Calvert Cliffs GSI-191 Program

Summary of Risk-Informed Results and Plans for LAR Submittal

May 21, 2018

Exelon Generation.

CCNPP Attendees

- Jeff Chizever – Senior Manager Design Engineering
- Chris Junge – M&CU Engineering Manager
- Andre Drake – Lead Responsible Engineer GSI-191
- Enrique (Rick) Villar – Corporate Licensing
- Ken Greene – Site Regulatory Assurance
- Craig Sellers – Project Manager GSI-191
- Eric Federline – Project Support
- Tim Sande – Project Support/Engineer of Choice (via telephone)

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Agenda

- Introductions
- Objectives for Meeting
  - Present Summary of Risk-Informed Results
  - Discuss Plans for LAR Submittal
  - Discuss Initial Staff Technical Questions
    - Address these questions in submittal
    - Potentially avoid one round of RAIs
- Staff Questions & Concerns

Summary of CCNPP Risk-Informed Approach

- The Calvert Cliffs simplified risk informed approach involves the following steps:

1. Determine the maximum allowable head loss for the strainer.
   This must consider NPSH, deaeration, and structural requirements.

2. Identify acceptable strainer chemical effects head loss tests.
   The quantity of fine fiber, particulate, and WCAP-16530 surrogate precipitate used in the tests, and the clean screen head loss, conventional (non-chemical) head loss, and chemical head loss become the criteria for identifying LOCA breaks that satisfy deterministic qualification methods and those breaks that must be addressed through risk analysis.

3. Perform a BADGER debris generation calculation to determine the quantity of insulation, fire barrier, and radiation shielding jacket debris generated by breaks in all class 1 welds upstream of normally closed valves.

4. Perform NARWHAL analysis to determine the particulate, calculate chemical precipitate debris quantities and time-dependent accumulation of debris on the strainer and compare against the strainer acceptance criteria to determine which breaks pass and fail.

5. Assume 100% of the debris dislodged from targets is transported to the containment post-LOCA pool to maximize contribution to chemical effects.

Summary of CCNPP Risk-Informed Approach (continued)

6. Assume 100% of the particulate debris, chemical precipitate, and fine fiber debris, including those fine fibers produced through erosion of small and large pieces of fibrous debris, is transported to the strainer to contribute to strainer head loss.

7. Identify breaks at welds that produce strainer head loss that exceeds the allowable head loss for each break. This defines the *Critical Break Size*. The head loss for each break scenario is compared to the allowable head loss criteria established in Step 1.
   a. Break scenarios producing strainer head loss less than allowable satisfy strainer performance criteria using NRC-accepted analysis methods and do not contribute to an increase in CDF or LERF.
   b. Critical Breaks producing more head loss than allowable are assumed to threaten strainer performance and must be evaluated for impact on CDF and LERF.

Summary of CCNPP Risk-Informed Approach (continued)

8. Evaluate the risk contribution of Critical Breaks against the Regulatory Guide 1.174 qualitative criteria for CDF, ΔCDF, LERF, and ΔLERF.
   a) CDF and LERF are taken from the Calvert Cliffs PRA Model of Record.
   b) ΔCDF is determined from the LOCA exceedance frequency for the Critical Break size from NUREG-1829 and the strainer conditional failure probability (CFP) calculated using NARWHAL.
      i. The NUREG-1829 LOCA frequency is apportioned across all welds equal to or greater than the smallest Critical Break size within the NUREG-1829 LOCA Category.
         a. Plant-wide LOCA frequencies are based on the break frequencies in NUREG-1829 with log-linear interpolation for intermediate break sizes.
         b. The frequency for a given break size is allocated to individual welds (that can experience a break of that size).
      ii. PRA model LOCA categories (e.g., very large breaks) are broken up into size ranges to more accurately calculate the overall CFP for the LOCA category. Smaller breaks within the size range are assumed to have the same probability as larger breaks within the size range.
      iii. The CFP for a PRA LOCA category can be approximated by dividing the number of welds in the LOCA category that threaten strainer performance by the total number of welds analyzed in the LOCA category. NARWHAL performs a much more comprehensive calculation for CFP.
      iv. ΔCDF is defined as the product of the CFP and the LOCA exceedance frequency for the Critical Break size.
   c) ΔLERF is determined by obtaining a CDF multiplier from the Calvert Cliffs LERF model that is bounded by a worst case accident sequence for the Critical Break scenarios.
   d) Compare CDF, ΔCDF, LERF, and ΔLERF results against Regulatory Guide 1.174 criteria for Region III.
   e) Verify other requirements (for example, safety margin, defense in depth) of Regulatory Guide 1.174 are met.

9. If all requirements are met, the simplified risk informed approach is complete and the results are acceptable.

Scope

- Calvert Cliffs performed a systematic risk assessment considering all accident sequences leading to a demand for recirculation.
  - This includes the entire spectrum of LOCAs, RCP seal LOCA, secondary system high energy line breaks, and accident sequences leading to once-through-core-cooling (feed & bleed).

- Screened Plant Operating Modes
  - MODE 3 with pressurizer pressure < 1750 psia and MODE 4 LOCAs have been screened because these lower pressure plant conditions do not support generation or transport of large quantities of debris. MODE 5 and MODE 6 were also screened because LOCAs capable of generating debris are not considered in these low pressure modes.

- Breaks Downstream of Normally Closed Valves
  - The probability for welds downstream of normally closed valves to rupture resulting in a jet generating debris and resulting in recirculation is at least 10^{-3} less than welds upstream of the valves.

- Secondary System Breaks
  - Secondary system breaks were evaluated and screened due to the insignificant increase in risk estimated through a conservative and bounding evaluation considering breaks down to 1” in diameter.
    - ΔCDF = 5.97×10^{-8}
    - ΔLERF = 5.04×10^{-9}

- Non-Piping LOCA initiators
  - SG Manway Covers, Valves, Reactor Head Penetrations
    - In same vicinity of piping welds but significantly smaller diameter

Scenario Development

- Plant Operating Modes
  - Calvert Cliffs is a two train plant with a single emergency recirculation suction strainer.
  - The risk assessment considered plant operating modes 1, 2, and MODE 3 with pressurizer pressure ≥ 1750 psia.
  - With a single strainer, two train operation is the limiting operating scenario as it maximizes the recirculation flow rate, debris transport to the strainer, and debris bed head loss.

- Long-Term Period of Performance
  - A 30-day mission time was considered for all breaks evaluated.
  - The long-term period of performance is until after the containment atmospheric temperature reduces to 120°F, which is the temperature at which containment spray is terminated and recirculation flow rate is significantly reduced.
  - A safe and stable end state is one in which strainer head loss remains within allowable head loss.

- Human Actions Credited
  - Securing both low pressure safety injection (LPSI) pumps prior to recirculation actuation signal (RAS).
  - Throttling HPSI pump flow to achieve balanced flow of 250 gpm per header.
  - Securing one CS pump when containment pressure reduces to 4.0 psig after RAS.

- Assumptions and Considerations
  - As discussed above

Failure Mode Identification

- The Calvert Cliffs simplified risk informed approach considered the following debris-related failure modes:
  - Excessive head loss at the strainer leads to loss of net positive suction head (NPSH) margin for adequate operation of the pumps;
  - Excessive head loss at the strainer causes mechanical collapse of the strainer;
  - Excessive head loss at the strainer lowers the fluid pressure, causing release of dissolved gases (i.e., deaeration); and
  - Debris prevents adequate flow to the strainer or prevents the strainer from attaining adequate submergence.

- The Calvert Cliffs risk informed approach did not consider the following debris-related failure modes:
  - Debris in the system downstream of the strainer exceeds ex-vessel limits (e.g., blocks small passages in downstream components or causes excessive wear);
  - Debris results in core blockage and decay heat is not adequately removed from the fuel; and
  - Debris buildup on cladding results in inadequate decay heat removal.
  - Downstream effects failure modes are addressed using existing NRC-accepted methodologies.

Debris Source Term

- Calvert Cliffs prepared multiple calculations to determine the debris source term. The types of debris include the following:
  - Fibrous Debris: Nukon, Thermal Wrap, Mineral Wool, Temp-Mat, lead wool shielding blanket cover, and latent fiber.
  - Particulate Debris: Marinite Board, calcium silicate, failed coatings, latent dirt and dust.
  - Chemical Debris: Sodium Aluminum Silicate precipitate.

- The debris quantities and characteristics were determined using NRC-accepted methodologies.

Debris Transport

- Calvert Cliffs assumed 100% of the debris that was dislodged from a target transported to the containment pool.
  – This maximized the production of chemical precipitates.

- Calvert Cliffs also assumed 100% transport of fine fibers, particulate, and precipitate debris to the strainer. In conjunction with this we assumed 0% transport of small and large pieces of fiber to the strainer.
  – This maximized strainer head loss which was the performance acceptance criteria for the analysis.
  – Small and large pieces reduce strainer head loss based in plant-specific testing.

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Impact of Debris

- Maximum Allowable Head Loss
  - The maximum allowable strainer head loss was determined using existing NRC-accepted methodologies.
  - Deaeration is identified as the limiting failure mode for the Calvert Cliffs strainer.
    - Incipient deaeration occurs at the downstream face of the strainer when debris bed head loss exceeds strainer submergence.
  - Strainer submergence is dependent on LOCA size and break location.
    - Smaller LOCAs have less water injected because the Safety Injection Tanks do not inject
    - The break location for less than complete double-ended guillotine breaks (DEGBs) and equivalent size breaks on longitudinal welds in the primary RCS loops can retain more water inside the reactor coolant system.
  - A minimum sump water temperature of 120°F is appropriate.
    - Lower sump water temperatures result in lower water level due to the increased fluid density and decreased volume.
    - The Calvert Cliffs containment response analyses demonstrate that in the long-term cooling phase the containment vapor temperature remains lower than the sump water temperature at sump temperatures below 120°F.
    - Containment spray is terminated at a vapor temperature of 120°F and the strainer head loss due to only HPSI pump flow is negligible
- Maximum Allowable Head Loss:

Break Size	Sump Water Temperature (°F)	Maximum Allowable Head Loss (feet)
1) DEGB of Hot Leg/Cold Leg or Equivalent Size Longitudinal Breaks	$120 < T_{sump} \leq 140$	2.21
	$140 < T_{sump} \leq 220$	2.09
2) Other Break Sizes > 0.08 ft²	$120 < T_{sump} \leq 140$	1.89
	$140 < T_{sump} < 220$	1.77
3) Break Sizes ≤ 0.08 ft²	$120 < T_{sump} \leq 140$	1.47
	$140 < T_{sump} \leq 220$	1.35

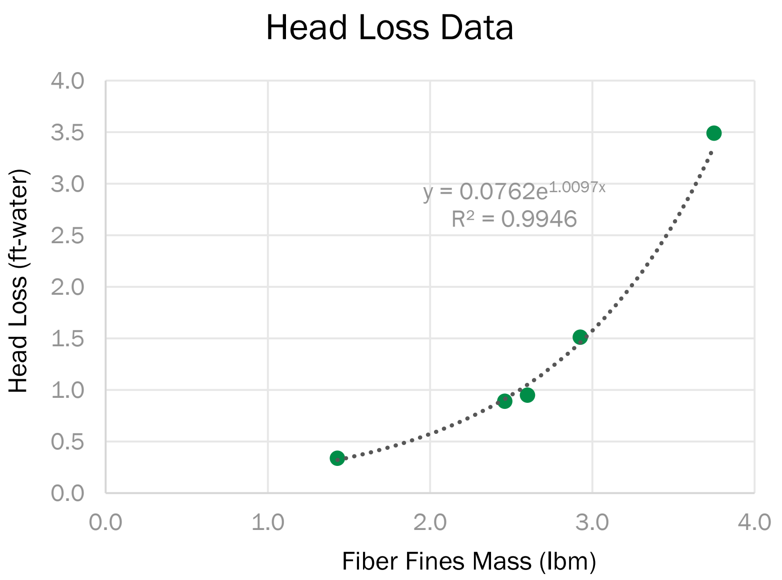
Impact of Debris (continued)

- Acceptable Head Loss Tests
  - Five Acceptable Tests from 2010 Test for Success Campaign

Test #	Mass of Fiber Fines (lbm)	Debris Bed Head Loss (ft-water)	
		Clean Screen	Debris Bed Maximum
2	1.429	0.288	0.34
3	3.750	0.288	3.49
4	2.460	0.288	0.89
5	2.926	0.288	1.51
7	2.599	0.288	0.95

- Total Head Loss plotted as function of mass of fine fiber shows head loss is a direct function of fiber mass

- Calvert Cliffs does not use a head loss correlation in the analysis of strainer performance



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Impact of Debris (continued)

- BADGER Debris Generation Calculation
  - Computed the quantity of fibrous, particulate, and metal insulation, fire barrier, and lead shielding blanket debris produced by high energy line breaks at each class 1 weld using existing NRC-accepted methodologies.
  - Produced debris source terms for more than 17,500 breaks.
  - Included latent debris.
  - Did not include coatings, chemical precipitate, or tags & label debris
- NARWHAL Calculation
  - NARWHAL uses the debris results from the BADGER calculation,
  - Adds to these qualified and unqualified coatings debris, and
  - Determines break-specific fibrous and particulate debris loads.
  - NARWHAL model uses 100% debris transport to the pool for debris dislodged from targets and calculates break-specific WCAP-16530 chemical precipitate quantities.
  - These analyses are performed in accordance with existing NRC-accepted methodologies.

Impact of Debris (continued)

- Strainer Head Loss Acceptance Criteria
  - NARWHAL determines a strainer head loss for each break based on the fiber fines, particulate, and chemical precipitate quantities for each break location and the results of Calvert Cliffs strainer head loss testing.

  - NARWHAL compares the break-specific head loss values to the allowable head loss acceptance criteria for each break.
    - Head Loss Acceptance Criteria include:
      - Strainer Structural Margin
      - Pump NPSH Margin
      - Strainer Gas Void Fraction

  - Weld locations that produce higher head loss than allowable are classified as potential threats to strainer performance and are assumed to lead to core damage and possibly large early release.

- Critical Break Size
  - The smallest break size that generates higher head loss than allowable defines the *Critical Break Size.*

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Impact of Debris (continued)

- NARWHAL Head Loss Look-Up Tables
  - Sorted by increasing head loss.
    - When any debris criteria in a row is exceeded, NARWHAL moves down to the next row to select the head loss value.
    - For example, if a break produces 734 lb_m of fiber fines, 11.18 ft^3 of particulate, and 54.1 lb_m of precipitate, NARWHAL will report a conventional head loss value of 0.058 ft-water and a chemical head loss value of 1.74 ft-water.
  - Conventional Head Loss

Test	Total Fiber Fines (lb_m)	Total Particulate (ft^3)	Conventional Head Loss (in)	Conventional Head Loss (ft)
2	403	11.18	0.4	0.03
7	734	8.887	0.57	0.048
4	695	9.076	0.61	0.051
5	826	11.38	0.69	0.058
3	1058.6	11.18	1.0	0.08

  - Chemical Head Loss

Test	Fiber Fines (lb_m)	Particulate (ft^3)	SAS (lb_m)	Chemical Head Loss (in)	Chemical Head Loss (ft)
3*	1058.6	11.18	0	0	0
2	403	11.18	59.70	0.6	0.05
7	695	9.076	47.90	11.3	0.842
4	734	8.877	56.60	10.1	0.942
5	826	11.38	54.10	20.9	1.74
3	1058.6	11.18	59.70	55.3	4.61

  - Clean Screen Head Loss
    - 0.288 ft per vendor calculation, included cartridges, axial flow channel, and radial plenum

Impact of Debris (continued)

- NARWHAL Error
  - NARWHAL was found to have an error that resulted in an incorrect interpretation of the chemical head loss look-up table
  - Identified an alternate approach that provides conservative results
  - Alternate approach for chemical head loss look-up table

Test	SAS (lb_m)	Fiber Fines (lb_m)	Particulate (ft^3)	Chemical Head Loss (in)	Chemical Head Loss (ft)
3*	0	1058.6	11.18	0	0
2	47.9 ~~59.70~~	403	11.18	0.6	0.05
7	47.90	695	9.076	11.3	0.842
4	54.1 ~~56.60~~	734	8.877	10.1	0.942
5	54.10	826	11.38	20.9	1.74
3	59.70	1058.6	11.18	55.3	4.61

  - SAS values must be in first column and in ascending order
  - Impact of alternate approach
    - Six (6) 24” partial breaks in 30” and 42” RCS legs fail
    - Manual review of results data shows these breaks do not fail strainer
  - Error will be corrected and results updated prior to implementation of license amendment

Results

- A total of 13,894 breaks in 394 welds analyzed
- 266 breaks in 79 welds result in strainer head loss that exceeds acceptance criteria.
- Critical Break Size is 24” in the following lines:
  - 42-RC-11-3
  - 30-RC-12A-5
  - 30-RC-12B-7
  - 30-RC-12B-8

- This is based on NARWHAL analysis with error & alternate approach.
- Manual analysis of results shows these 24” breaks do not threaten strainer performance.
- Critical Break size becomes 28” partial break in 30” and 42” RCS legs.

ΔCDF

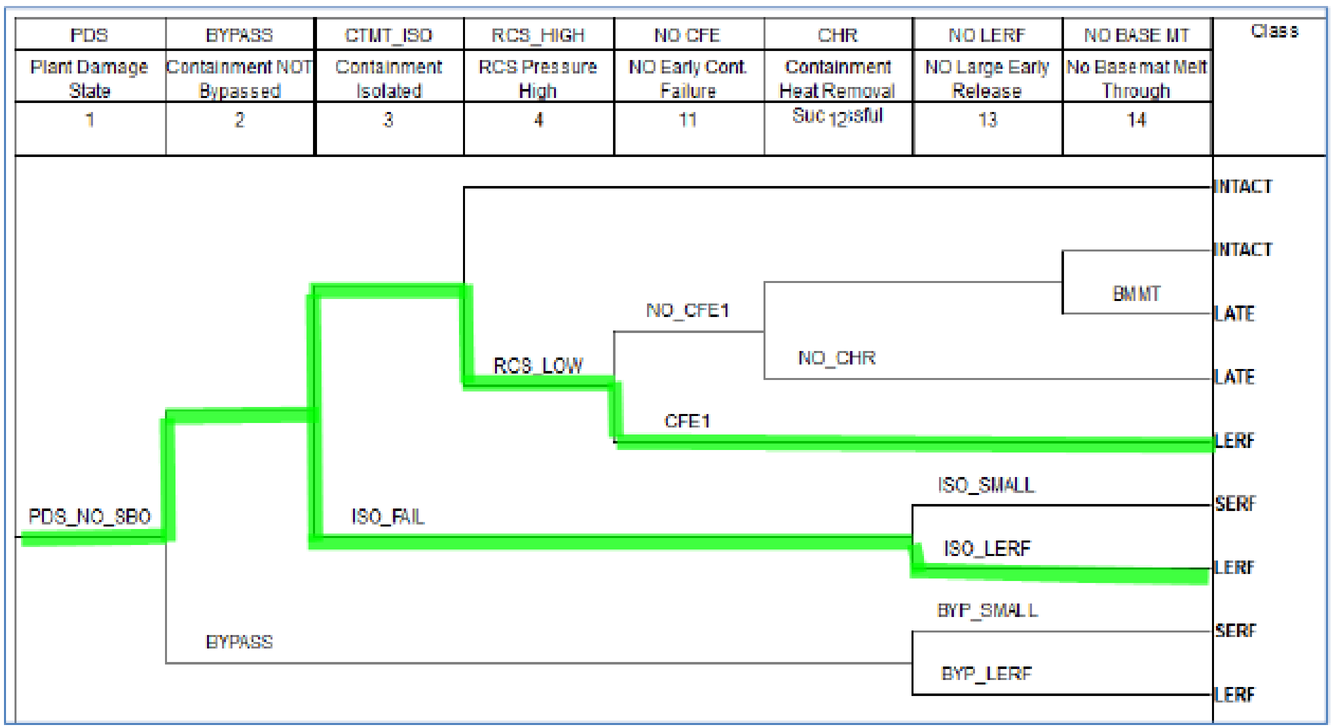
- ΔCDF as calculated in NARWHAL
  - $\Delta CDF = \sum_{i=0}^{i=N} \sum_{j=0}^{j=x} IEF_i \times CPF_{ij} \times FFPj$
  - Where:
    - i = Each PRA size category
    - j = Each equipment configuration
    - IEF = Initiating event frequency for each size category
    - CFP = Conditional failure probability for each PRA size category and each equipment configuration
    - FFP = Functional failure probability for each equipment configuration

- Calvert Cliffs has only one bounding equipment configuration and only very large LOCAs threaten strainer performance
  - Therefore the ΔCDF equation reduces to *ΔCDF = IEF X CFP*
  - Where:
    - IEF = Initiating Event Frequency for very large LOCA (from NUREG-1829)
    - CFP = Very large LOCA conditional failure probability (calculated in NARWHAL)

- Conditional Failure Probability (CFP) = 0.0471
- NUREG-1829 LOCA Frequency for >14" = 4.8E-07/yr
- ΔCDF = 0.0471 * 4.8E-07/yr = 2.26E-08/yr

ΔLERF

- ΔLERF is determined by obtaining a CDF multiplier from the Calvert Cliffs LERF model that is bounded by a worst case accident sequence for the Critical Break Size.
- Only very large LOCA events threaten strainer performance.
- Therefore, ΔLERF can be reasonably estimated by summing the frequency of containment failure and containment isolation failure due to very large LOCA (VLLOCA).
- A simplified Level 2 event tree, showing only the branches discussed for this analysis is shown below.



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ΔLERF (continued)

- Starting from the left, the first top event is "BYPASS" for "Containment NOT Bypassed." When the containment is bypassed, the recirculation mode is not questioned, as the RCS inventory is assumed to exit the containment and CDF and LERF events occur regardless of the status of the containment emergency recirculation sump strainer performance. Therefore, the upper branch (i.e. not BYPASS) is selected.

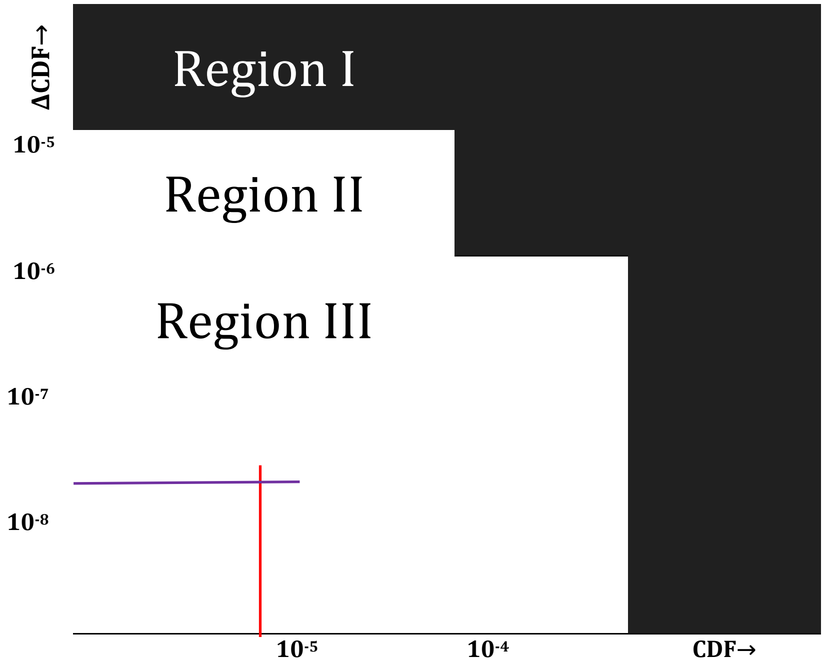
- The next top event is "CTMT_ISO" for Containment Isolated. This event branch is considered for the GSI-191 CDF-to-LERF multiplier. LERF sequences are identified by branch "ISO_LERF."

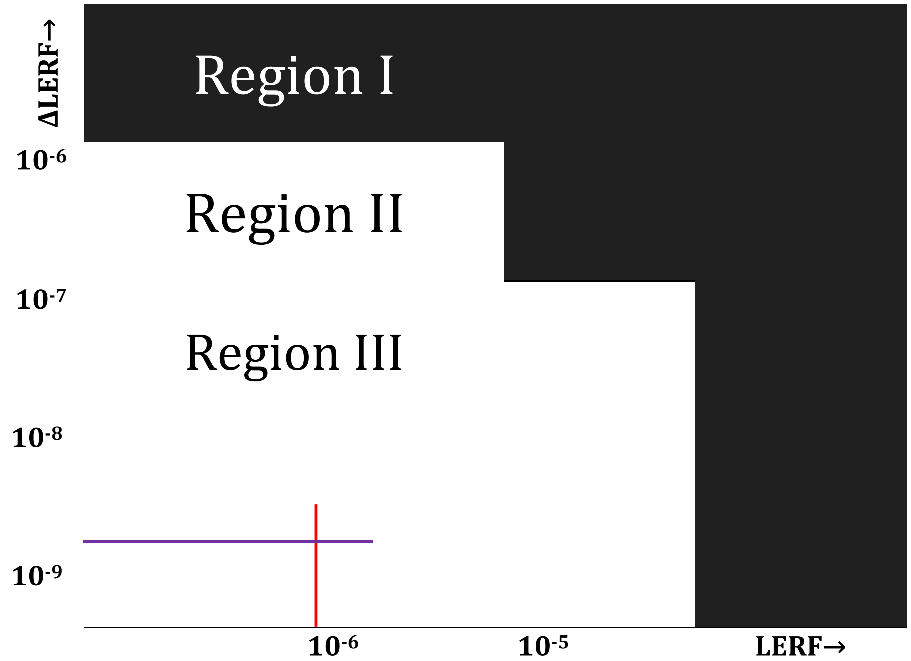
- For non-ISO_FAIL events (e.g. Containment NOT bypassed and Containment Isolation successful), the next top event is "RCS_HIGH" for "RCS Pressure High. Large LOCAs are low RCS pressure events. In the Level 2 event trees, the branch for low RCS pressure is "RCS_LOW." LERF sequences are identified by early containment response event "CFE1."

- ΔLERF multiplier is the sum of containment isolation failure and containment failure probabilities due to VLLOCA.
  - Containment Isolation Failure Probability for VLLOCA = 1.11E-03
  - Containment Failure Probability for VLLOCA = 5.95E-02
  - ΔLERF multiplier = 6.06E-02

Preliminary Results

- CDF = 9.63E-06 ΔCDF = 2.26E-08
- LERF = 1.24E-06 ΔLERF = 1.37E-09





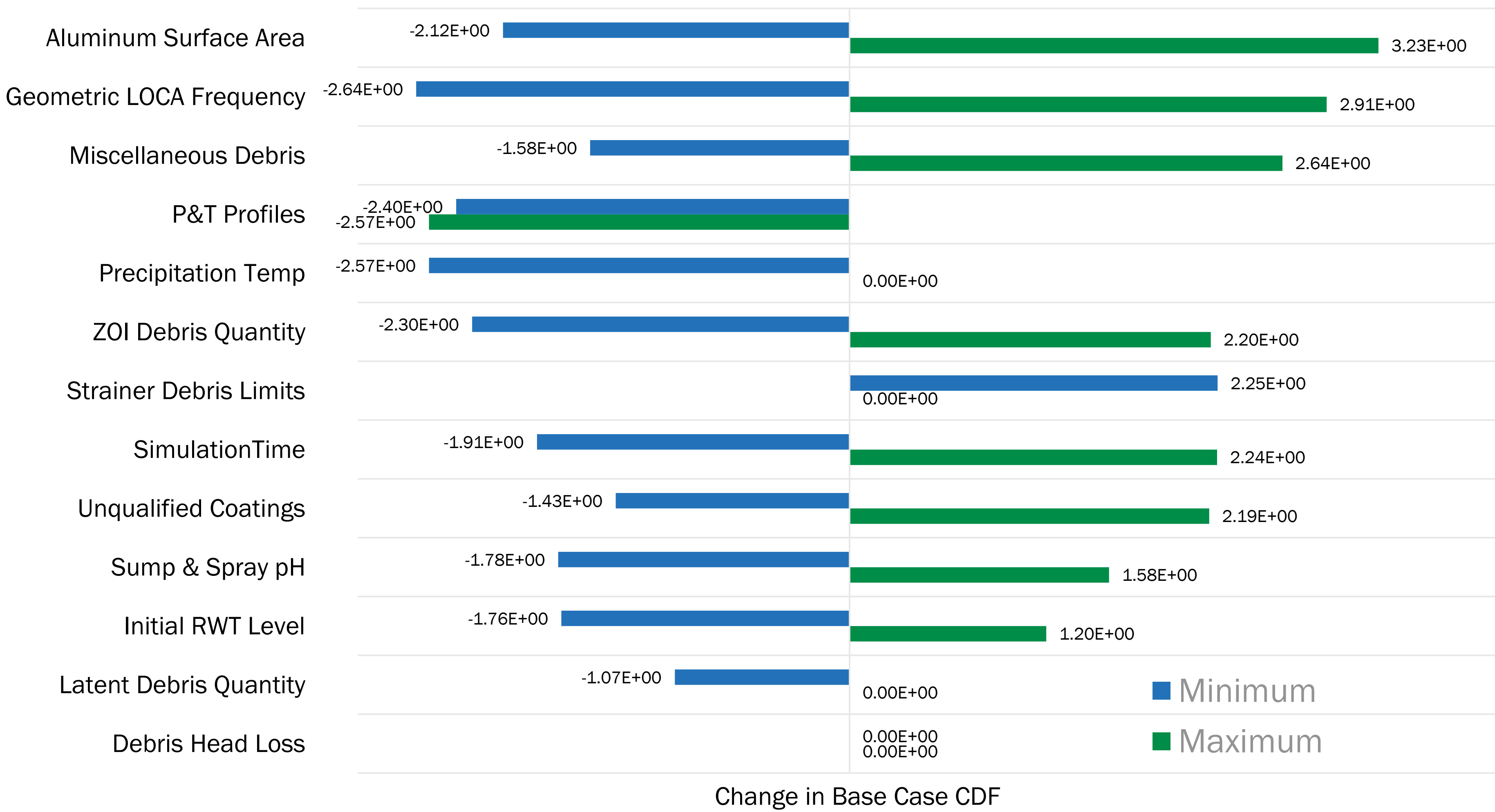
- Results well within RG 1.174 Region III
- Even with NARWHAL error and conservative alternate approach

Parametric Sensitivity Analysis

- Individual input parameters varied.
- Minimum and maximum values selected.
  - In some cases exceeding actual bounding conditions.

Input Parameter	ΔCDF at Minimum Input	ΔCDF at Maximum Input
Simulation Time	1.85E-08	3.16E-08
Initial Refueling Water Tank (RWT) Mass	1.97E-08	2.34E-08
Pressure and Temperature Profiles	9.73E-09	3.71E-09
Sump and Spray pH	1.96E-08	2.46E-08
ZOI Debris Quantity	1.24E-08	3.08E-08
Unqualified Coatings Quantity	2.13E-08	3.06E-08
Latent Debris Quantity	2.20E-08	2.27E-08
Miscellaneous Debris Quantity	2.07E-08	4.50E-08
Aluminum Surface Area	1.59E-08	1.09E-07
Debris Head Loss	2.26E-08	2.26E-08
Strainer Debris Limits	3.16E-08	2.26E-08
Precipitation Temperature	3.71E-09	2.26E-08
Geometric LOCA Frequency Values	3.34E-11	6.44E-08

Parametric Sensitivity Study Results



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Additional Fiber Sensitivity

- The quantity of fine fiber was increased in increments to determine the quantity of fiber that would increase strainer failures resulting in a ΔCDF exceeding RG 1.174 Region III guidelines
  - Fiber increase also increased chemical precipitates

Fine Fiber Increase		ΔCDF
(lb_m)	%	
0	0%	2.26E-08
100	7%	2.46E-08
500	35%	1.43E-07
600	42%	2.24E-07
700	50%	*1.42E-06*

- A 50% increase in fine fiber results in a ΔCDF exceeding RG 1.174 Region III guidelines

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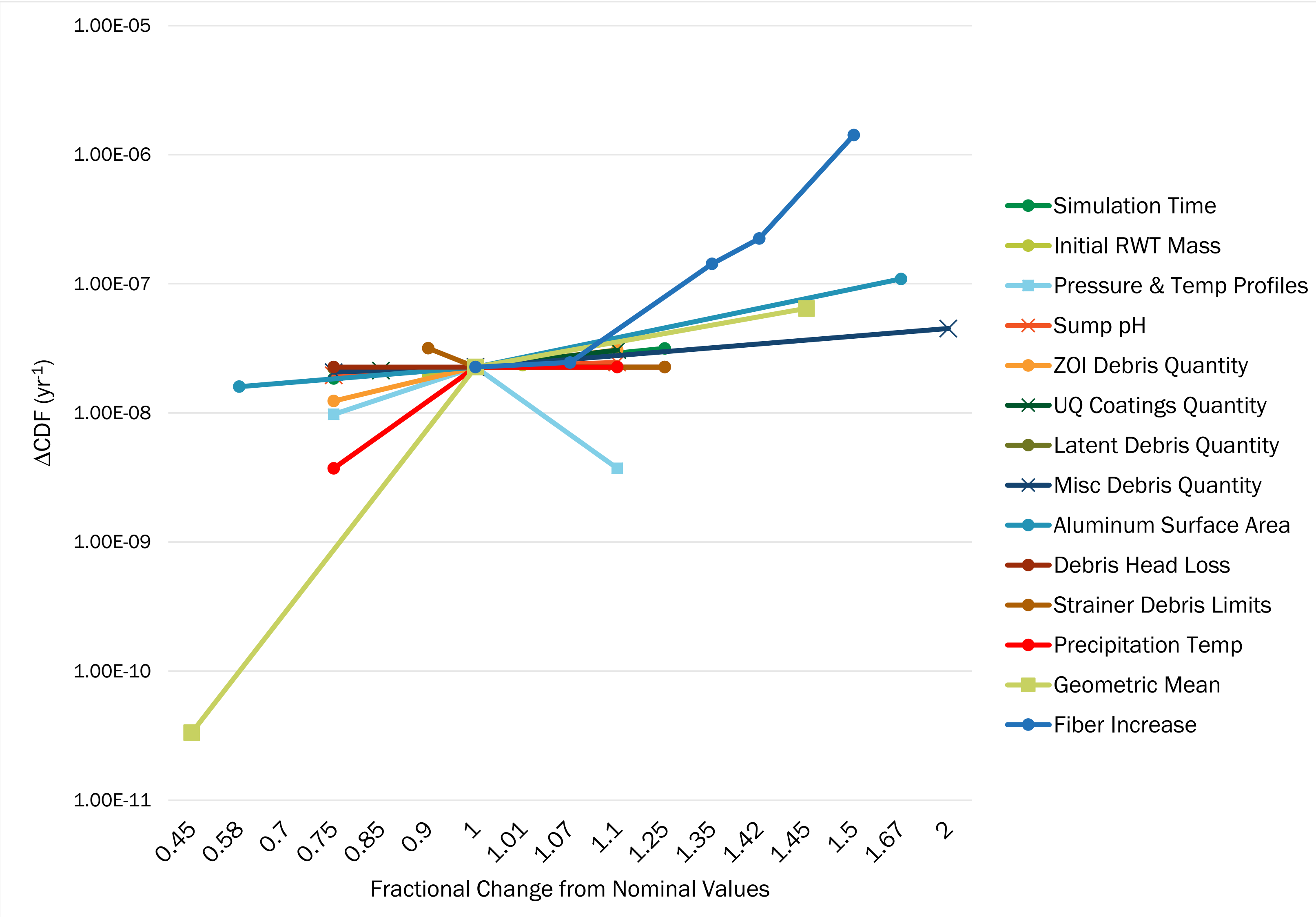
Parametric Sensitivity Study Results



Uncertainty Analysis

- Model Uncertainty
  - The model uncertainty was evaluated using alternative models for the models where no consensus approach exists.

Model with No Consensus	Sensitivity Case	ΔCDF	Change in ΔCDF from Base Case
Continuum Break Model	DEGB-Only Model	9.27E-08	7.01E-08
Top-Down LOCA Frequency Allocation with NUREG-1829 Geometric Mean Values	Top-Down LOCA Frequency Allocation with NUREG-1829 Arithmetic Mean Values	3.63E-07	3.40E-07
	Top-Down LOCA Frequency Allocation with NUREG-1829 60-year Mean Values	8.64E-08	6.38E-08
Methodology to Allocate LOCA Frequency to Welds	Hybrid Allocation Methodology: Skewed to High Rupture Probability Welds	2.26E-08	0.00E+00
	Hybrid Allocation Methodology: Skewed to High and Medium Rupture Probability Welds	2.26E-08	0.00E+00
	Hybrid Allocation Methodology: Spread Equally Across all Welds (top-down)	2.26E-08	0.00E+00
	Hybrid Allocation Methodology: Lower Weight on Longitudinal Welds	2.11E-08	-1.50E-09
	Hybrid Allocation Methodology: Higher Weight on Longitudinal Welds	3.11E-08	8.47E-09
LBLOCA Size Range Discretization (14-24 and 24-60 inches)	Bias 1 (14-20 and 20-60 inches)	2.80E-08	5.36E-09
	Bias 2 (14-30 and 30-60 inches)	2.52E-08	2.60E-09
Time Step Size	2 minutes	2.26E-08	0.00E+00
	3 minutes	2.29E-08	2.85E-10
	4 minutes	2.26E-08	0.00E+00
	5 minutes	2.81E-08	5.43E-09
	15 minutes	4.20E-08	1.94E-08
Precipitation Solubility Option	ANL Solubility Equation; Precipitation forced at 24 hours	2.26E-08	0.00E+00
Head Loss Test Comparison	Head loss data with lowest head loss results	1.31E-08	-9.53E-09
Unit 2 Comparison	Unit 2 Debris Database	1.45E-08	-8.08E-09

Uncertainty Analysis

- Parametric Uncertainty Analysis
  - Parametric Sensitivity Studies Performed – Slides 22-25
  - Bounding direction for most variables demonstrated
  - Competing factors associated with pool volume,
    - Two cases run

- Strainer Failure Case 1 (Minimum Water Volume)
  - Minimum Water Volume (Base Case Inputs)
  - Maximum HPSI Flow Rate
  - Maximum LPSI Flow Rate
  - Maximum CSS Flow Rate (Base Case – conservatively skewed toward maximum)
  - Maximum pH Profile
  - Maximum LOCA Frequency (95th Percentile)

- Strainer Failure Case 2 (Maximum Water Volume)
  - Maximum Water Volume (Max RWT Value)
  - Maximum HPSI Flow Rate
  - Maximum LPSI Flow Rate
  - Maximum CSS Flow Rate (Base Case – conservatively skewed toward maximum)
  - Maximum pH Profile
  - Maximum LOCA Frequency (95th Percentile)

Case	ΔCDF	Change in ΔCDF from Base Case
Min Water Volume	7.37E-08	5.11E-08
Max Water Volume	8.22E-08	5.95E-08

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Final Submittal and LAR

- To be formatted similar to STP Submittal

1. Calvert Cliffs Risk-Informed Approach to Closure for GSI-191
   - 1-1 Introduction
   - 1-2 Deterministic (Approved Methodologies) Bases
     - 1-2.1 Diagrams of the Calvert Cliffs ECCS and CS systems
     - 1-2.2 Aluminum Precipitate Head Loss Considerations at the Cliffs Nuclear Power Plant
   - 1-3 Risk-Informed Bases
   - 1-4 Defense in Depth and Safety Margin
2. Requests for Exemption Calvert Cliffs Risk-Informed Approach to Closure for GSI-191
   - 2-1 General
   - 2-2 Request for Exemption from 10CFR50.46(a)(1)
3. License Amendment Request for Calvert Cliffs Risk-informed Approach to Closure for GSI-191
   - 3-1 Technical Specification Page Markups
   - 3-2 “Clean” Technical Specification Pages
   - 3-3 Technical Specifications Bases Page Markups (Information Only)
   - 3-4 Calvert Cliffs UFSAR Page Markups (Information Only)
4. List of Commitments

- Will keep Deterministic and Risk-Informed technical portions separate

- UFSAR page markups limited to those describing the risk-informed treatment of debris

- Schedule for Submittal – July 2018

Questions/Concerns

- Jointly Review Issues, Questions, and Concerns for Future Communication

Next Steps

- Address Staff questions and comments
- Finalize GL 2004-02 Final Submittal and Risk-Informed GSI-191 LAR
- Submit GL 2004-02 Final Submittal and Risk-Informed GSI-191 LAR – July 2018

Backup Slides

- Development of NARWHAL Head Loss Lookup Tables
  - Conventional Head Loss
    - Conventional head loss is the maximum head loss from each test prior to flow reduction for introduction of chemical precipitates.
  - Chemical Head Loss
    - Chemical head loss is the maximum head loss from each test after the beginning of introduction of chemical precipitates.
    - These values are reduced by subtracting the conventional head loss at the start of chemical addition in each test. The subtracted conventional head loss is is lower than above due to test flow rate reduction.
    - This head loss value will be scaled for a higher flow rate than was used in the test by the ratio of $(2900/2400)^2$.
  - Clean Screen Head Loss
    - Clean screen head loss is taken from CCI calculation.
    - Accounts for head loss in axial flow duct and radial plenum.
  - Total Head Loss
    - This is the sum of conventional head loss, scaled chemical head loss, and clean screen head loss.

Backup Slides

- Development of NARWHAL Head Loss Lookup Tables (continued)

Test	Strainer Head Loss									
	Conventional		Chemical					Clean	Total	
	(mbar)	(in-water)	Max (mbar)	Conv. (mbar)	Net (mbar)	Net (in-water)	Scaled (in-water)	(in-water)	(in-water)	(ft-water)
2	1.0	0.4	1.5	0.6	0.9	0.4	0.6	3.456	4.5	0.38
3	2.5	1.0	94.6	1.3	93.3	37.9	55.3	3.456	59.8	4.98
4	1.5	0.61	17.9	0.8	17.1	6.94	10.1	3.456	14.2	1.18
5	1.7	0.69	36.2	0.9	35.3	14.3	20.9	3.456	25.0	2.08
7	1.4	0.57	19.6	0.6	19.0	7.72	11.3	3.456	15.3	1.28