Unjacketed Nukon	[ft^3]	49	0.1883	9.23
SS MEI (Fiberglass)	[ft^3]	0	0.93	0
Min-K	[ft^3]	0.4	1.00	0
Microtherm	[ft^3]	4.2	1.00	0.6
Transco RMI	[ft^2]	0	0.75	0
Qualified Coatings	[ft^3]	0	1.00	0
Unqualified Coatings	[ft^3]	31.02	*	21.71
Latent Debris	[lb_m]	250	1.00	250
Foreign Materials:	[ft^2]	151	1.00	151

* Inorganic zinc, coatings within the ZOI, and indeterminate coatings are considered to transport 100% to the sump. The inventory of failed coatings for use in the sump screen design is the portion which enters the pool on or near the sump strainer, the non-depletable or non-settling portions of the inventory originating within the break ZOI that is considered small fines, the inventory of inorganic zinc which is considered small fines, and the inventory of indeterminate coatings.

3.f Head Loss and Vortexing

NRC Issue 3.f

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.

1. *Provide a schematic diagram of the emergency core cooling system (ECCS) and containment spray systems (CSS).*
2. *Provide the minimum submergence of the strainer under small-break loss-of-coolant accident (SB LOCA) and large-break loss-of-coolant accident (LB LOCA) conditions.*
3. *Provide a summary of the methodology, assumptions and results of the vortexing evaluation. Provide bases for key assumptions.*
4. *Provide a summary of the methodology, assumptions, and results of prototypical head loss testing for the strainer, including chemical effects. Provide bases for key assumptions.*
5. *Address the ability of the design to accommodate the maximum volume of debris that is predicted to arrive at the screen.*
6. *Address the ability of the screen to resist the formation of a "thin bed" or to accommodate partial thin bed formation.*
7. *Provide the basis for the strainer design maximum head loss.*

8. *Describe significant margins and conservatisms used in the head loss and vortexing calculations.*
9. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.*
10. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis.*
11. *State whether the sump is partially submerged or vented (i.e., lacks a complete water seal over its entire surface) for any accident scenarios and describe what failure criteria in addition to loss of net positive suction head (NPSH) margin were applied to address potential inability to pass the required flow through the strainer.*
12. *State whether near-field settling was credited for the head-loss testing and, if so, provide a description of the scaling analysis used to justify near-field credit.*
13. *State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.*
14. *State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.*

WF3 Response 3.f.1:

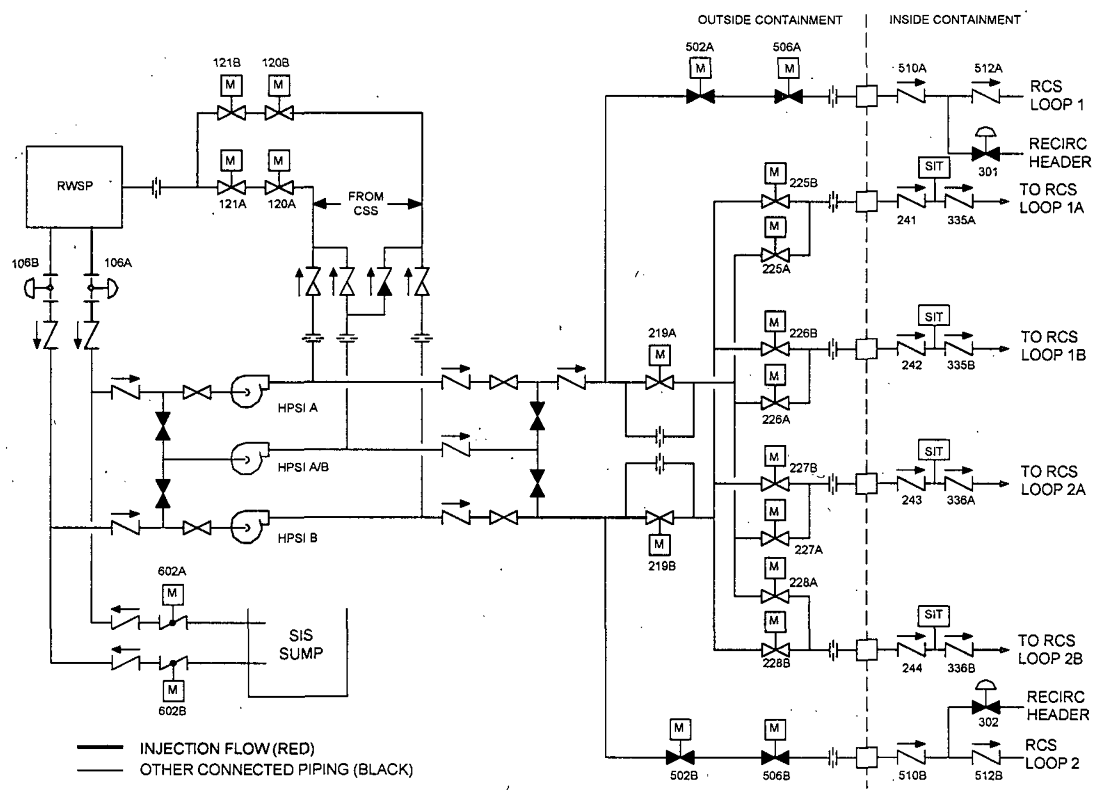

Figure 3.f.1-1: HPSI – Injection Mode

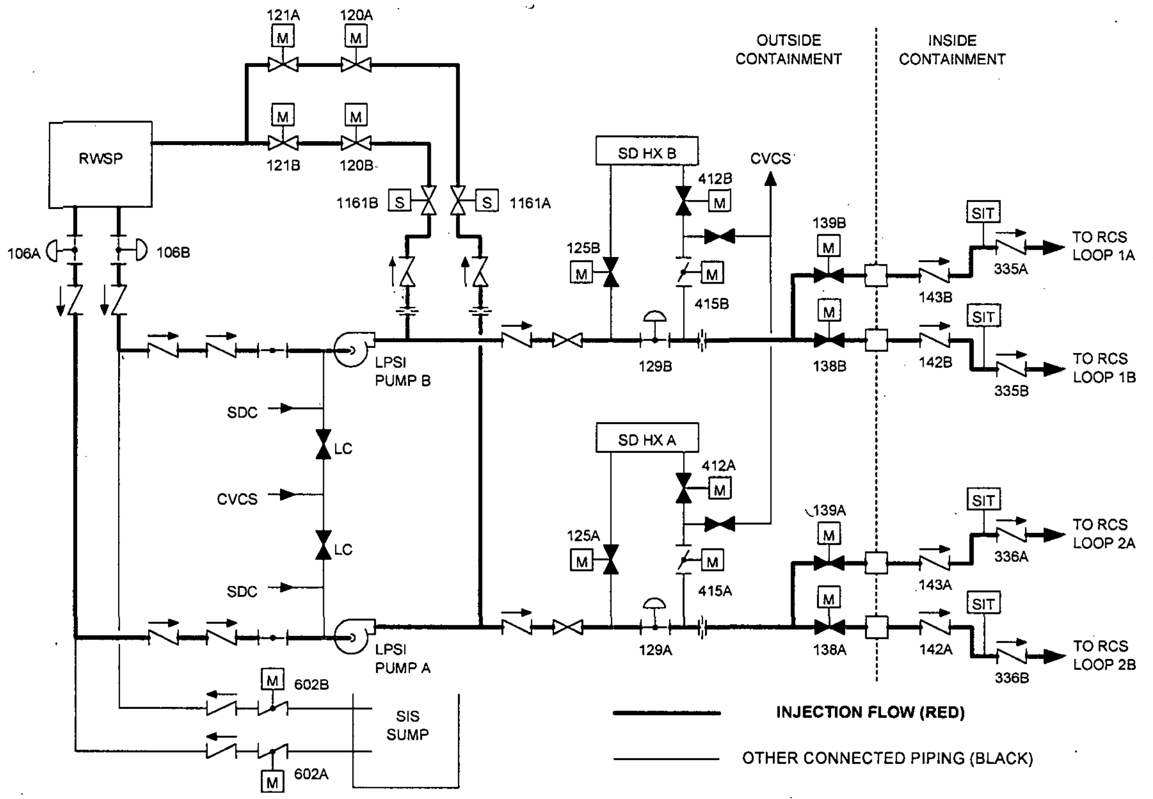

Figure 3.f.1-2: LPSI – Injection Mode

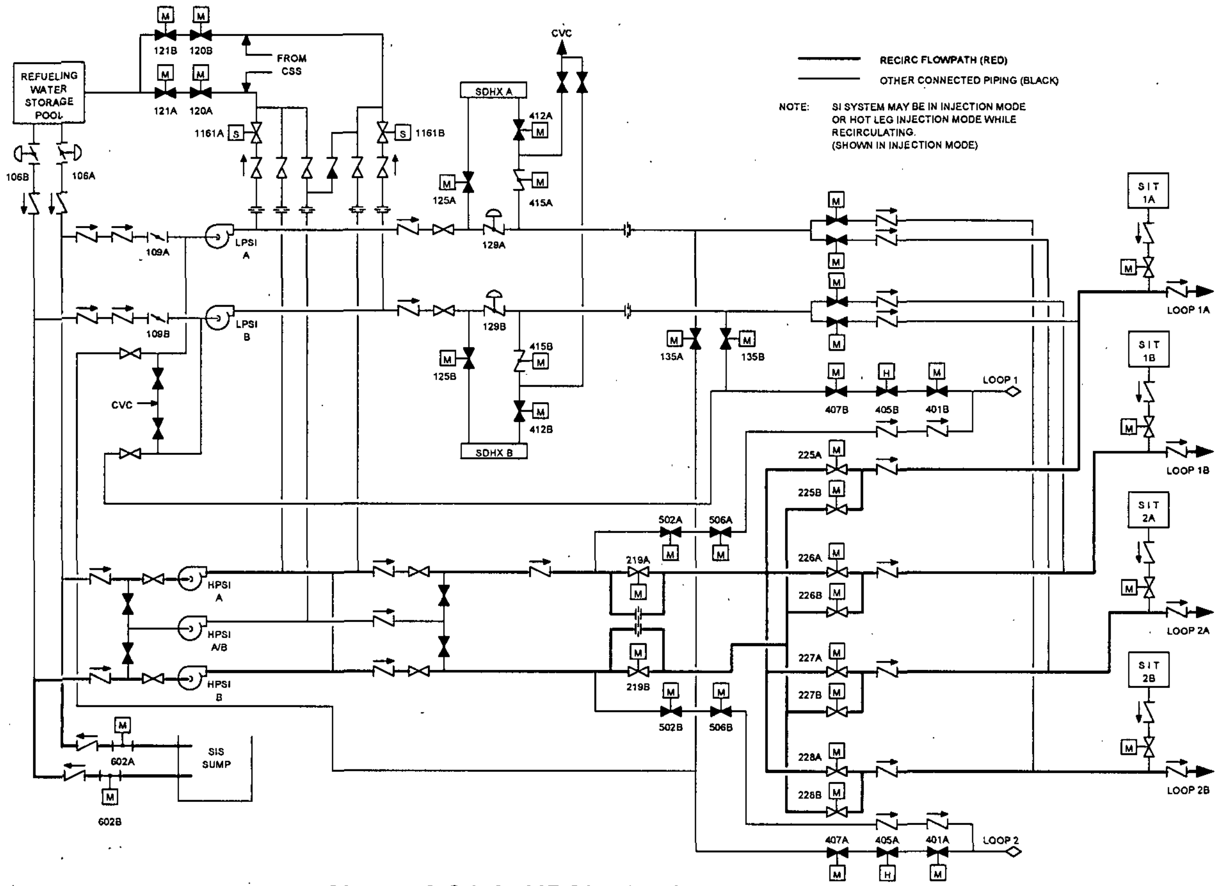

Figure 3.f.1-3: HPSI - Recirculation Mode

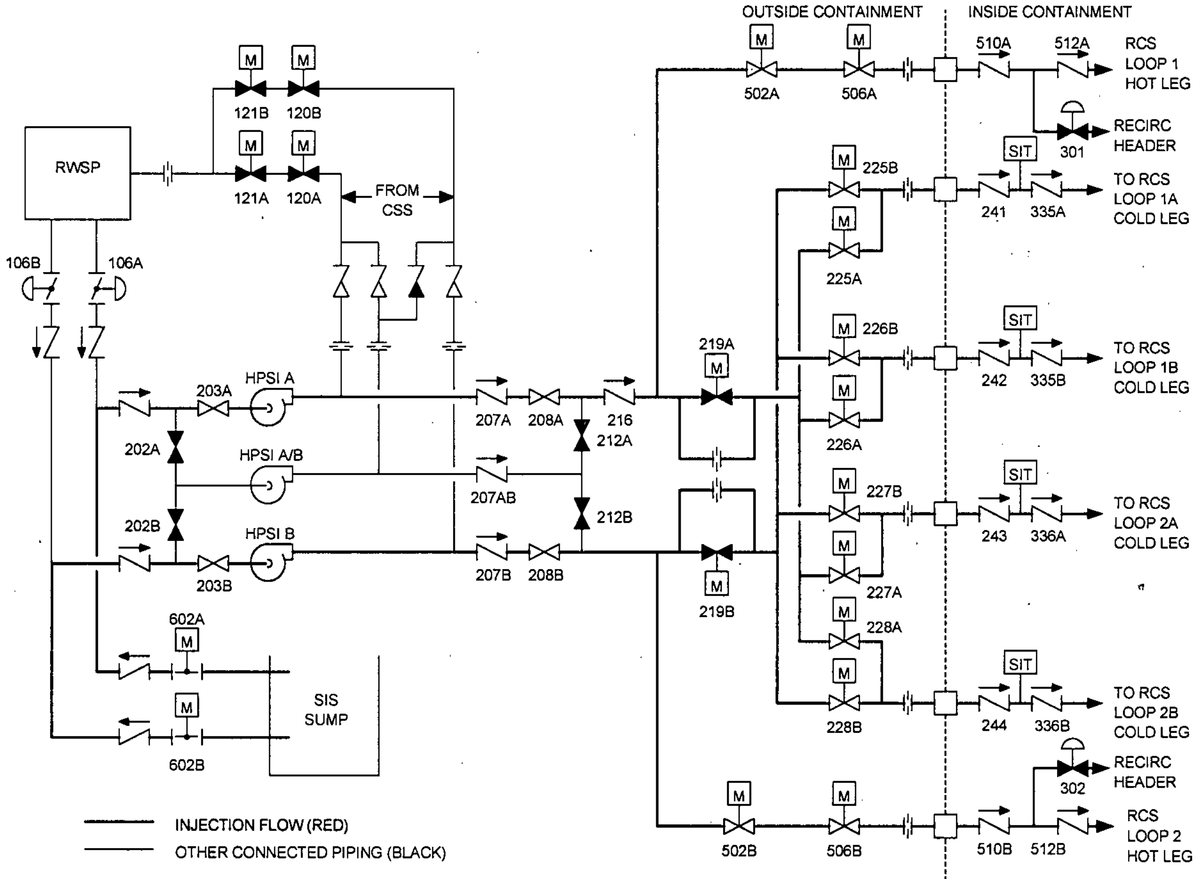

Figure 3.f.1-4: HPSI – Hot Leg Injection

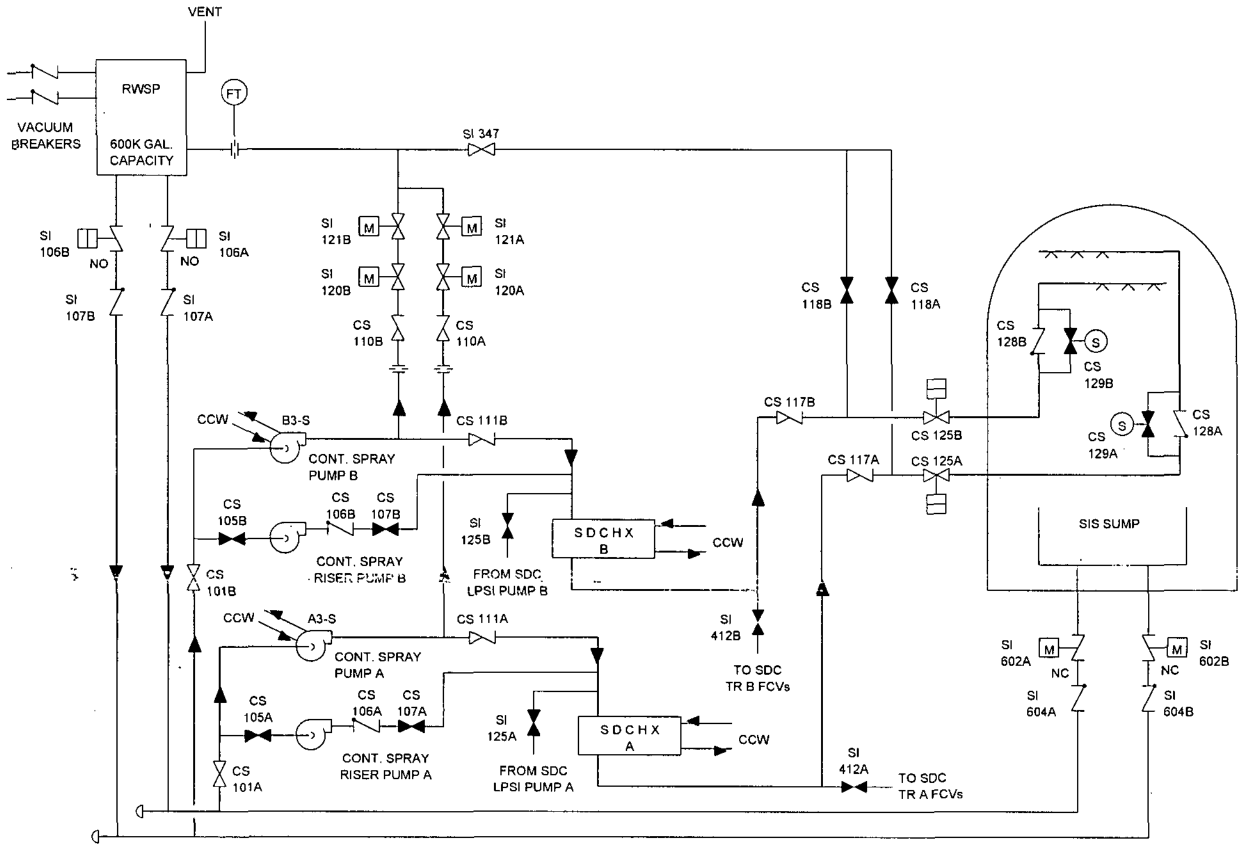

Figure 3.f.1-5: Containment Spray – Injection Mode

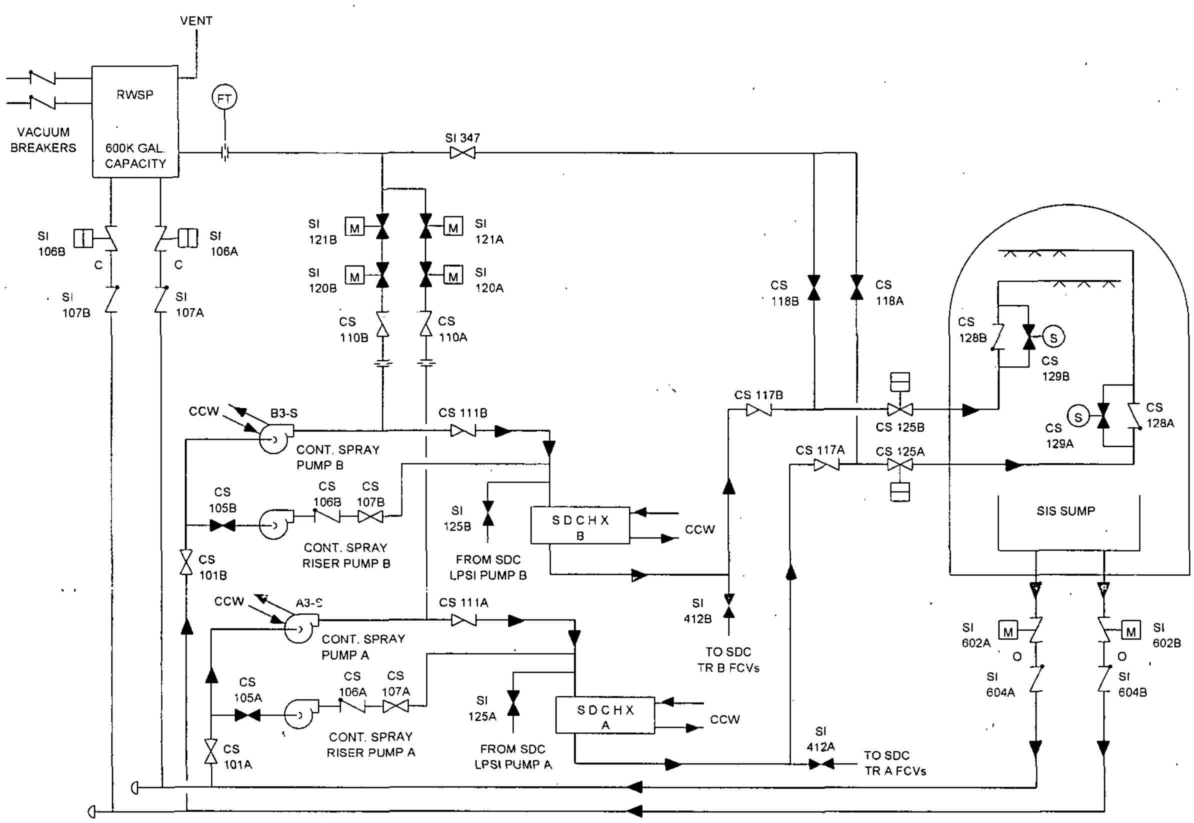

Figure 3.f.1-6: Containment Spray – Recirculation Mode

WF3 Response 3.f.2:
Based on the current draft of the WF3 minimum water level calculation (Reference 37), the strainers will be submerged by about 3 inches of water for a SBLOCA and 8 inches for a LBLOCA. The minimum water level calculation is currently being revised to address open item 13 from the NRC WF3 GSI-191 Generic Letter 2004-002 Corrective Actions Audit Report (Reference 57).

WF3 Response 3.f.3:
No tests were run specifically for vortexing with specific assumptions. Instead vortexing observations were and are being made as part of the module head loss test program. Module testing is conducted with the water depth over the strainers similar to the plant configuration (Reference 33). No vortexing or air entrainment has to date been observed during testing. Ongoing testing is being performed that includes observation for vortexing at water levels 4-inches above the strainer (typical of plant minimum sump water level), 3-inches above the top of the strainers, 2-inches above the top of the strainer, and 1-inch above the top of the strainer, for the full range of debris loads. This test program shall ensure a high degree of confidence that a vortex or other form of air entrainment shall not occur with the WF3 strainer.

WF3 Response 3.f.4:
Module testing consists of scaling the plant's debris load and measuring the debris induced head loss across a module of a strainer. These tests determine the head loss characteristics of plant-specific debris as a function of scaled debris load and scaled flow rate.

Six module tests are being performed to analyze the six strainer bounding cases, with constant flow rates and scaling factors, and with varying particulate/fiber ratios, nominal debris bed thicknesses, and low density fiberglass quantities (Reference 33).

The test module is composed of ten 40" X 40" square perforated disks. The test module is mounted on the center of the test pool with same floor clearance as its simulating strainer. Water level shall be maintained 4" above the top of the test article, typical of the plant installation.

The flow rates for the module tests are calculated using Equation 3.f.4-1, which yields the same circumscribed approach velocity for the test module as for the proposed plant strainers. Because the debris loads evaluated by the module tests result in thick, circumscribed debris beds, the circumscribed area approach velocity is appropriate for this test. The module test flow rate is 367 gpm (for both circumscribed area scaled flow rate and perforated area scaled flow rate).

$$Q_{test.module} = Q_{plant} \times \frac{Area_{circumscribed.test.module}}{Area_{circumscribed.plant} - Area_{Sacrificial} \times \dfrac{Area_{circumscribed.plant}}{Area_{perforated.plant}}} \qquad (3.f.4\text{-}1)$$

Q = Flow Rate (gpm)
Area = Surface Area (ft^2)

The module test debris quantities in the test matrix were calculated using the debris loads provided by Reference 34, and Equation 3.f.4-2, which yields the same circumscribed debris bed thickness for the module test as in the proposed plant strainer.

$$Mass_{debris.test.module} = Volume_{debris.transported.to.sump} \times \rho_{debris} \times \frac{Area_{circumscribed.test.module}}{Area_{circumscribed.plant} - Area_{Sacrificial} \times \dfrac{Area_{circumscribed.plant}}{Area_{perforated.plant}}} \qquad (3.f.4\text{-}2)$$

$Volume_{debris.transported.to.sump}$ = Volume of debris that is transported to sump (ft^3)
ρ_{debris} = As-manufactured density of debris (lb/ft^3)
Area = Surface Area (ft^2)

The module tests make use of the following assumptions:
- The flow rate is proportional to the circumscribed area of the strainers;
- The debris load and flow rate is distributed equally among the strainers;
- The debris bed is uniform – same thickness throughout perforated surface;
- In the debris load calculation, the circumscribed surface area of a plant installed strainer is the actual circumscribed surface area minus the portion of sacrificial area attributed to the circumscribed area.

Chemical Effects Tests are being run separately. Chemical effect precipitate amounts used in hydraulic tests originate from WCAP 16785-NP (Reference 53) silicate model for maximum and minimum water volumes. Long-term (30-day duration) chemical effects tests, at temperatures close to actual sump values, are run to verify head loss impact of calcium phosphate above 140 deg F and sodium aluminum silicate at lower temperatures, in addition to sump pH. No credit is being taken from containment pressure in these tests.

The impact of chemical effects will be applied when available by determining a factor by which chemical effects increase head loss, and applying that factor to debris (i.e., non-chemical effects) head loss test results.

WF3 Response 3.f.5:
During a LOCA at WF3, the following types of debris may be generated by the high-energy steam and liquid impingement and water wash down/flow (Reference 34), with the assumption of 100% transport to the sump area:

- Fibrous Insulation: Nukon Fiber Blankets and Owens-Corning TIW II insulation of 581 ft^3 volume. All fiber insulation generated is assumed to be transported to the sump screen.
- Granular Insulation: Min-K and Microtherm insulation of 4.6 ft^3 volume.
- Latent Debris: 250 lbm of latent debris is considered to be 15% by mass of fiber, and 85% particulate. All latent debris is assumed to be transported to the sump screen.
- Qualified and Unqualified Coating: Qualified Coatings (steel and concrete) of 13.5 ft^3 with a ZOI of 4D, and Unqualified Coatings of 21.70 ft^3 (within and outside the ZOI of 4D). This represents a total of 36.49 ft^3 of coatings. All coatings are conservatively assumed to fail as particulate. Transport fractions for both qualified and unqualified coatings are conservatively assumed to be 100%.
- Foreign Materials: The foreign materials (sacrificial area) are assumed to be 151 ft^2 in area without taking credit for 50% overlap.

Testing was performed with two types of test articles: sectors and modules. **[Proprietary Information Removed]**

The percentage of transported debris that adheres to each strainer is assumed to be equal to the strainer's percentage of total flow.

WF3 Response 3.f.6:

The nominal debris bed thickness for the tests ranges from 0.12" to 7.1" (Reference 33) in plant installed units with worst case-operating scenario. There is potential for a bed thickness matching the "thin bed" description to be formed during the strainer operation; however, the limiting head loss did not occur with a "thin bed" during WF3 testing. The highest head loss occurs when 100% of the fiber is transported to the strainer, which included sufficient fibrous insulation to fill the strainer gaps and extend beyond the strainer perimeter, forming a "circumscribed" bed.

WF3 Response 3.f.7:

The GE hydraulic suction strainer design methodology is based on plant specific debris head loss testing. Debris head loss correlations were developed using the laboratory test results, scaled to the full plant design conditions. From a structural standpoint, the allowable head loss (i.e., crush pressure) is 1.0 psid.

The head loss is determined by summing up all the head loss components, as follows:

$$Head\ Loss = HL_{debris\_plant} + HL_{clean\_plant} + HL_{chemical\_effects} + HL_{pipes\,\&\,plenum}$$

where:

Head Loss = maximum head loss of the strainer.
HL_{debris_plant} = debris head loss at plant conditions.
HL_{clean_plant} = clean head loss at plant conditions.
$HL_{pipes\&plenum}$ = head loss on pipes and / or plenum.
$HL_{chemical\_effect}$ = head loss due to chemical effect.

WF3 Response 3.f.8:

The assumptions, margins and conservatisms are listed as follows (Reference 35):

- The flow rate is proportional to the perforated (sector test) or circumscribed (module) area of the strainers;
- The debris load and flow rate are is distributed equally among the strainers;
- The debris bed is uniform – same thickness throughout perforated surface;
- In the debris load calculation, the circumscribed surface area of a plant installed strainer is the actual circumscribed surface area minus the portion of sacrificial area attributed to the circumscribed area.
- 100% of particulate debris transported to the sumps is assumed to adhere to the strainers and contribute to head loss.
- All the labels and tags are modeled with 100% transport to the sump screen. The total sacrificial area is calculated by an equivalent to 100% of the original single sided surface area, counting for 0% overlap.

- Due to extremely low approach and perforated flow velocities, laminar flow is assumed for debris head loss calculations.
- Minimum water level at sump.
- All coatings transported to the sump are assumed to be particulate.
- Head loss is calculated for indicated low end of sump water temperature and highest ECCS flow rate.
- The upper circumscribed surface is assumed to be bounding in terms of air ingestion because air ingestion is evaluated at the top of the module, which is the closest surface to the water level.

WF3 Response 3.f.9:
Clean strainer system head loss is due to clean strainer head loss and plenum head loss.

Plant strainer clean head loss is calculated by scaling the test module clean head loss. Clean strainer head loss is due to the head loss inside the strainer discs, head loss as the flow exits the discs and enters the central cavity, and head loss inside the central cavity. The geometry of the test strainer is similar to that of the plant strainer. It is assumed that clean strainer head loss results primarily due to turbulent flow in the central cavity of the strainer, because the velocity through the perforated plates is relatively low and because water experiences an abrupt turn as it exits the discs and enters the central cavity. For central cavity strainers, assuming the gap width is the same, the scaling factor is based on the square ratio of the flow velocities at the entrance of the central cavity:

$$\mathrm{Headloss}_{\mathrm{Clean}} := \mathrm{Headloss}_{\mathrm{Test.Clean}} \cdot \left(\frac{\dfrac{\mathrm{FlowRatePlantDisc}}{\mathrm{dPlant}}}{\dfrac{\mathrm{FlowRateTest}}{\mathrm{dTest}}} \right)^2$$

where:
Head $\mathrm{loss}_{\mathrm{Clean}}$ = plant strainer clean head loss
Head $\mathrm{loss}_{\mathrm{Test.Clean}}$ = test strainer clean head loss
FlowRatePlantDisc = plant disc flow rate, 34.599 gpm
dPlant = plant central cavity diameter, 10.5 inches
FlowRateTest = the test flow rate, varied by test
dTest = test strainer central cavity diameter, varied by test

Clean head loss data measured from module test is the sum of module clean head loss, connecting pipe entrance head loss and dynamic head because the pressure transducer was installed inside the exiting piping just outside of the test module.

Results of the clean head loss and detail calculation can be found in the future revision of the S0100 report (Reference 36).

Plenum head losses are due to the hydraulic losses associated with flow exiting the strainer into the ECCS sumps from the north and east strainers. Predicted plenum losses for the proposed WF3 plenums are calculated in Appendix 2 of Reference 36 to be 0.067 ft.

WF3 Response 3.f.10:

Because containment sump water temperature following a LOCA is usually considerably greater than the temperature at which the hydraulic tests are run, debris head loss needs to be scaled to plant conditions as follows:

$$HL_{debris\_plant} = HL_{debris\_test} * \left[\left(\frac{viscosity_{plant}}{viscosity_{test}} \right) * \left(\frac{velocity_{plant}}{velocity_{test}} \right) * \left(\frac{debris\_thickness_{plant}}{debris\_thickness_{test}} \right) * \left(\frac{water\_density_{test}}{water\_density_{plant}} \right) \right]$$

where:
HL = debris head loss through strainer in feet of water.
viscosity = dynamic viscosity of water in lbm/ft-sec.
water_density = density of water in lbm/ft^3.
velocity = approach velocity in ft/sec.
debris_thickness = nominal debris bed thickness in ft.

Nominal debris bed thickness is calculated as follows:

$$debris\_thickness = \frac{mass_{fiber}}{density_{fiber} * perforated\_area}$$

where:
$mass_{fiber}$ = mass of fiber debris in lbm.
$density_{fiber}$ = as-fabricated density of the fiber debris in lbm/ft^3.
perforated_area = total surface area of the perforated plates in ft^2.

The debris bed is assumed to be uniform, same thickness throughout perforated surface.

As previously stated, head loss testing is currently being re-performed for WF3 to address various identified for the original design basis test.

WF3 Response 3.f.11:

The strainers operate in fully submerged condition and are not vented to the atmosphere for any accident scenario. In addition to NPSH availability, failure criteria included the presence of vortexing or other forms of air entrainment, or the potential for a single large fiber bed to blanket multiple strainers (during circumscribed bed formation) and block flow to some strainers. Vortexing and air entrainment was not observed during several tests that mimicked the full range of plant debris loads, with either a representative water level or conservatively lowered water level. There is enough distance between strainers to preclude one large common fiber bed from obscuring some strainers; the nominal circumscribed debris bed is 7 inches under

100% fiber load conditions, and the closest distance between any two strainers is 32 inches, ensuring that fiber will not bridge between adjoining strainers and that water will have a path to each side of any individual strainer.

WF3 Response 3.f.12:
[Proprietary Information Removed]

The schematic of the pool configuration for the module test is shown in Figure 3.f.12-1. **[Proprietary Information Removed]**

[[]]

Figure 3.f.12-1: Module Test Setup for Strainer

WF3 Response 3.f.13:
Test strainer head loss is scaled based on velocity, viscosity, and bed thickness differences. Debris head loss and clean strainer head loss are scaled independently.

The debris bed head loss results are scaled using the following equation:

$$\frac{hl_{plant}}{hl_{test}} = \frac{\nu_{plant}}{\nu_{test}} \frac{\frac{Q_{plant}}{A_{plant}}}{\frac{Q_{test}}{A_{test}}} \frac{t_{plant}}{t_{test}}$$

Where:

hl	=	Debris Bed Head Loss (ft.)
ν	=	Water Viscosity (lbm/sec-ft)
Q	=	Sump Flow rate (ft^3/s)
A	=	Perforated Area of strainer(s) (ft) (Does not include top and bottom external surfaces)
t	=	Debris bed thickness on perforated area (in.)

Testing was and is being performed at a temperature less than plant temperature. The reduced test temperature results in an increase in viscosity. This difference in viscosity is accounted for by the first term in the equation above. The test head loss is multiplied by the ratio of plant water viscosity to test water viscosity, along with the other terms in the equation, to provide a test head loss that is representative of the plant conditions.

Viscosity scaling was performed for sector tests S7-2S-100-CS and S7-1S-59.2-CS, and for module test S3-2M-100-PS. Boreholes were not present in these tests based on the test vendor's report.

Presence of boreholes in the debris bed is apparent in the photographs of the disassembled test sector taken after the test S7-4S-13.8A-CS. Viscosity scaling was not applied to this test. This is the 1/8-inch bed case for break S7. Clumps of debris are seen on the debris plate on other areas of the strainer. The strainer used a debris plate, which is intended to mitigate thin bed effects on head loss.

WF3 Response 3.f.14:
Follow-up design-basis testing is currently being performed by GE. This testing will result in a revised strainer head loss. Upon issuance of the GE S0100 report (Reference 36), WF3 will evaluate the potential for vapor flashing.

3.g Net Positive Suction Head (NPSH)

<u>NRC Issue 3.g</u>

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

1. *Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level.*
2. *Describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.*
3. *Provide the basis for the required NPSH values, e.g., three percent head drop or other criterion.*
4. *Describe how friction and other flow losses are accounted for.*
5. *Describe the system response scenarios for LB LOCA and SB LOCAs.*
6. *Describe the operational status for each ECCS and CSS pump before and after the initiation of recirculation.*
7. *Describe the single failure assumptions relevant to pump operation and sump performance.*
8. *Describe how the containment sump water level is determined.*
9. *Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.*
10. *Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.*
11. *Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.*
12. *Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.*
13. *If credit is taken for containment accident pressure in determining available NPSH, provide description of the calculation of containment accident pressure used in determining the available NPSH.*
14. *Provide assumptions made which minimize the containment accident pressure and maximize the sump water temperature.*
15. *Specify whether the containment accident pressure is set at the vapor pressure corresponding to the sump liquid temperature.*
16. *Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.*

<u>WF3 Response 3.g.1:</u>

Pump Flow Rates

Item	Injection Flow (pre RAS)	Recirculation Flow (post RAS)
HPSI Pump	985 gpm	985 gpm
LPSI Pump	5650 gpm	0 gpm
CS Pump	2250 gpm	2250 gpm
Per Train Sump	8885 gpm	3235 gpm

Table: 3.g-1: Applicable Pump flow Rates

Notes: (1) WF3 has a common sump for both ECCS/CS trains
(2) Pump flow rates are run-out values

Sump Temperature
An analysis was performed to determine a maximum Sump Fluid temperature profile for a period of 30 days post LOCA (Figure 3.g.1-1). The Analysis was performed using the GOTHIC 7.0 program package. Conservative assumptions made in the development of the profile as stated in section 3.g.2.

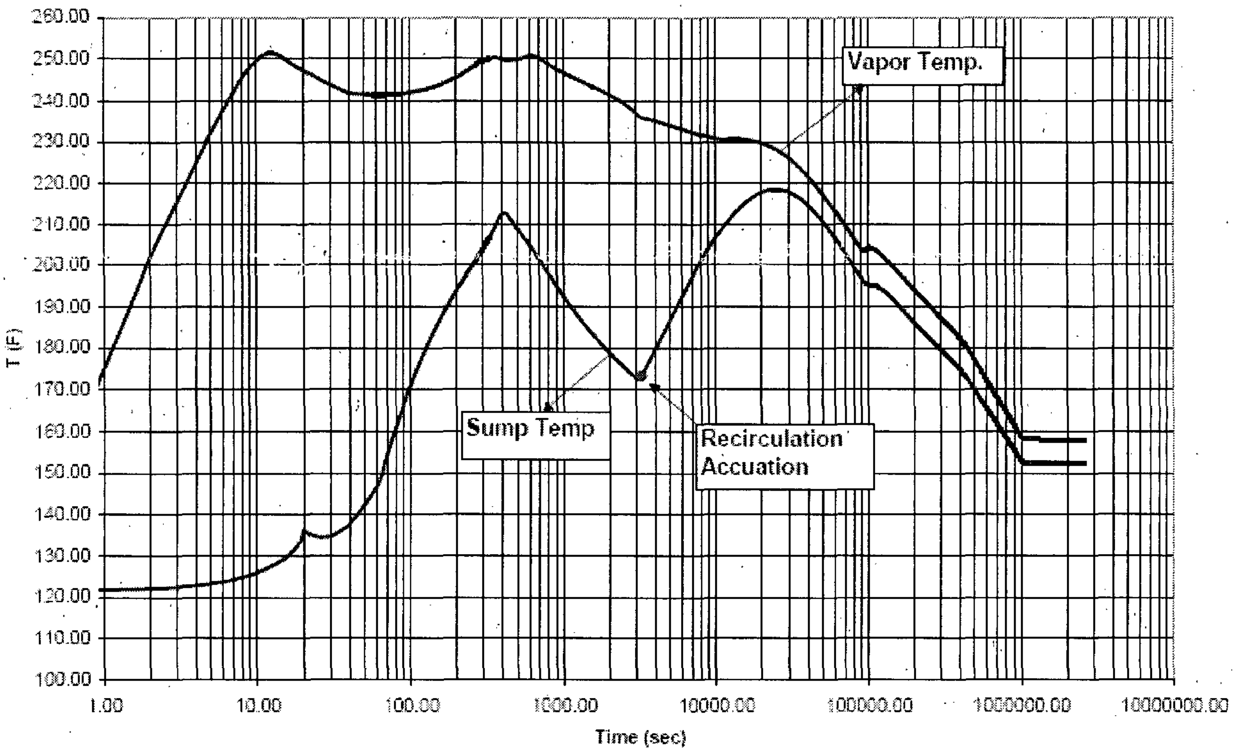

Figure 3.g.1-1: Safety Injection Sump Maximum Temperature Profile

	Time (Sec)	Sump Temp. (degF)
RAS	3253	173
RAS + 30 min	5053	187
Peak	24716	219
LOCA + 1 Day	86400	198
LOCA + 2 Day	172800	188
LOCA + 5 Day	432000	173
LOCA + 10 Day	864000	156
LOCA + 30 Day	2592000	152

Table 3.g.1-2: Temperature Points of Interest

Minimum Water Level
The WF3 Minimum water level analysis is currently being revised to address items identified during and prior to the NRC GSI-191 Audit of WF3. Preliminary results indicate that the strainers will be fully submerged during both a SBLOCA and LBLOCA. Discussion of the analysis used to determine minimum water level can be found in section 3.g.8.

WF3 Response 3.g.2:
Flow Rate Assumptions
- All pump flow rates are run-out values. This maximizes suction loses which minimizes available NPSH.
- Both trains of ECCS and CS are in operation to maximize flow through common sump screen.

Temperature Assumptions
- Base input data is that used for licensing basis LOCA peak 24 hr pressure analysis with added uncertainties
- Only one train of Containment Spray in operation at design flow
- RWSP at conservative high temperature
- 1 out of 4 Containment Fan Coolers in Operation
- Shutdown Cooling Heat Exchanger parameters selected to minimize heat rejection to Ultimate Heat Sink
- Minimum Safety Injection Flow

Minimum Water Level Assumptions
- Assumptions for the Minimum water level analysis are discussed in section 3.g.9

WF3 Response 3.g.3:
The required NPSH values are taken from the vendor certified pump performance curves and associated test data. WF3 calculation ECM07-001 (Reference 51) uses a least squares curve fit polynomial to extrapolate the required NPSH curve data out to the pump's run-out flow rate.

WF3 Response 3.g.4:
Friction loss is being determined using the software program Pipe-FLO®. Pipe-FLO® performs steady state hydraulic analysis of fluid filled piping system using standard industry approved methods such as defined by Crane® Technical Paper No. 410. All system configurations are being modeled for the suction side of the pumps and the system configuration resulting in the smallest NPSH available is used to determine acceptable screen head loss. Vendor supplied flow performance data is being utilized for components such as valves when available. When vendor information is not available conservative assumptions are being made using standard data from Crane® Technical Paper No. 410. As stated in section 3.g.2, pump run-out flows are being utilized in all analysis to maximize friction loss.

Calculations are being performed for a maximum saturated sump water temperature of 210 degF. This temperature was determined to be the most limiting based on the significant increase in vapor head below 210 degF which is slightly below the saturation temperature for containment; which is initially at minimum pressure of 14.275 psia prior to the Loss of Coolant Accident (LOCA) event. The increase in vapor head more than compensates for the increase in piping/component losses due to the increase in viscosity of the fluid at temperatures below 210 degF. At temperatures above 210 degF, the increase in vapor pressure is offset by the conservative assumption that containment pressure is equal to the vapor pressure of the sump water which eliminates containment air pressure as a contributor to NPSH available. Higher temperatures also decrease water viscosity which decreases friction losses and further improves NPSH available.

The above methodology is consistent with Regulatory Guide 1.1 in that no credit is being taken for an increase in containment pressure due to the accident.

WF3 Response 3.g.5:
Safety Injection System Response Scenarios for LBLOCA and SBLOCA

The Safety Injection System (SIS) is arranged with two independent redundant trains, each functionally identical to the other normally aligned to the Refueling Water Storage Pool (RWSP). The SIS is activated by the Safety Injection Actuation Signal (SIAS) which is initiated by either low pressurizer pressure or high containment pressure. The SIAS automatically starts the High Pressure Safety Injection (HPSI) and Low Pressure Safety Injection (LPSI) pumps and opens the motor operated valves (MOVs) that provide a flow path from the discharge of these pumps to the Reactor Coolant System. These MOVs don't actually go full open, but open to a preset position (set by valve position limit switch adjustment) to achieve a balanced flow and to prevent pump run-out. An installed spare HPSI pump is available which can be aligned to replace either of the other two HPSI pumps.

The HPSI system responds to an SIAS by automatically starting the aligned HPSI pumps and opening the cold leg injection flow control valves. If RCS pressure has not fallen below the 1450 PSIG shutoff head of the HPSI pumps, the system operates on recirculation flow until pressure decreases. As pressure decreases; HPSI flow will initiate and continue to increase as pressure falls.

The LPSI system responds by automatically starting the LPSI pumps and opening the cold leg injection flow control valves. The system will operate on recirculation flow until RCS pressure drops below the shutoff head of the pumps.

When a low level (10%) is sensed in the RWSP, the recirculation mode is initiated by the Recirculation Actuation Signal (RAS). At this time the HPSI pump suction is diverted to the Safety Injection Sump and the LPSI pumps are stopped.

Simultaneous hot and cold leg injection is used for both small break and large break LOCAs at 2-3 hours after the start of the LOCA and the RCS is not filled. In this mode, the HPSI pumps discharge lines are realigned so that the total injection flow is divided equally between the hot and cold legs. Simultaneous injection into the hot and cold legs is used as the mechanism to prevent the precipitation of boric acid in the reactor vessel following a break that is too large to allow the RCS to refill. Injecting to both sides of the reactor vessel ensures that fluid from the reactor vessel (where the boric acid is being concentrated) flows out the break regardless of the break location and is replenished with a dilute solution of borated water from the other side of the reactor vessel.

Action is taken no sooner than 2 hours after the LOCA, since the fluid injected to the hot leg may be entrained in the steam being released from the core. After 2 hours, the core decay heat has dropped sufficiently so that there is insufficient steam velocity to entrain the fluid being injected to the hot leg. Action is taken no later than 3 hours after the LOCA, in order to ensure that the buildup of boric acid is terminated, well before the potential for boric acid precipitation occurs (approximately 4 hours). Even though the action is required only for large breaks, it is taken for any LOCA so that the operator need not be required to distinguish between large and small breaks so early in the transient. Simultaneous hot and cold leg injection is not required for small breaks because, for small breaks, the buildup of boric acid is terminated when the RCS is refilled. Once the RCS is refilled, the boric acid is dispersed throughout the RCS via natural circulation.

Hot leg injection is established by closing the HPSI header flow orifice bypass valves and opening the hot leg header isolation valves. The orifices are preset to establish a 50% ±5% flow balance between the hot and cold leg injection headers while preventing pump run-out conditions.

Long term cooling is initiated when the core is reflooded after a LOCA and is continued until the plant is secured. Two basic modes of long term cooling are available to the operator.

Entry into shutdown cooling (SDC) may be necessary if steam generator heat removal is lost, for certain sized breaks (small breaks). The shutdown cooling system is utilized if certain plant conditions exist.

When possible, the time necessary to refill the RCS and regain control of pressure and inventory depends on break size, break location, RCS cooldown rate and the number of HPSI pumps and charging pumps actuated. With only one HPSI pump actuated, for a break of about 3 inch diameter located on the bottom of the cold leg, it may take as long as 8 hours to refill the RCS. With all injection pumps operable, the time is about 1 hour.

Before SDC is operated, RCS activity levels must be determined since the RCS fluid will be circulated outside of the containment building. When high activity is present, circulation outside containment has the potential for release to the environment. If potential for significant releases exists, it may be more desirable to continue cooling with the steam generator. The condensate inventory must be checked to ensure that the supply is sufficient to cool down the plant.

If SDC operation is determined to be appropriate, the SIS is aligned for cold leg injection and the RCS is cooled down and depressurized to allow entry into shutdown cooling.

If SDC operation is not appropriate or if the system is not available, it is desirable to continue RCS heat removal via the steam generators until no further steam is generated.

For large breaks, simultaneous injection provides effective long-term cooling by inducing a flushing flow through the core which will eventually result in a subcooled core. The core cooling is actually provided by the Containment Spray System via the Shutdown Cooling Heat

Exchangers. This provides cooling for the Safety Injection Sump water which also provides a water source to the HPSI Pumps.

CSS Response Scenarios to LBLOCA and SBLOCA

The Containment Spray (CS) System consists of two independent and duplicate trains to achieve the required redundancy. One loop operating alone is capable of providing the necessary post-accident heat removal. Each loop contains a CS Pump, a CS Riser Pump, a Shutdown Cooling Heat Exchanger, four spray ring headers, 116 spray nozzles, and the controls and instrumentation necessary to provide for proper system operation.

The CS System is actuated when the SIAS and the High-High Containment Pressure signal are coincident. This generates a Containment Spray Actuation Signal (CSAS) which opens the CS header isolation valves and starts the CS Pumps. The pumps initially take suction from the RWSP through a common header with the SIS pumps and delivers borated water to the spray nozzles located in the top portion of the steel containment. When RAS is initiated the CS pumps continue operation with the suction being taken from the Safety injection Sump.

WF3 Response 3.g.6:

Pump	Pre RAS (Injection Phase)	Post RAS (Recirculation Phase)
HPSI	Operating	Operating
LPSI	Operating	Secured
CS	Operating	Operating

Table 3.g.6-1: Operational Status of ECCS and CS Pumps

WF3 Response 3.g.7:
Only one single failure is being assumed in the NPSH analysis. This single failure is a LPSI pump failing to trip upon receiving a Recirculation Actuation Signal. This results in an increased flow through the safety injection sump for an assumed time period of 30 minutes. Upon initiation of the Recirculation Actuation Signal, Operations procedures guide operators to verify that the LPSI pumps have stopped. If the pump has not tripped upon RAS, operators will take appropriate action as necessary to secure the pump.

Failure of a flow control valve will have no effect on the NPSH analysis due to the fact that the analysis assumes pumps are operating at run-out flows.

WF3 Response 3.g.8:
The minimum Safety injection Sump water level is determined by comparing water inventories available to fill the sump with the physical layout of the sump. Conservative assumptions intended to minimize the water level are made concerning available inventories, hold-up mechanisms, and the sump physical layout. Two single worst case (i.e., not time dependent) water levels are determined; one for the SBLOCA scenario and one for the LBLOCA scenario. The results of the water level analysis can be found in section 3.g.1 while the additional detail

on the analysis can be found in sections 3.g.9, .10, .11, & .12. Original minimum water level analysis was found to require revision during the 2007 NRC GSI-191 Audit.

WF3 Response 3.g.9:

- Containment sump and Safety Injection sump do not communicate due to clogged drains.
- Containment sump fills to elevation of (+)7.5 ft (point of overflow to safety injection sump).
- Steam volume in containment at max containment temperature and is saturated.
- Refueling cavity assumed to not holdup water due to existence of 2 - 6" floor drains in locations which are unlikely to clog. Drains go directly to Containment floor.
- Safeguards pump are assumed to leak a combined total of 0.5 gpm for 24 hours.
- Film thickness for condensation assumed to be larger than that determined analytically.

Other assumptions are described in sections 3.g.10, .11, & .12.

WF3 Response 3.g.10:
Empty spray pipe – A portion of the Containment Spray System piping is empty prior to initation of Containment Spray. This piping is credited for consuming an appropriate portion of the available inventory.

Water droplets – Containment Spray droplets are in transient from the spray nozzles to the containment floor. The volume of spray droplets for two CS trains operating at pump run-out flows are credited for consuming an appropriate portion of the available inventory.

Condensation – Heat sink surfaces condense steam from the atmosphere and develop a condensation film. The volume of the condensation film is credited for consuming an appropriate portion of the available inventory.

Holdup on horizontal and vertical surfaces – Other than condensation on heat sink surfaces, holdup was not considered on other horizontal or vertical surfaces. All concrete flooring above the containment floor has drains or is adjacent to steel grating with no curb to trap water. Floor drains direct water to the containment sump which is assumed to fill completely and overflow into the safety injection sump.

WF3 Response 3.g.11:
Credit is only taken for structural concrete below the flood level for the displacement of water. Conservatively no credit is taken for the following items:

- Reactor Drain Tank
- Grout Pads
- TSP Baskets
- Strainer Steel
- RCP support steel
- Structural steel

WF3 Response 3.g.12:
The following assumptions are made for the sources of water:

- Technical Specification minimum protected RWSP Volume only injected
- RWSP water at maximum Technical Specification temperature
- Safety injection tanks credited for Large Break LOCA only
  - Water at minimum Technical Specification Level
  - Water at maximum pre accident Containment Temperature
- No credit for Reactor Coolant Spillage
- No credit for charging flow from Volume Control Tank or Boric Acid Makeup Tanks

WF3 Response 3.g.13:
No credit is taken for containment pressure above that present prior to the onset of the accident. This is consistent with Regulatory Guide 1.1 (Reference 52).

WF3 Response 3.g.14:
As stated in section 3.g.13, no credit has been taken for containment pressure above that present prior to the onset of the accident.

WF3 Response 3.g.15:
As stated in section 3.g.4, NPSH available values are being calculated with a sump temperature of 210 degF with vapor pressure equal to saturation pressure. For the cases that assume a single LPSI pump fails to trip, credit is taken for the sump fluid being sub cooled at 190 degF with respect to containment being at atmospheric pressure.

WF3 Response 3.g.16:
Original NPSH analysis resulted in small margins and is currently being revised.

3.h Coatings Evaluation

NRC Issue 3.h
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.

1. *Provide a summary of type(s) of coating systems used in containment, e.g., Carboline CZ 11 Inorganic Zinc primer, Ameron 90 epoxy finish coat.*
2. *Describe and provide bases for assumptions made in post-LOCA paint debris transport analysis.*
3. *Discuss suction strainer head loss testing performed as it relates to both qualified and unqualified coatings and what surrogate material was used to simulate coatings debris.*
4. *Provide bases for the choice of surrogates.*

5. *Describe and provide bases for coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on ZOI size for qualified and unqualified coatings.*
6. *Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.*
7. *Describe any ongoing containment coating condition assessment program.*

WF3 Response 3.h.1:
The following types of coating systems are present, or approved to be used, inside Containment, per WF3 Engineering Procedures and Specifications (Reference 42 and 43).

- Ameron Dimetcote 6(N)
- Ameron Amercoat 66 over Ameron Nu-Klad 110AA primer
- Ameron Amercoat 66 over Ameron Nu-Klad 114 primer
- Ameron Amercoat 90
- Ameron Amercoat 90 over Ameron Amercoat 66 primer
- Ameron Amercoat 90 over Ameron Amercoat 71 primer
- Ameron Amercoat 90 over Ameron Dimetcote 6(N) primer
- Ameron Amercoat 90 over Ameron Dimetcote E-Z primer
- Ameron Amercoat 90 over Carboline CZ11SG primer
- Ameron Amerlock 400 NT
- Ameron Dimetcote E-Z
- Carboline 801
- Carboline 890
- Carboline 890 over Carboline Nutec 11S primer
- Carboline 890 over Carboline Nutec 11 primer
- Carboline 890 over Carboline Nutec 1201 primer
- Carboline Carbo-Zinc 11
- Carboline CZ11SG
- Carboline Nutec 1201 over Carboline Nutec 11 primer
- Carboline Nutec 1201 over Carboline Nutec 11S primer
- Carboline Phenoline 305 over Carboline CZ11SG primer
- Carboline Phenoline 305 over Carboline 191 primer
- Carboline Phenoline 305 over Carboline Phenoline 305 primer
- Tnemec 801
- Unqualified coatings (alkyds, enamels, and epoxies) from various manufacturers.

WF3 Response 3.h.2:
In accordance with the guidance provided by the NEI and SER (References 2 and 3), all qualified coating debris within the ZOI is considered particulate and as such is modeled as transporting to the sump strainer.

50% of the qualified coatings on the containment liner dome and the liner above elevation 112' are assumed to fail. This is a conservative number based on coating failures at WF3 to date.

Unqualified epoxy coating systems (degraded qualified coatings) are considered to fail as chips (see response to 3.h.6 below) and are subject to settling in low velocity area of the pool such that only a portion of the generated debris transport to the strainer. Unqualified zinc coatings and indeterminate coatings are considered to fail as particles with 100% transport to the strainer. Degraded qualified coatings that fall on or near the strainer are considered not to have a chance to settle. Conservatively 20% of degraded qualified coatings are considered to fall on or near the strainer and thus transport to the strainer. For analysis of the remaining degraded qualified coating transport additional CFD runs were performed. The additional CFD simulations consider break locations farther from the strainer in order to maximize the portion of the pool where flow velocity is too high for settling to occur. The study in Reference 19 found that the lowest incipient tumbling velocity, the velocity at which the coating chips similar to WF3 debris would move on the floor was 0.264 feet per second for the "curled" 1-to-2-inch chips. Conservatively a transport velocity of 0.2 feet per second is used for all chips with a size greater than 1/64th inch. Based on the CFD simulations the bounding portion of the containment pool area with a velocity in excess of 0.2 feet per second is determined to be 12.7%. As a judgment, this area is increased to 15% and the failed coatings in the remaining 85% of the pool are considered subject to settling.

<u>WF3 Response 3.h.3 and 3.h.4:</u>
The prior WF3 sector test results indicated that the bounding condition for simulating plant LOCA debris-generation is 100% fiber and 100% particulate (Reference 36).

All coatings are conservatively assumed to fail as particulate.
[Proprietary Information Removed]

This will have a greater effect on head loss than would the heavier latent dirt.

<u>WF3 Response 3.h.5:</u>
In order to determine the amount of qualified coating debris generated at WF3, structural and civil drawings are consulted. The bounding break location is determined from inspection of these drawings, then the total surface area of coated steel and concrete within a 4D ZOI of the break location is calculated. The maximum allowable coating thickness, per the plant coating specification, is then applied to this surface area to determine the total coating debris volume. A spherical ZOI of 4D for qualified coatings was selected based on WCAP-16568-P (Reference 22). This testing concluded that a spherical ZOI of 4D is conservative for the qualified epoxy and the qualified zinc coatings used by WF3.

Unqualified (degraded qualified or indeterminate) coatings are assumed to 100% fail. The unqualified coating debris volume is based on the thickness of similar coatings on other materials in containment.

WF3 Response 3.h.6:
In accordance with the guidance provided in the NEI (Reference 2) and SER (Reference 3) documents, all qualified coating debris and unqualified zinc coating debris and indeterminate coating debris are treated as particulate and are therefore transported entirely to the sump strainer.

Degraded qualified coatings are considered to fail as chips with a size distribution per References 25 and 26. Reference 25 stated that 49.5% of coating particles were less than 1/8th inch in size. Reference 26 further identifies that 12.375% (25% of 49.5%) of the coating particles are 6 mils (0.006 inches) and 37.125% (75% of 49.5%) are 15.6 mils (1/64th inch). 100% of coating particles with a size less than 1/64th inch will not settle and will transport to the sump. This quantity amounts to approximately 12.375% of the inventory. The remaining 87.625% of the inventory may settle in favorable flow conditions.

The degraded qualified coating systems at WF3 are compared with the test data using references 19, 25, 26 and 27. The data reported in Reference 19 are for the failure characteristics of many coatings, including epoxy applied as a topcoat over inorganic-zinc. The epoxy top coats applied over a zinc rich primer, Category ZE, are similar to the Carboline Phenoline 305 applied as a topcoat over Carboline Carbo-Zinc 11. The painting system used on the containment dome is Carboline Phenoline 305 applied as a topcoat over Carboline Carbo-Zinc 11 primer. This system is also one of four Service Level 1 paint systems approved for the containment liner. The other systems include Carboline 305 topcoat over Carboline 191 primer, Carboline 801 as a primer and topcoat and Amerlock 400 NT (a one coat system). All are epoxy systems, which are expected to exhibit failure characteristics of Carboline 305. Reference 27 confirms that the size distribution presented in references 25 and 26 is applicable to Carboline Phenoline 305 coatings systems. Reference 27 also confirms that 100% of inorganic-zinc coatings will fail as small fines.

WF3 Response 3.h.7:
WF3 performs an inspection of containment coatings each refueling outage. As defined in Reference 42, the scope of the coating inspections are coated concrete and steel surfaces inside the SI Sump, the containment liner plates, and approximately 10% of the remaining coated surfaces excluding concrete and insulated piping.

3.i Debris Source Term

NRC Issue 3.i
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.

Provide the information requested in GL 04-02 Requested Information Item 2.(f) regarding programmatic controls taken to limit debris sources in containment.

GL 2004-02 Requested Information Item 2(f)

A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) will be assessed for potential adverse effects on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, "A Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.

In responding to GL 2004 Requested Information Item 2(f), provide the following:

1. *A summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. Specifically for RMI/low-fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.*
2. *A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.*
3. *A description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.*
4. *A description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.*

If any of the following suggested design and operational refinements given in the guidance report (guidance report, Section 5) and SE (SE, Section 5.1) were used, summarize the application of the refinements.

5. *Recent or planned insulation change-outs in the containment which will reduce the debris burden at the sump strainers*
6. *Any actions taken to modify existing insulation (e.g., jacketing or banding) to reduce the debris burden at the sump strainers*
7. *Modifications to equipment or systems conducted to reduce the debris burden at the sump strainers*
8. *Actions taken to modify or improve the containment coatings program*

<u>WF3 Response 3.i.1</u>
Entergy's fleet wide FME program procedure provides the requirements and guidance to prevent and control introduction of foreign materials into structures, systems, and components. Also included within this procedure are steps to take to reestablish and maintain FME areas to prevent foreign material intrusion and to recover/monitor when a loss of FME integrity has occurred.

Housekeeping and foreign material assessments after a plant outage and prior to heat up are performed at the direction of the WF3 operating procedure which provides the requirements and guidance to perform walkdowns of the RCB to assess debris that may represent a risk of blocking the SI recirculation sump screen.

WF3 Response 3.i.2
See Response to Issue 3.i.1.

WF3 Response 3.i.3
The Entergy fleet configuration control procedure controls permanent plant changes inside the RCB so as to not change the analytical assumptions and numerical inputs. A design input consideration was added to the Entergy fleet design input and configuration control impact screening procedures to specifically address the SI Sump GL 2004-02 program. Engineers are required to review the impact of a proposed change on the documentation that forms the design basis for the response to Generic Letter 2004-02. Site procedures require reviews of physical changes in the RCB to address specific areas. The specific areas that are addressed, as a minimum, are:

- Insulation inside containment
- Coatings inside containment
- Volumes in containment
- Addition of materials inside containment that may produce chemical effects in the post-LOCA flood pool/environment.

WF3 Response 3.i.4
Temporary changes at WF3 are subject to similar requirements for reviews as for permanent changes. Therefore, design input and impact screenings will determine if the temporary change should be reviewed for any potential impact on the SI Sump screens. Entergy fleet procedures also provide guidance such as the 50.59 Review Process procedure, which provides details and guidance on maintenance activities; and the On-Line Work Control Process procedure, which establishes the administrative controls for performing on-line maintenance of SSCs in order to enhance overall plant safety and reliability.

WF3 Response 3.i.5
There are no recent or planned insulation change-outs in the WF3 containment which will reduce the debris burden at the sump strainers.

WF3 Response 3.i.6
No modifications to existing insulation were performed to reduce the debris burden at the sump strainers.

WF3 Response 3.i.7

There were no modifications made to equipment or systems to reduce the debris burden at the sump strainers.

WF3 Response 3.i.8
The coatings procedure for WF3 was revised to provide better instructions to the craft on cleanliness when preparing surfaces.

3.j Screen Modification Package

NRC Issue 3.j
The objective of the screen modification package section is to provide a basic description of the sump screen modification.

3. *Provide a description of the major features of the sump screen design modification.*
4. *Provide a list of any modifications, such as reroute of piping and other components, relocation of supports, addition of whip restraints and missile shields, etc., necessitated by the sump strainer modifications.*

WF3 Response 3.j.1:
The modification for the SI Sump replaced the original box type screen over the SI Sump. To prevent debris from entering the open sump, the original rectangular box shaped screen had 0.078 inch square openings (0.11 inch diagonally) and completely covered the sump inlet. The box screen provided approximately 198.2 ft^2 of available flow area. In addition, the box screen was mounted approximately 3.75" above the containment floor which prevented sediment from entering the pit. A divider screen separated the two (SIS) suction lines located in the sump. During RF14, a modification installed a passive, safety-related, Nuclear Modularized Stacked Disk Strainer assembly engineered and manufactured by General Electric Energy in place of the original screen. The new strainer arrangement for WF3 consists of 11 strainer modules mounted on top of the plenum mounted over the existing sump and over the concrete floor to the north and to the east of the sump. The new SI Sump partition that separates the two SIS suction lines is a section of stainless steel grating made of 1" x 1/8" bars separated at 1-3/16". The partition is supported by angles attached to the existing anchor plates. The modification was installed during the 2006 refueling outage.

The effective surface area of the new strainer for each module is 336.3 ft^2, for a total of approximately 3,700 ft^2. There are 11 essentially identical modules mounted on the 8" high plenum over the SI Sump. Each module is bolted to the plenum and the plenum is bolted to the containment floor. The plenum prevents debris from entering the system between the modules.

Each module is constructed of 17 stacked perforated disk sets with hole-diameters of 0.093 inch. A disk set is composed of two perforated disks separated from each other by radial fingers and by an outer support, the finger frame. The water enters from the top and bottom disks into the intermediate space, travels towards the center and then axially towards the strainer base. Perforated inner spacer rings separate the disk sets from each other. The modules are located on top of the plenum, approximately 8 inches above the containment floor.

The sump is now totally enclosed by the plenum, preventing material from falling directly into the sump without passing through the strainer assemblies.

The plenum extensions to the north and east side of the sump have internal dimensions 7.25 inches high by 41 inches wide.

The plenum has openings in the top to admit flow of strained water from the modules. The modules are bolted to the plenum, which in turn is bolted to the containment slab. The plenum is made of structural shapes: angles and plates. The strainer design allows for disassembly, replacement of modules, or addition of future modules as needed. The plenum has two access openings to allow access into either side of the sump during outages for inspection and testing. The access openings are approximately 40" X 40". The access covers are bolted to the plenum to control access. Each module also has an inspection port on top to allow visual inspections inside the module, if necessary.

WF3 Response 3.j.2:
A safety related low level switch was relocated due to the installation of the new SIS sump strainer assembly. The switch is now mounted on top of the plenum and is on the north end of the sump so that it can detect water at the lowest point of the SIS sump floor. The switch elevation at the new location is identical to the previous elevation and maintains the same function and switch setpoint. This switch is seismically mounted on the top of the plenum. The level switch guard pipe and mounting plate were modified to match the plenum mounting plate and are seismically installed to preclude the potential for a strainer bypass path. The seismic bracing mounted at the sump floor was relocated to align with the guard pipe. The portion of the new guard pipe above the plenum is welded to 150-lb flange and welded to the bolted cover plate. This portion of guard pipe has no holes on the pipe wall. The instrument plate-to-plate bolted connection to strainer plenum has a zero gap preventing debris from entering the sump.

Nineteen (19) TSP baskets were relocated to eliminate interference with the new strainer assembly. The new location is at the same elevation of the containment, but at the north end of the building. The relocated TSP baskets are seismically mounted on the concrete floor of containment at elevation -11.0 feet.

The sensors for Reg. Guide 1.97 Type B, Category 1 Level transmitters were temporarily removed from the mounting plate inside the sump to allow for installation of the new strainer. After installation of the new strainer was completed the sensors were remounted to the same mounting plate inside the sump. There was no change to the transmitter mounting and the setpoint. The ¼" diameter capillary tubing and tube track between the level transmitters and the sensors was re-routed. The capillary tubing penetrates the top of the plenum. A plenum opening of 6" x 6" with a ¼" diameter slotted hole and a cover plate with a slotted hole was provided to allow the re-mounting of the instrument without disconnecting the capillary tubing from the instrument. The slotted hole design ensures zero gap thereby preventing debris from entering the sump.

3.k Sump Structural Analysis

NRC Issue 3.k
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. Provide the information requested in GL 2004-02 Requested Information Item 2(d)(vii).

GL 2004-02 Requested Information Item 2(d)(vii)
Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under flow conditions.

1. *Summarize the design inputs, design codes, loads, and load combinations utilized for the sump strainer structural analysis.*
2. *Summarize the structural qualification results and design margins for the various components of the sump strainer structural assembly.*
3. *Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable).*
4. *If a backflushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.*

WF3 Response 3.k.1:
The inputs and loads are discussed in the following paragraphs.

Differential Crush Pressure is the pressure difference across the strainer components. The value is equal to the static pressure outside the strainer minus the static pressure inside the strainer system. The "Design" crush pressure is analogous to design pressure for a pressure vessel; in that it is ≥ the limiting pressure loss across the equipment specified for hydraulic system design. Crush pressure was applied to the assembly to demonstrate adequacy for pressure loading of the strainer perforated plates, perforated spacer rings and plenum plates including supports.

Equivalent solid plate properties (Poisson's Ratio and Modulus of Elasticity) including a stress multiplier were determined for the disc perforated plates by performing a finite element analysis of perforated plate and solid plate following the guidance contained in the ASME Code Section III, Appendix A, Article A-8000. A finite element model of the strainer assembly was then developed with the perforated plates modeled as equivalent solid plates. The strainer disks are modeled as shell and beams while the plenum consists of solid elements. The equivalent solid plate properties are used to model the strainer perforated plates for structural analyses. The equivalent properties for the perforated plate are:

$E^* = 0.43$ E, equivalent modulus of elasticity
$\nu^* = 0.33$, equivalent Poisson's ratio
$\kappa = 2.33$ stress multiplier

The equivalent properties were applied to the solid plates in the ANSYS finite element model to simulate the plate perforations.

Modal frequencies in air and in water were determined according to the seismic analysis requirements and were used to determine the seismic accelerations. The load cases required by the design specification were analyzed to determine stresses in all components.

The strainers are designed for a 40-year life. Thermal fatigue was evaluated qualitatively, and dismissed as insignificant since the normal operation temperature cycle ranges are small (50°F) and there is only one LOCA temperature cycle with a range of 199°F. Material Properties were based on stainless steel SA 240, Type 304 which is the material of construction. The material properties used were selected from the ASME code and are shown in Table 3.k.1-1.

Table 3.k.1-1 Material Properties

Material / Property	Unit	Temperature 300°F
SA-240, Type 304		
Elastic modulus`	psi	27.0E+6
Coefficient of thermal expansion	In/in-°F	9.0E-6
Poisson's ratio	-	0.3
Density	lb/in^3	0.289
Stress Allowable	psi	16700
Tie-rod bolt material SA-193, B8		
Elastic modulus	psi	27.2E+6
Coefficient of thermal expansion	in/in-°F	9.0E-6
Yield Strength	psi	22500 (1)

(1) Yield strength of SA-193, B8 material at 70F is 30,000 psi.

Load Definitions and Combinations

Strainers, Plenums, the Partition and the Sensor and supports are designed for the loads and load combinations described in this section.

Load Definitions

W	Strainer Assembly Weight in Air, Normal Plant Operation
WD	Strainer Assembly Weight in Water + Debris Weight + Hydrodynamic Mass, LOCA
TE_{max}	Thermal Expansion in Water, LOCA
TE_{op}	Thermal Expansion in Air, Normal Plant Operation
P_o	Containment Pressure
P_d	Containment Design Pressure
P_{cr}	Differential Crush Pressure, LOCA
OBE1	Operating Basis Earthquake Inertia Loading in Air
OBE2	Operating Basis Earthquake Inertia Loading in Water + Debris Mass + Hydrodynamic Mass
SSE1	Safe Shutdown Earthquake Inertia Loading in Air
SSE2	Safe Shutdown Earthquake Inertia Loading in Water + Debris Mass +Hydrodynamic Mass

Load Combinations

Strainers and Plenums

Design = $W + TE_{op} + P_o + OBE1$
Level B = $P_d + WD + OBE2 + TE_{max} + P_{cr}$

Support Structures

Design = $W + TE_{op}$
Level B = $WD + OBE2 + TE_{max}$
Level D = $WD + SSE2 + TE_{max}$

The strainer assembly shall withstand a live load of 250 lbs during outages. This load is negligible compared to operating loads and no specific analysis was performed.

The seismic loads are based on the horizontal and vertical inertial accelerations specified by the seismic response spectrums according to the first mode frequency in water. The design pressures, P_o and P_d, have no impact and add nothing to the load combinations cited above because the strainer system is an open system that is not pressurized by containment pressure but is loaded by crush pressure, P_{cr}. Hydrodynamic mass values and debris weights, are included where applicable.

Table 3.k.1-2 Mass Properties

Dry weight of 1 strainer	lb	2,374
Submerged weight of 1 strainer	lb	3,560
Dry weight of plenum	lb	9,753
Submerged weight of plenum in vertical direction	lb	47,788
Submerged weight of plenum in x and z direction	lb	12,679
Dry weight entire assembly	lb	35,862
Submerged weight of entire assembly in vertical direction	lb	86,952

Table 3.k.1-3 Coefficients Used for Seismic Analysis*

OBE lateral	0.25 g
OBE vertical	0.20 g
SSE lateral	0.38 g
SSE vertical	0.30 g

* These accelerations are above the ZPA value, therefore no multiplier is applied

The structural response due to OBE & SSE is different depending on whether the equipment is in air or in water.

Loads used in the stress analysis include the weight of the strainer assembly, debris, contained water, crush pressure due to pump operation, and seismic loads. The lateral and vertical inertial accelerations were obtained from the seismic response spectra corresponding to the first mode frequency of the equipment when submerged.

Crush pressure was applied to the strainer plates, spacer rings and plenum plates. The weight of the equipment in water was analyzed as the sum of the weight of the assembly in air, the debris weight and the hydrodynamic mass and contained water. A 1-"g" inertial load in the vertical direction was used to represent the dead weight of the equipment.

WF3 Response 3.k.2:
All Qualification information is contained in GE report 26A7056, Revision 3 (Reference 56).

Finite element analyses were performed for all components using ANSYS Version 10 computer program. Stresses from design load combinations are compared with the ASME Code Section III, Subsections NC, and ND stress limits Stress margins for the limiting components were calculated for the Design Condition, Service Level B, and Service Level D Load Combinations. Table 3.k.2-1 shows selected calculated stresses. The minimum stress margins are shown in Tables 3.k.2-2 (Strainer Components), 3.k.2-3 (Partition Components) and 3.k.2-4 (Sensor Components).

Table 3.k.2-1 Stress Summary for Strainer Components

	Load Combinations & Max Calculated Stresses, ksi		
Component	**Design W + OBE1**	**Level B WD + OBE2 + P_{cr}**	**Level D WD + SSE2 + P_{cr}**
Perforated Plate (1)	1.8	3.5	4.0
Frame & Fingers	3.3	4.7	5.8
Spacers	7.4	10.3	12.5
Strainer Base	1.8	2.3	2.8
Tie Rod	1.1	1.2	1.7
Plenum	9.0	12.8	14.8
Allowable Pm Stress(2)	1.0 x S	1.1 x S	2.0 x S
Allowable Stress (2)	16.7	18.4	33.4

Notes:
1) Perforated plate includes intensification factor of 2.33
2) For conservatism, the allowable for membrane stress is used, which is the lowest

Table 3.k.2-2 Margin Summary for Strainer Components

	Load Combinations & Margins (1)		
Component	**Design W + OBE1**	**Level B WD + OBE2 + P_{cr}**	**Level D WD + SSE2 + P_{cr}**
Perforated Plate (1)	8.3	4.3	7.4
Frame & Fingers	4.1	2.9	4.8
Spacers	1.2	0.8	1.7
Strainer Base	8.4	6.9	10.9
Tie Rod	14.6	14.4	18.6
Plenum	0.9	0.4	1.3

Notes:
1) Margin = (Allowable/Calculated) – 1

Table 3.k.2-3 Stress (ksi) Summary for Partition Components

Component	Design	Level B	Level D
Partition Assembly	1.3	6.4	16.9
Allowable Stress	16.6	18.4	33.4
Partition Margin	11.8	1.9	1.0

Table 3.k.2-4 Stress (ksi) Summary for Sensor Components

Component	Design	Level B	Level D
Sensor Assembly	0.4	7.4	11.6
Allowable Stress	16.6	18.4	33.4
Sensor Margin	40.5	1.5	1.9

The strainer disk surfaces are covered by a woven wire cloth, which is resistance welded to the perforated plate. In the Waterford application this woven wire mesh is used solely to enhance the debris carrying capability with respect to hydraulic head loss of the disks and no structural credit is taken for its presence; however the mass is included in the analysis. It is necessary to assure that the Woven Wire remains attached to the disk when the disk is subjected to seismic loading and when the disk deflects due to the pressure drop across the disk faces. This assurance is obtained as the result of testing performed by GEH in which the composite of perforated plate and woven wire was deflected over 1" with the wire remaining attached. This deflection is at least an order of magnitude greater than will be experienced in service.

<u>WF3 Response 3.k.3:</u>
An evaluation has been performed which concluded that the strainer assembly is not subject to pipe whip, jet impingement, or missile impact associated with a HELB.

<u>WF3 Response 3.k.4:</u>
A backflushing strategy is not credited in the WF3 analyses.

3.l Upstream Effects

<u>NRC Issue 3.l</u>
The objective of the upstream effects assessment is to evaluate the flowpaths upstream of the containment sump for holdup of inventory, which could reduce flow to and possibly starve the sump. Therefore, provide a summary of the upstream effects evaluation including the information requested in GL 2004-02, "Requested Information," Item 2(d)(iv) including the basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flowpaths.

1. *Summarize the evaluation of the flow paths from the postulated break locations and containment spray washdown to identify potential choke points in the flow field upstream of the sump.*
2. *Summarize measures taken to mitigate potential choke points.*

3. *Summarize the evaluation of water holdup at installed curbs and/or debris interceptors.*
4. *Describe how potential blockage of reactor cavity and refueling cavity drains was evaluated, including likelihood of blockage and amount of expected holdup.*

WF3 Response 3.I.1:
The WF3 containment is mostly uncompartmentalized with the exception of the pressurizer room. There are no structures totally surrounding the major components (SG, RCP, etc.) of the RCS. All RCS components with the exception of the pressurizer are within the SG cavities (D-Rings), but the SG cavities are open to each other (on the north side below elevation -4 ft., open to the annulus below elevation -1 ft and are open to the dome above elevation +62.25 ft. The PZR is located in a separate room with an opening in the floor that connects to the containment annulus.

WF3 does not have any significant inactive volumes other than the reactor cavity and containment sump. For significant quantities of debris to be trapped in the reactor cavity or containment sump, the break location would have to be at the reactor (within the reactor cavity). As described in Section 3.e, relatively small quantities of debris that transport to the sump will be created for any break in the reactor cavity itself. For breaks outside the primary shield wall, significant quantities of debris would not be transported to the reactor cavity or containment sump by flowing water during the pool fill-up. This is because the only flow paths from the active pool to the reactor cavity and containment sump at the minimum flood elevation are through several floor drains located in the containment at elevation -11.0 ft that drain to the containment sump.

WF3 Response 3.I.2:
As no potential choke points were identified for WF3, no mitigation measures were necessary.

WF3 Response 3.I.3:
WF3 does not have any curbs on the -11 ft basemat elevation. Throughout containment, where slabs are adjacent to open areas or grating areas, there are no concrete curbs. For open areas, there are kickboards on the handrails, but these are not flush against the surface of the concrete and will allow water to flow under and around them.

WF3 Response 3.I.4:
Calculation 2005-05500 (Reference 29) documents that the refueling cavity has two 6-inch drain lines (without screens) that drain to the containment floor, and by one 4-inch line that drains to the containment sump. In the event that large debris is propelled over the SG cavity walls into the refueling cavity, the debris must land on a drain in order to clog it since the velocities in the cavity are too low to transport a large piece of debris to a drain. During plant operations, the Upper Guide Structure Lift Rig (UGSLR) is stored directly above one of the 6" drains. The UGSLR will prevent any debris larger than 6" from falling directly on the drain. The diver stairs are located above the other 6" drain and are permanently mounted in the refueling cavity. These stairs will prevent any debris larger than 6" from falling directly onto the drain. Any smaller debris that transports to these two 6" drains will pass through the drains since they do

not contain screens. Therefore, there will always be drainage available from the refueling cavity to the active pool.

3.m Downstream Effects – Components and Systems

<u>NRC Issue 3.m</u>
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. Provide the information requested in GL 04-02, "Requested Information," Item 2.(d)(v) and 2.(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in the ECCS and CSS downstream of the sump by explaining the basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface. For GL 2004-02, Item 2(d)(vi) provide verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

1. *GL 2004-02 Requested Information Item 2(d)(v)*
   The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.
2. *GL 2004-02 Requested Information Item 2(d)(vi)*
   Verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.
3. *If NRC-approved methods were used (e.g., WCAP-16406-P with accompanying NRC SE) briefly summarize the application of the methods.*
4. *Provide a summary and conclusions of downstream evaluations.*
5. *Provide a summary of design or operational changes made as a result of downstream evaluations.*

<u>WF3 Response 3.m.1:</u>
As a result of GSI-191 new containment sump screens were installed in WF3. The nominal perforated plate hole in the screens is 3/32 inches (Reference 30).

The ability of the ECCS equipment required to pass debris laden fluid during the recirculation phase after a postulated accident is evaluated in Calculation 2005-02820, Revision 0 (Reference 31). This evaluation determines the ECCS equipment that would be in the post-accident recirculation path and reviews the dimensions of close-tolerances in this ECCS equipment against the acceptance criteria of 1.1 and 2 times the screen hole size. The gaps in the bushings and wear rings of the HPSI and CS pumps were determined to have clearances less than 1.1 times the screen hole size. Decreases in flow through the pump gaps would enhance the performance of the pumps so that flow decrease due to blockage is not a concern. Blockage leading to packing wear is evaluated as described below. The HPSI pumps, CS pumps, CS headers solenoid operated valves, HPSI pump recirculation flow orifices, HPSI header throttle valves and RC loop throttle valves were determined to have minimum flow clearances small enough to require wear evaluations. These components are in the process of being reviewed for the effect of wear on their performance per WCAP 16406-P Revision 1 (Reference 54).

WF3 Response 3.m.2:
Blockage of components is addressed above; wear of close tolerance components and systems is addressed in this paragraph. Calculation 2005-12840, Revision 1 (Reference 32) primarily addressed component wear; however, it also included instrument lines, relief valves, piston check valves and post accident sampling system components for the potential for blockage due to debris. For equipment being addressed by WCAP-16406-P, Revision 1, August 2007, the methods and acceptance criteria are in accordance with the WCAP.

WF3 Response 3.m.3:
The methods of WCAP-16406-P are being used with interpretations of the November 2007 draft of the SER to the WCAP and with interpretations described during the September 2007 PWROG/NEI training teleconference. Calculation 2005-12840, Revision 1 used more detailed methods where additional quantification of was required.

Section 5 of WCAP-16406-P describes a methodology for calculating debris depletion over time. The WCAP also provides values of depletion coefficients by way of example. The WCAP does not provide specific depletion coefficients. Based on flow rates, volumes and settling velocities at WF3, plant specific depletion coefficients were calculated. These depletion coefficients also credited filtration of particulates as well as fibers on the sump screen where such filtration is supported by plant specific testing.

WCAP-16406-P, Revision 1 provides information on size distribution and settling fraction of coatings. It states that qualified coatings fail as 10 micron particles. This is conservative for pressure drop calculations, but not for downstream calculations. The WF3 specific evaluation used a larger size particle based on vendor information about size of pigments in the coatings. This results in more calculated wear and is conservative. WCAP-16406-P assumes that unqualified coatings larger than 100 microns will settle. The WF3 calculation uses an empirical correlation for friction factor and benchmarks the resulting settling size against NRC-sponsored settling tests. Because the paint chips were all assumed to settle with the widest cross section perpendicular to the direction of settling, calculation showed a larger settling size for a given paint chip and settling velocity. This results in a conservative, benchmarked, plant-specific settling size for particulates.

A pump curve after wear is being calculated for each WF3 ECCS pump rather than utilizing WCAP Figure 8.1-3. The curve in the WCAP is based on a single stage pump with a particular specific speed and does not bound the calculated wear effect for multi-stage high head, low flow pumps like the High Pressure Safety Injection pump. The more conservative method is being used in 2005-12840, Revision 1. WCAP-16406-P recommends a minimum friction factor for maximizing the packing wear.

WCAP-16406-P, Revision 1, Appendix O, Section 2.3 recommends an assumed friction factor of 0.01 to maximize wear. During the performance of the calculation it was found that the rate of wear, measured as gap increase, would be maximum when the combination of parameters, friction factor times bearing length divided by clearance, was set equal to 2/3. Since this can be demonstrated mathematically it is no longer necessary to make an assumption about the friction factor in order to maximize the wear.

Entergy understands that Section 7.2 and 8.1.3 of the WCAP and the draft SER mean that if debris laden fluid is piped from the recirculation stream to flush a pump's seal then the primary seal would fail as a direct consequence of the postulated LOCA. That would constitute a common mode failure and all such pump seals would fail concurrently during the recirculation phase of the postulated LOCA. Conversely, if fluid from the recirculation stream is not piped to a pump's seal then there is no credible source of debris to fill the seal chamber and the primary pump seal is not assumed to fail as a direct consequence of the postulated LOCA. Such seals would still be subject to a postulated random failure of the pressure boundary as a moderate or high energy line break. The applicable requirements of SRP 15.6.5 as committed to in the USAR would remain applicable. For future reference, the leakage rate through pump seal one-half hour after a postulated primary seal failure is being calculated. The calculation will include the affects of wear on the components in the seals that would remain intact after a primary seal failure.

Rounding the inlet to an orifice in conjunction with increasing the orifice diameter decreases the flow resistance more than just increasing the diameter. In order to account for the effects of rounding the inlet of an orifice by debris, Section 8.4 of WCAP-16406-P, Revision 1 recommended a formula taken from the first edition of Idelchik's "Handbook of Hydraulic Resistance". The first edition, translated from Russian in the 1960's has been updated and the corresponding formula from the third edition of Idelchik's "Handbook of Hydraulic Resistance" is being used.

<u>WF3 Response 3.m.4:</u>
Those ECCS components and systems that are required to operate and pass debris laden fluid during the recirculation phase of recovery from a postulated LOCA have been identified. These ECCS components are in the process of being evaluated for blockage and wear from debris that would pass through the new containment sumps screens. The results of the analysis will be made available upon completion.

<u>WF3 Response 3.m.5:</u>
At this time no operational changes have been made nor have any been identified for WF3.

3.n Downstream Effects – Fuel and Vessel

<u>*NRC Issue 3.n*</u>

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 core cooling.

Show that the in-vessel effects evaluation is consistent with, or bounded by, the industry generic guidance (WCAP-16793), as modified by NRC comments on that document. Provide a basis for any exceptions.

<u>WF3 Response 3.n</u>

WF3 has contracted with Westinghouse Electric Company to perform the fuel and vessel analysis in accordance with industry guidance provided in WCAP-16793.

3.o Chemical Effects

<u>*NRC Issue 3.o*</u>

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

> *Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.*
>
> *Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425).*

<u>WF3 Response 3.o</u>

Chemical effects testing is still ongoing at this time. 30 day integrated chemical effects testing is being performed by Alion Science and Technologies. Results of the test when complete will be reviewed by GE and incorporated into the S0100 hydraulic design report (Reference 36).

3.p Licensing Basis

<u>*NRC Issue 3.p*</u>

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications. Provide the information requested in GL 04-02, "Requested Information," Item 2.(e) regarding changes to the plant licensing basis.

That is, provide a general description of and planned schedule for any changes to the plant licensing bases resulting from any analysis or plant modifications made to ensure compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

<u>WF3 Response 3.p</u>
Entergy does not plan to request any license basis changes in association with compliance to Generic Letter 2004-02. Major changes that have been made to the WF3 Licensing Basis to meet compliance with Gerneric Leter include modification to the Safety Injection Sump Strainer, relocation of the Trisodium Phosphate (TSP) Baskets and revision to the Safety Injection Sump NPSH parameters.

An Updated Final Safety analysis Report (UFSAR) change incorporating the above has been prepared under 10 CFR 50.59. Per Entergy letter W3F1-2007-0051 dated November 14, 2007 (Reference 55) and subsequent approved NRC letter to Waterford 3 dated December 10, 2007, (Reference 44) the WF3 licensing basis will be updated within 60 days of completion of refueling outage 15, which is currently scheduled for completion on May 24, 2008.

Open Items

OI.1 *The licensee should justify its assumption of a 2D zone of influence (ZOI) for the Waterford Unit 3 metal encapsulated insulation (MAI) fiberglass.*

OI.1 Response

The debris generation calculation (Reference 28) was revised to use a 4D ZOI for the MEI insulation instead of the 2D ZOI originally used. The justification for this is presented in Alion Report ALION-REP-ENTG-4771-02 (Reference 39). The design of the RMI and MEI insulation cassettes are comparable. The filler material in either one does not contribute to the strength of the insulation system. Therefore, the ZOI for the Transco MEI cassettes should be equal to the ZOI for Transco RMI (2D ZOI). However, to ensure conservatism, and since there is no specific destruction testing that has been performed for the MEI, a 4D ZOI is used for Transco MEI such as used in WF3.

OI.2 *The licensee should provide comprehensive documentation of the characteristics (macroscopic densities, microscopic densities, and characteristic debris sizes) of the actual plant debris at Waterford Unit 3 and compare these characteristics to the surrogate debris properties used for head loss testing, justifying any differences.*

OI.2 Response

This is addressed in section 3.h of this supplemental response.

OI.3 *The licensee should provide an analysis that shows that the coating debris test data credited by Waterford Unit 3 was generated using coating chips that are representative of or bounding with respect to the plant-specific failed coating chips.*

OI.3 Response

This is addressed in section 3.h of this supplemental response.

OI.4 *The licensee should (1) justify that the percentage of debris transporting along the containment floor from the east and west sides of containment is equal to the percentage of flow approaching the sump from the east and west sides of containment and (2) provide a clear definition of the starting points for debris transport paths to avoid contributing to an underestimation of debris transport on the side of containment opposite the break.*

OI.4 Response

The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.5 *The licensee should explain how it has addressed the following four deficiencies in the existing transport analysis for unqualified coating chips: (1) lack of adequate data to justify the assumed size distribution for failed coating chips, (2) improper application of* *settling data for coating chips with a 400-micron thickness to particle-like coating debris with a 400- micron diameter, (3) lack of justification of the use of an analysis intended for the vertical flow conditions typical of a reactor vessel core inlet plenum for the horizontal flow conditions in the Waterford Unit 3 containment pool, and (4) lack of consideration of the possibility that coating chips that fall into the containment pool in the vicinity of the sump may transport to the sump in suspension in the containment pool prior to settling on the containment floor.*

OI.5 Response

The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.6 The licensee should justify that the debris transport fractions in the transport calculation are representative of the replacement strainer configuration.

OI.6 Response

The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.7 The licensee should provide results of analysis of the potential effects of a low-pressure safety injection (LPSI) pump failure to stop on a recirculation actuation signal (RAS).

OI.7 Response

The WF3 NPSH analysis is currently being revised which will address this issue and results are not available at this time. As discussed in response section 3.g.7, a single LPSI pump is being assumed to operate for a 30 minute period post Recirculation Actuation Signal.

OI.8 The licensee should describe how it has implemented prototypically fine fibrous debris preparation in its head loss testing.

OI.8 Response

For follow-up thin-bed testing, fiber is being shredded five times in sequence, resulting in significantly reduced fibrous debris clump size that is more representative of small fines for thin-bed tests. Fiber sizes are generally small clumps of fiber or individual fibers which are representative of eroded fibers.

OI.9 The licensee should describe and justify how it has conducted adequate testing to determine thin bed peak head losses.

OI.9 Response

For follow-up design basis testing, the scope of tests was expanded so that the following fiber thicknesses are included in testing: 0.125, 0.25 inches, 0.5 inches, 0.75 inches, and

1 inch (gap-filled), to ensure that any localized peaks due to thin-bed effect would be discovered.

OI.10 *The licensee should provide the results of assessment of the potential for non-prototypical settling and non-prototypical bed formation due to debris agglomeration during partially stirred strainer testing.*

OI.10 Response
The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.11 *The licensee should describe and justify how it has resolved the potential for non-prototypical flows during module testing due to "solid modeled" trisodium phosphate(TSP) baskets located near the strainer modules.*

OI.11 Response
WF3 is in the process of performing six (6) new head loss tests with the baskets completely removed. These tests mirror the current installed condition of the SI Sump strainer system with the TSP baskets removed that were near the strainer modules.

OI.12 *The licensee should provide the results of evaluation of the potential for and effects of vapor flashing due to strainer head loss being greater than the strainer submergence.*

OI.12 Response
Follow-up design-basis testing is currently being performed by GE and results are not available at this time. This testing will result in a revised strainer head loss. Upon issuance of the GE S0100 report (Reference 44), WF3 will evaluate the potential for vapor flashing.

OI.13 *The licensee should explain how the following four additional water holdup mechanisms are modeled in the analysis of minimum containment pool water level: (1) water holdup due to condensation films, (2) water holdup due to spray droplet holdup in the containment atmosphere (as opposed to water vapor holdup in the containment atmosphere), and (3) refill of the reactor pressure vessel with colder and therefore denser water, and (4) the reactor water safety pool (RWSP) water temperature specified to be at the warmer normal operating containment temperature.*

OI.13 Response
The WF3 minimum water level analysis is currently being revised to address the identified items.

OI.14 *The licensee should justify treating unqualified coatings debris characteristics in the same manner as for qualified coatings.*

OI.14 Response

The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.15 The licensee should summarize how it has addressed the following aspects of structural analysis for the new strainer:

Part 1 - The licensee should revise the high-energy line break (HELB) report to provide definitive statements in the conclusions concerning pipe whip and missile impacts to the new strainer assembly and clarification of the bases for those conclusions.

Part 2 - The licensee should revise the sump strainer design specification to clearly identify the damping to be two percent.

Part 3 - The licensee should correct errors and discrepancies in the sump strainer design specification and stress analysis report.

Part 4 - The licensee should correct the temperature delta in the sump strainer stress analysis report.

Part 5 - The licensee should clarify the sump strainer acceleration values in the sump strainer stress analysis report.

Part 6 - The licensee should correct the values for E/E and κ in the sump strainer stress analysis report.*

Part 7 - The licensee should correct the whole strainer and plenum maximum deflection values in the stress analysis report.

Part 8 - The licensee should correct stress limits, safety factor values and certain units used for stress limits in certain tables of the sump strainer stress analysis report.

Part 9 - The licensee should address discrepancies identified in the hydrodynamic mass analysis.

OI.15 Response – Part 1

Section 3.5 of the UFSAR documents the evaluation of missiles inside and outside the WF3 RCB. Table 3.5-4 of the UFSAR contains a list of the potential missiles inside containment. None of these are located in an area where they could impact the new strainer assembly.

The closest potential high energy line breaks are located over 20 feet from the closest strainer. Therefore, there is no possibility of impacting the strainers with a whipping pipe.

The HELB report (GENE-0000-0048-9192) has been revised to provide definitive statements in the conclusions concerning pipe whip and missile impacts to the new strainer assembly.

OI.15 Response – Part 2
The curves in the specification have a designation on the lower right of the curve that states these are 2% damping.

OI.15 Response – Part 3
The sump strainer design specification, GE Design Specification 26A6870, and the stress analysis report, GENE-0000-0054-9349, have been revised to correct errors and discrepancies.

OI.15 Response – Part 4
The design specification (GE 26A6870) and the stress analysis report (GENE-0000-0054-9349) have both been revised to address the temperature delta in the sump strainer stress analysis report.

The questions pertaining to the temperature delta did not result in significant changes since the equipment is constructed of a single material, austenitic stainless steel. Therefore, there are no significant differential thermal expansions within the structure and no thermal stresses would be developed.

OI.15 Response – Part 5
The inertial acceleration values used in the analyses were extracted directly from the Design Envelope spectra contained in the design specification. However, the values reported in the stress report are the ANSYS input values adjusted to account for hydrodynamic mass and debris load to facilitate the ANSYS analyses. Since hydrodynamic mass and debris load are also reported in these same tables, the reader cannot ascertain what was actually used in the analysis. Therefore, the stress report (GENE-0000-0054-9349) was revised to reflect the seismic accelerations specified in the design specification.

OI.15 Response – Part 6
The values for E^*/E and κ in the revision of the stress analysis report reviewed by the staff during the NRC GSI-191 audit at W3 were incorrect. A review of the displacement numbers showed that the calculation E^*/E is 0.43 and $\kappa = 2.33$. Since the original values used were incorrect, the stresses were reevaluated with the new and correct values. All safety factors will remain above 1.0 even with the increased and correct values. These new and corrected values were included in the latest revision of the stress report, GENE-0000-0054-9349.

OI.15 Response – Part 7
The deflection results in the reviewed version of the stress report (GENE-0000-0054-9349) were provided to assist the review in understanding the behavior of the structure, and had no significance beyond that. The latest revision of the stress report (GENE-0000-0054-9349) corrected the labels.

OI.15 Response – Part 8

The errors in the stress report (GENE-0000-0054-9349) were revised in the latest revision of this stress report. There was no adverse impact on the structural adequacy conclusions.

<u>OI.15 Response – Part 9</u>
The discrepancies in the hydrodynamic mass analysis have been corrected. The corrections are in the latest revision to GE Report 26A7056 (Reference 56). There was no adverse impact on the structural adequacy conclusions.

OI.16 The licensee should summarize how it has evaluated the potential for holdup in the refueling cavity due to falling debris.

<u>OI.16 Response</u>
Calculation 2005-05500 (Reference 29) documents that the refueling cavity has two 6-inch drain lines (without screens) that drain to the containment floor, and by one 4-inch line that drains to the containment sump. In the event that large debris is propelled over the SG cavity walls into the refueling cavity, the debris must land on a drain in order to clog it since the velocities in the cavity are too low to transport a large piece of debris to a drain. During plant operations, the Upper Guide Structure Lift Rig (UGSLR) is stored directly above one of the 6" drains. The UGSLR will prevent any debris larger than 6" from falling directly on the drain. The diver stairs are located above the other 6" drain and are permanently mounted in the refueling cavity. These stairs will prevent any debris larger than 6" from falling directly onto the drain. Any smaller debris that transports to these two 6" drains will pass through the drains since they do not contain screens. Therefore, there will always be drainage available from the refueling cavity to the active pool.

OI.17 The licensee should provide the results of a similitude evaluation for WCAP-16406-P versus conditions at Waterford Unit 3.

<u>OI.17 Response</u>
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will contain a similitude evaluation to demonstrate its acceptability for use at WF3.

OI.18 The licensee should provide the assumptions, the bases for assumption and the source documents for its downstream evaluation of components and systems.

<u>OI.18 Response</u>
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will provide a basis for all assumptions and source documents.

OI.19 The licensee should provide clearly defined technical bases for the designated mission times for shutdown cooling (SDC), high pressure injection (HPI) and containment spray (CS).

OI.19 Response

A review of the WF3 UFSAR, specifically Table 15.6-18, indicates that the analyzed mission time for a LOCA event is 30 days. During the 30 day mission time two trains of High Pressure Safety injection and Containment Spray are conservatively assumed to operate continuously.

OI.20 The licensee should develop and justify conservative, bounding values for system lineups, fluid flows and system pressures for the downstream effects components and systems analysis.

OI.20 Response

The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will utilize conservative bounding values for lineups, fluid flows, and system pressures.

OI.21 The licensee should justify the use of design curves, or re-analyze for degraded, actual or modified pump curves for the downstream effects components and systems analysis.

OI.21 Response

The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will contain degraded pump curves. These degraded curves will be compared to performance curves used in LOCA response analysis to ensure that the LOCA response analysis remains conservative.

OI.22 The licensee should provide the results of analysis of emergency core cooling system (ECCS) air entrainment (apart from vortexing) and the potential for waterhammer and slug flow.

OI.22 Response

The WF3 ECCS is designed as a water solid system. Post refueling outage, ultrasonic testing is performed at potential void formation point in the ECCS system. If a void is found, the system is flushed eliminating the void. The system is check multiple times to verify that all voids are eliminated. Various waterhammer analyses have been performed on the ECCS system throughout the life of the plant. The modifications done to date for WF3 do not affect any existing analysis nor create the potential for new waterhammer events.

OI.23 The licensee should re-calculate downstream component wear due to strainer bypass debris and provide the results.

OI.23 Response

The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will utilize a conservative debris distribution based on plant specific debris analysis.

OI.24 The licensee should re-perform its high-pressure safety injection (HPSI) recirculation throttle valve clogging analysis considering the full range of possible recirculation throttle valve positions or failure of the HPSI recirculation throttle valve to open to its pre-set position, and provide the results.

OI.24 Response
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis analyzes the valves at the flow balanced position. The valves open on receipt of a safety injection actuation signal to an electrical stop. Operations verify proper flow balance and adjust the valves as necessary to ensure a balanced flow. This is performed prior to Recirculation Actuation Signal and exposure to debris latent fluid.

OI.25 The licensee should describe how it has incorporated actions of its operational procedures into the downstream effects evaluation.

OI.25 Response
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis when complete will evaluate the ECCS and CS systems in all configurations as defined by operational procedures. The WF3 operational procedures do not require the securing of HPSI or CS pump at any time, therefore these pumps are analyzed to operate for a full 30 day mission time. At 1-2 hours post RAS, the ECCS system switches from cold leg only injection to simultaneous cold and hot leg injection. Both configurations are being considered and addressed in the downstream analysis. Conservative flows are being used for all components such to bound any possible operating flow.

OI.26 The licensee should justify emergency core cooling system (ECCS) pump wear rings to be "good as new," or determine a more conservative condition for these rings.

OI.26 Response
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The analysis conservatively assumes pre-LOCA running clearances are at the upper limits of the acceptable range. The analysis also takes into account pre-LOCA operational degradation based on operability test data.

OI.27 The licensee should provide the results of evaluation of high-pressure safety injection (HPSI) pump stage-to-stage degradation and its effect on pump hydraulic performance, and should provide the results of a pump vibration and rotor dynamics evaluation.

OI.27 Response
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. The revised analysis will contain an evaluation of the

HPSI pumps stage-to-stage degradation and its effect on pump hydraulic performance. The analysis also will address pump vibration and rotor dynamics.

OI.28 The licensee should summarize its evaluation of ECCS and CS pump leakage effects in its Safeguards Room.

OI.28 Response
WF3 currently has no analysis for dose consideration in the Safeguards rooms. Control Room dose analysis assumes a 0.5 gpm total leakage from all Engineered Safety Feature pumps. The need for additional evaluation will be addressed upon completion of the downstream effects analysis for the pumps.

OI.29 The licensee should summarize how it has determined the effects of settled material at emergency core cooling system (ECCS) low points and integrate these effects into the downstream effects evaluation.

OI.29 Response
The response to this open item will be provided in the final supplemental response within completion of GL 2004-02 actions per the WF3 extension request approved by reference 44.

OI.30 The licensee should consider the results of the various component wear evaluations and perform an overall system flow evaluation, and should provide a summary of the results.

OI.30 Response
The WF3 downstream effect analysis is currently being revised to meet the requirements of WCAP-16406-P Revision 1. Upon completion of the analysis, the results will be reviewed to determine effect on overall system flow.

OI.31 The licensee should provide the results of an analysis of downstream effects of post-LOCA debris and chemicals on the fuel and vessel.

OI.31 Response
WF3 has contracted with Westinghouse Electric Company to perform the fuel and vessel analysis in accordance with industry guidance provided in WCAP-16793.

OI.32 *The licensee should provide the results of resolution of chemical effects at Waterford Unit 3.*

<u>OI.32 Response</u>
Chemical effects testing is still ongoing at this time. 30 day integrated chemical effects testing is being performed by Alion Science and Technologies. Results of the test when complete will be reviewed by GE and incorporated into the S0100 hydraulic design report (Reference 36). WF3 has received an extension to complete the testing and analysis by the end of the WF3 RF15 outage as documented in Reference 44.

References

1. NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents for Pressurized-Water Reactors," dated September 13, 2004.

2. Nuclear Energy Institute (NEI) document NEI 04-07 Revision 0, December 2004, "Pressurized Water Reactor Sump Performance Evaluation Methodology."

3. Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), "Pressurized Water Reactor Sump Performance Evaluation Methodology," Issued December 6, 2004.

4. Regulatory Guide 1.82, "Water Sources for Long Term Recirculation Cooling Following a Loss of Coolant Accident," Revision 3, November 2003.

5. NUREG-0800, "U.S. Nuclear Regulatory Commission Standard Review Plan," Section 3.6.2, "Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," Revision 1, July 1981.

6. NUREG/CR-2791, "Methodology for Evaluation of Insulation Debris Effects, Containment Emergency Sump Performance Unresolved Safety Issue A-43," Issued September 1982.

7. NUREG/CR-3616, "Transport and Screen Blockage Characteristics of Reflective Metallic Insulation Materials," January 1984.

8. NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris, Final Report," Issued October 1995.

9. NUREG/CR-6369, "Drywell Debris Transport Study, Final Report," Volume 1, Issued September 1999.

10. NUREG/CR-6369, "Drywell Debris Transport Study: Experimental Work, Final Report," Volume 2, Issued September 1999.

11. NUREG/CR-6369, "Drywell Debris Transport Study: Computational Work, Final Report," Volume 3, Issued September 1999.

12. NUREG/CR-6762, Volume 1, "GSI-191 Technical Assessment: Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance," Issued August 2002.

13. NUREG/CR-6762, Volume 2, "GSI-191 Technical Assessment: Summary and Analysis of U.S. Pressurized Water Reactor Industry Survey Responses and Responses to GL 97-04," Issued August 2002.

14. NUREG/CR-6762, Volume 3, "GSI-191 Technical Assessment: Development of Debris Generation Quantities in Support of the Parametric Evaluation," Issued August 2002.

15. NUREG/CR-6762, Volume 4, "GSI-191 Technical Assessment: Development of Debris Transport Fractions in Support of the Parametric Evaluation," Issued August 2002.

16. NUREG/CR-6772, "GSI-191: Separate Effects Characterization of Debris Transport in Water," Issued August 2002.

17. NUREG/CR-6773, "GSI-191: Integrated Debris-Transport Tests in Water Using Simulated Containment Floor Geometries," Issued December 2002.

18. NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance," Issued February 2003.

19. NUREG/CR-6916, "Hydraulic Transport of Coating Debris, A Subtask of GSI-191," Issued December 2006.

20. Nuclear Energy Institute (NEI) Document 02-01, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments," Revision 1.

21. Not used.

22. WCAP-16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified / Acceptable Coatings," Revision 0.

23. C.D.I. Report 96-06, "Air Jet Impact Testing of Fibrous and Reflective Metallic Insulation," Revision A, included in Volume 3 of General Electric Document NEDO-32686-A, "Utility Resolution Guide for ECCS Suction Strainer Blockage."

24. Not used.

25. Alion Document No: ALION-REP-TXU-4464-02, Titled: TXU Paint Chip Characterization, Rev. 0.

26. Letter # TXX-07156 from Mike Blevins, Luminant Generation Company LLC, to the U.S. Nuclear Regulatory Commission, dated November 8, 2007.

27. Letter from Jon R. Cavallo, Vice President of Corrosion Control Consultants and Labs Inc. to Charles Feist, dated September 20, 2007.

28. Calculation 2004-07780, "Debris Generation Due to LOCA within Containment for Resolution of GL GSI-191," Revision 3.

29. Calculation 2005-05500, "Post-LOCA Debris Transport, Head Loss Across Safety Injection Sump Screen, and NPSH Evaluation for Resolution of GSI-191," Revision 2.

30. ER-W3-2003-0394-001, "Safety Injection Sump Modification."

31. Calculation 2005-02820, "GSI-191 Downstream Effects - Flow Clearances," Revision 0, dated August 18, 2005.

32. Calculation 2005-12840, "Evaluation of Downstream Components for Long Term Performance for Resolution of GSI-191."

33. Head Loss Testing of Waterford Unit 3 Safety injection Sump Strainers, 26A6833, Rev 8.

34. S0105 Task Design Input Request (DIR) Rev 5, DRF Object 0000-0079-0092.

35. Hydraulic Sizing and Head Loss Prediction for Suction Strainers (PWRs), TDP-0186.

36. Safety Injection Pump Passive ECCS Strainer System S0100 Hydraulic Sizing Report, Waterford Unit 3 Nuclear Power Plant, Document No. GE-NE-0000-0053-4416-P-R3.

37. WF3 Calculation MNQ6-4, "Water Levels Inside Containment."

38. WCAP-16710-P, Rev. 0, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON Insulation for Wolf Creek and Callaway Nuclear Operating Plants."

39. ALION-REP-ENTG-4771-02, Rev. 0, "Waterford 3 Metal Encapsulated Fiberglass Insulation ZOI and Size Distribution Report".

40. WF3 Calculation ECM89-083, Rev. 1, "Verification of Gaps at Whip Restraint U-Bolt for Min-K Insulation Required per CI258220, 265936, 266235, and 266371."

41. ALION-REP-ENT-4536-02, Rev. 0, "Waterford Unit 3 Low Density Fiberglass Debris Erosion Testing Report."

42. WF3 Procedure NOECP-451, Rev. 1, "Conducting Engineering Inspection of Reactor Containment Building Protective Coatings."

43. WF3 Specification 1564.734, Rev. 19, "General Protective Coating for Nuclear Power Plant."

44. NRC Letter from N. Kalyanam to K. Walsh, 12/10/07, "Waterford Steam Electric Station, Unit 3 – Approval of Extension Request for Corrective Actions Re Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency

Recirculation During Design Basis Accidents at Pressurized Water Reactors". (WF3 document # ILN07-0116).

45. WF3 Procedure OP-903-027, "Inspection of Containment."

46. WF3 Procedure PMC-002-007, "Maintenance and Construction Painting."

47. WF3 Procedure UNT-007-006, "Housekeeping."

48. WF3 Procedure W4.202, "System and Component Labeling."

49. WF3 Procedure EN-MA-118, "Foreign Material Exclusion."

50. WCAP-16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified / Acceptable Coatings."

51. WF3 Calculation ECM07-001, "NPSH Analysis of Safety Injection and Containment Spray Pumps."

52. Regulatory Guide 1.1, "Net Positive Suction Head For Emergency Core Cooling and Containment Heat Removal System Pumps."

53. WCAP-16785-NP, "Evaluation of Additional Inputs to the WCAP-16530-NP Chemical Model."

54. WCAP-16406-P, Rev. 1, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191."

55. Waterford 3 Letter W3F1-2007-0051, November 14, 2007, "Request for Extension of Completion Date for Corrective Action Required by GL 2004-02."

56. GE Report 26A7056, Waterford 3 Safety Injection Sump Strainer, Plenum, and Sensor Stress Report.

57. NRC Letter from N. Kalyanam to K. Walsh, 1/28/08, "WATERFORD STEAM ELECTRIC STATION, UNIT 3 - REPORT ON RESULTS OF STAFF AUDIT OF CORRECTIVE ACTIONS TO ADDRESS GENERIC LETTER 2004-02" (Waterford 3 Document ILN08-0015).

Attachment 3

W3F1-2008-0018

Affidavit

GE Hitachi Nuclear Energy Americas LLC

AFFIDAVIT

I, Tim E. Abney, state as follows:

(1) I am Vice President, Services Licensing, Regulatory Affairs, GE-Hitachi Nuclear Energy Americas LLC ("GEH"), have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosure 1 of GEH's letter, JB08-JXDYR-001, J. Betsill to G. Scott, entitled " GEH Proprietary Mark-ups of Draft Entergy Letter W3F1-2008-0018", dated February 22, 2008. GEH proprietary information in Enclosure 1, which is entitled "GEH Proprietary Mark-ups of Draft Entergy Letter W3F1-2008-0018", is identified by a dotted underline inside double square brackets. [[This sentence is an example.{3}]]. In each case, the superscript notation {3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner or licensee, GEH relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.390(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by GEH's competitors without license from GEH constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future GEH customer-funded development plans and programs, resulting in potential products to GEH;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a. and (4)b. above.

(5) To address 10 CFR 2.390(b)(4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GEH, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GEH, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge, or subject to the terms under which it was licensed to GEH. Access to such documents within GEH is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist, or other equivalent authority for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GEH are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed results of analytical model and method, as well as testing methods, applied to perform evaluations of emergency core cooling system and containment sprays strainers in Boiling Water Reactors ("BWR") and Pressurized Water Reactors. The development and approval of these models and methods was achieved at a significant cost to GEH, on the order of several million dollars.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GEH asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GEH's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GEH's comprehensive safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GEH.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GEH's competitive advantage will be lost if its competitors are able to use the results of the GEH experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GEH would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GEH of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing and obtaining these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 22nd day of February 2008.

Tim E. Abney
GE-Hitachi Nuclear Energy Americas LLC

Attachment 4

W3F1-2008-0018

List of Regulatory Commitments

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check One) ONE-TIME ACTION	CONTINUING COMPLIANCE	SCHEDULED COMPLETION DATE (If Required)
A complete supplemental response will be provided to the NRC per the NRC extension granted to W3 on December 10, 2007. And per the Revised Content Guide, the remaining information (final supplemental response) will be provided to the NRC within 90 days of completion of all actions needed to address GL 2004-02.		x	90 days after completion of RF15 (Mode 1).
The strainer head-loss testing and analyses will be completed by the end of Waterford 3 spring 2008 refueling outage.		x	End of RF 15 (Mode 1).
Entergy will update its licensing basis to reflect resolution of Waterford 3 GSI-191 issues within 60 days of completion of the Waterford 3 RF15.		x	60 days after the completion of RF 15 (Mode 1).