US NRC Assessment of Nuclear Power Plant ECCS Sump Performance

U. S. NRC
Commissioner Briefing
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PRESENTATION PACKAGE

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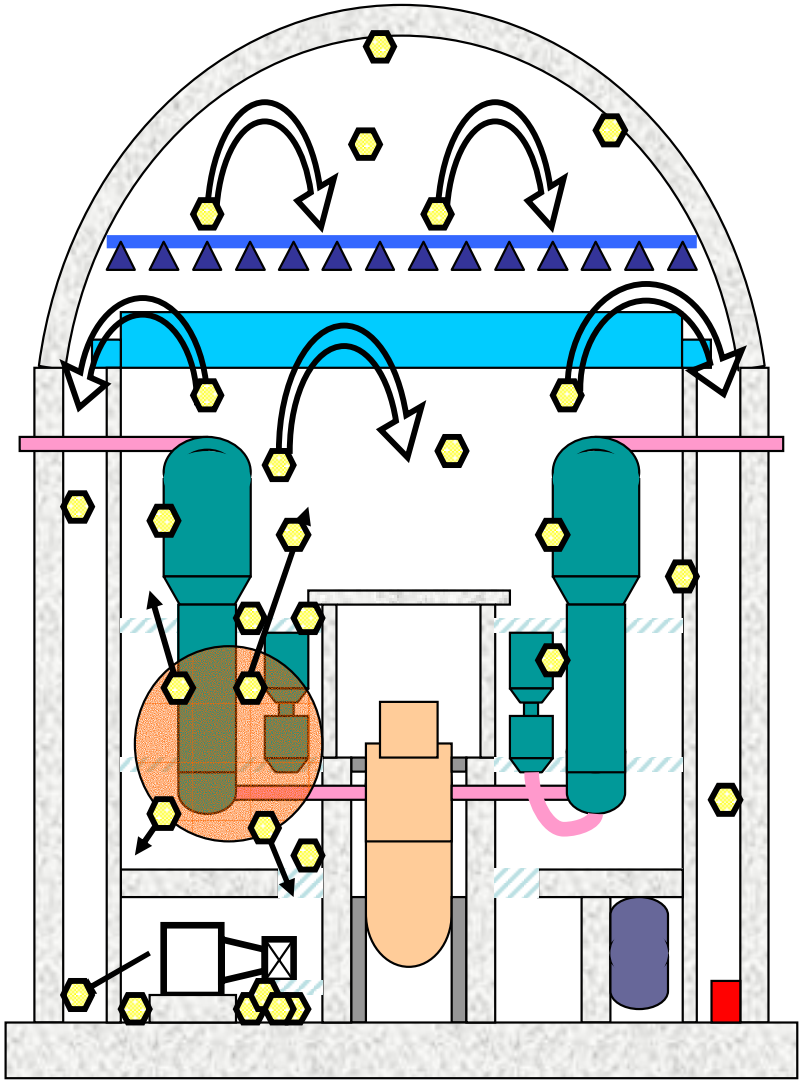
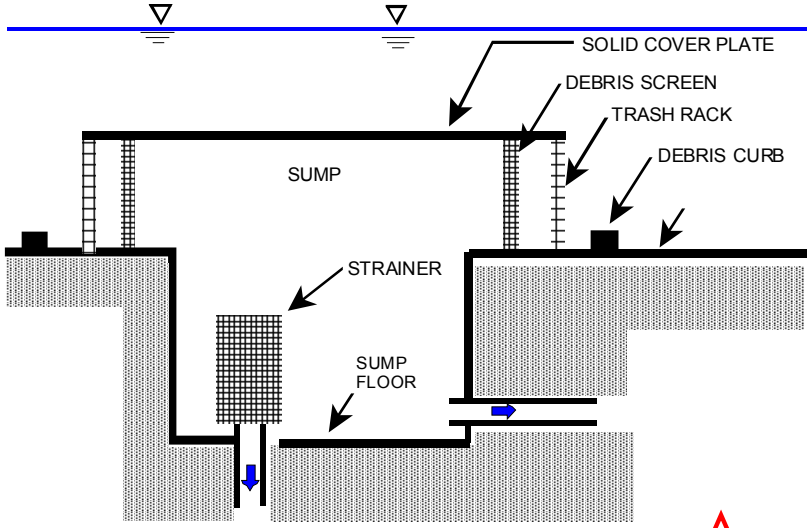
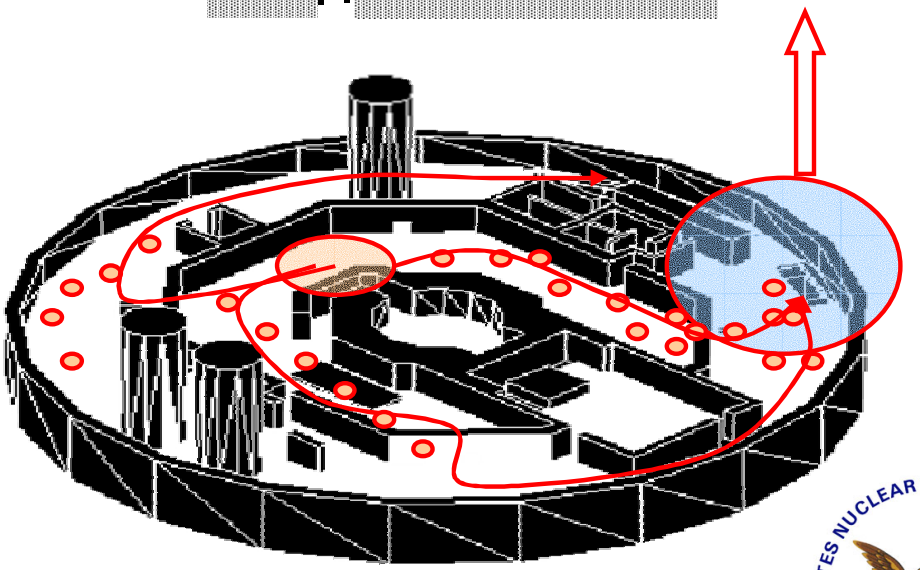
Opening Remarks







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Information Requested:

- Issue History
- BWR issue/concerns/resolution
- PWR Background
- PWR Regulatory approach/basis
- Ongoing testing
- Policy issues
- Current status

Issue History

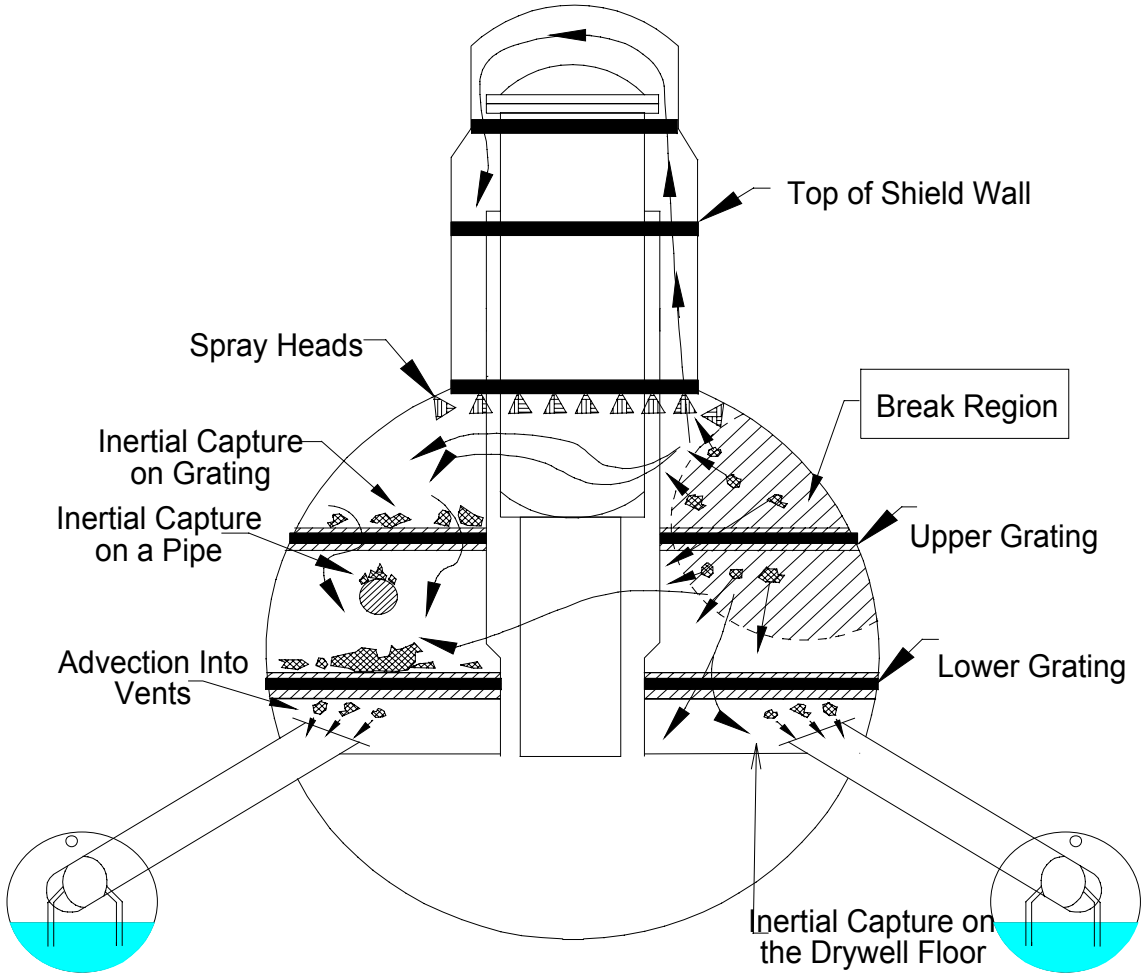
Regulatory Requirements For Core Cooling

- 10 CFR 50.46(b)(5), Long-term Cooling
- 10 CFR 50, Appendix A, Criterion 35, Emergency Core Cooling

Issue History

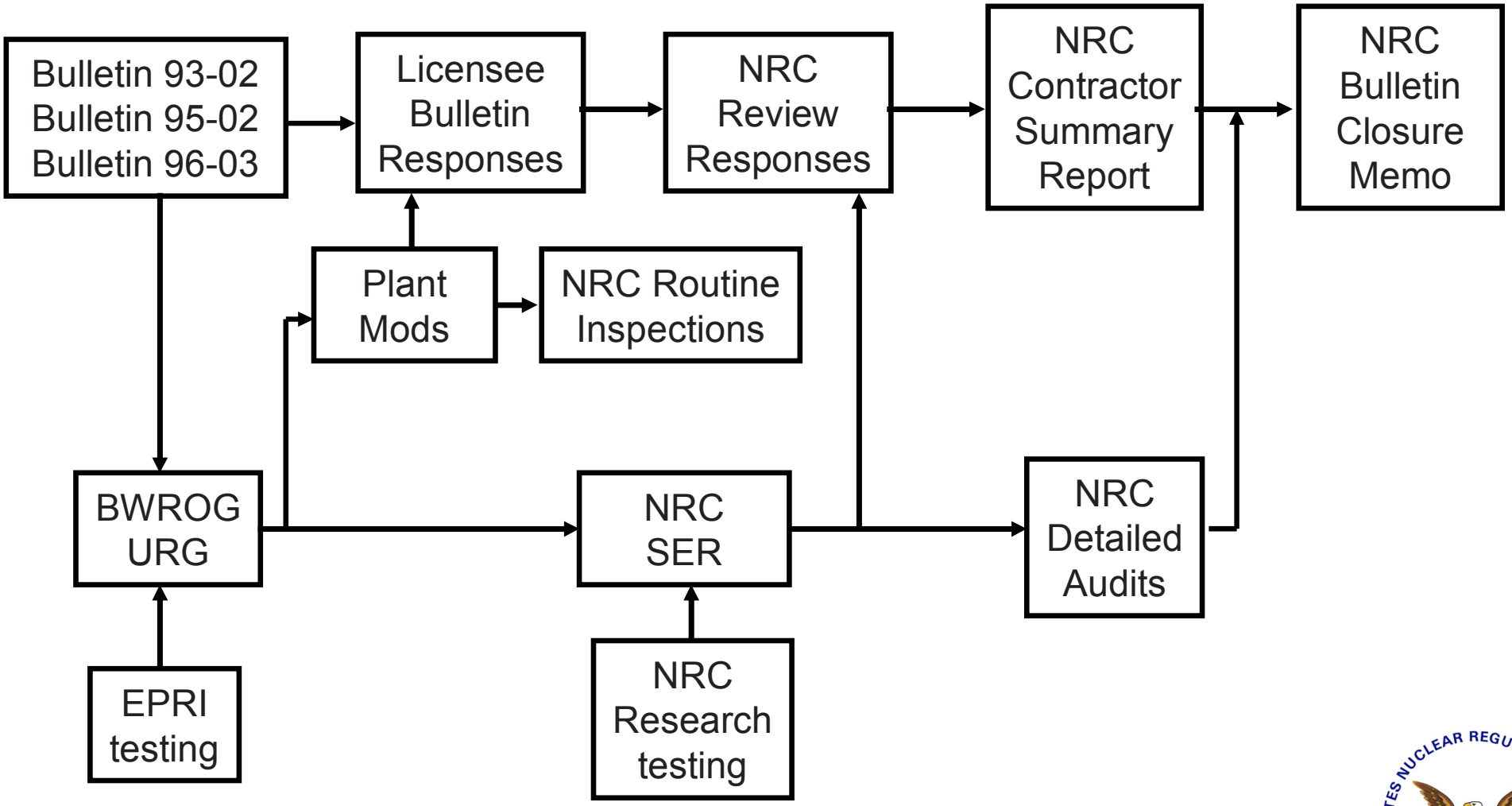
- USI A-43 issued in 1979 to address concerns with emergency suction strainer performance
  - closed in 1985 (GL 85-22 and RG 1.82, Revision 1)
  - Did not impose new regulatory requirements (no backfit)
  - Recommended replacing 50% sump blockage design assumption with a mechanistic assessment
- BWR events lead to Bulletins 93-02,95-02, and 96-03; request BWRs take action to ensure ECCS safety function
- GSI-191 established in 1996 to re-assess PWR sump performance due to BWR events and Research findings

BWR Issue/Concerns

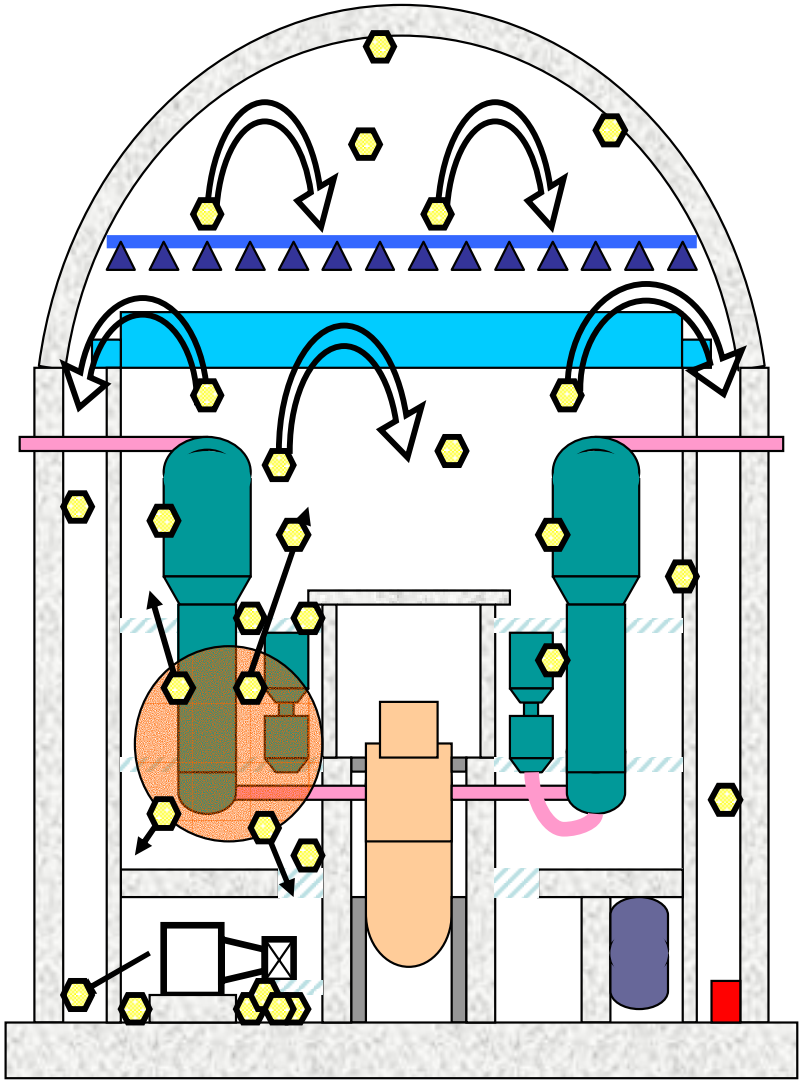


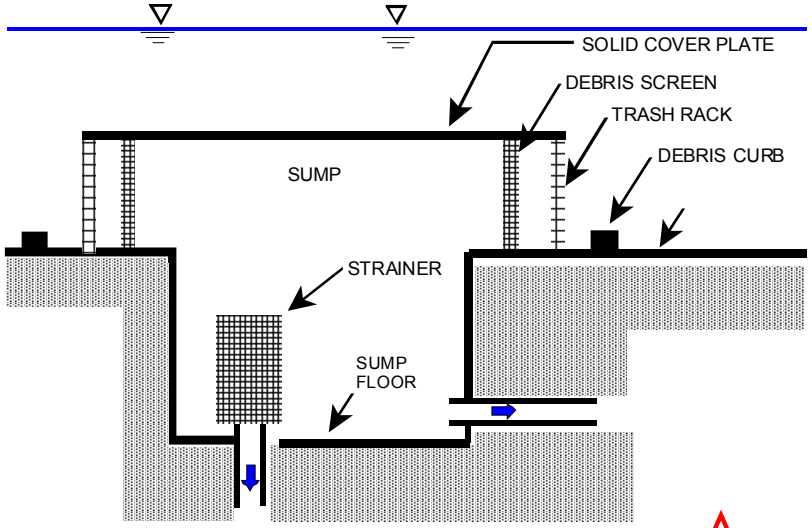
A. Blowdown Phase

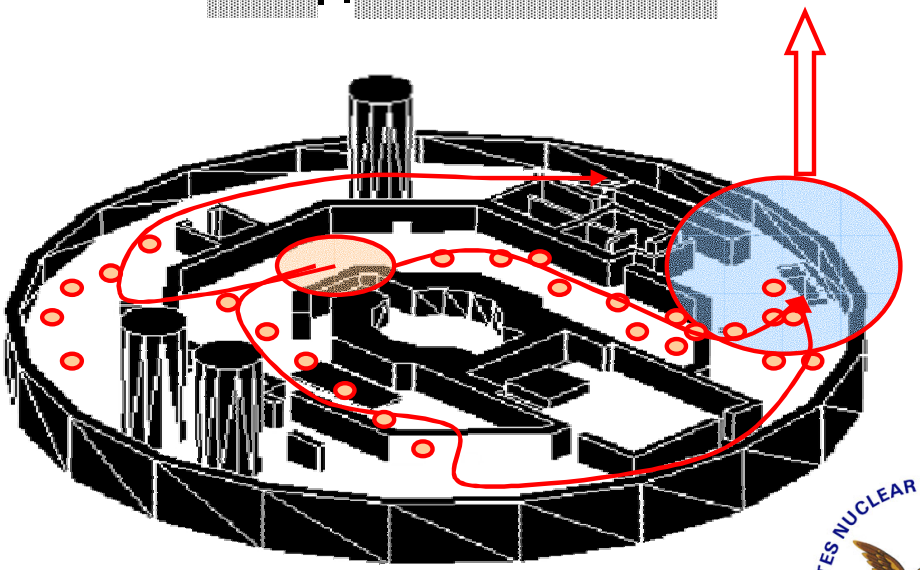
BWR Resolution



PWR Background
LB LOCA Description







PWR Background
Risk Insights

- Baseline:

  CDF = 3.3E-6/year (LOCA without debris accumulation being considered)
- Non Plant-Specific Estimate (Parametric Study):

  CDF = 1.5E-4/year (LOCA with debris accumulation)
- Operator Recovery Actions:

  CDF = 5E-6/year (LOCA with debris accumulation with operator recovery actions)

PWR Regulatory Approach/Basis

Two Phase Approach

- Bulletin 2003-01, “Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors” (Issued June 2003)
- Generic Letter 2004-02, “Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized Water Reactors” (Issued September 2004)

PWR Regulatory Approach/Basis
Bulletin 2003-01

Bulletin 2003-01

- Informs licensees of the issue
- Requests licensees to confirm compliance with 10 CFR 50.46(b)(5)
- Evaluate/Implement Interim Compensatory Measures (ICM) to reduce risk
- All Bulletin Responses have been reviewed, RAI's issued. 6 Close-out letters issued.

PWR Regulatory Approach/Basis
Generic Letter 2004-02

- Action Requested
  - Plant specific evaluation using a mechanistic analysis to demonstrate compliance
  - Description and schedule of corrective actions and plant modifications (if required)
- Submittal Schedule
  - 90 day response (March 7, 2005) – planned actions and schedule to complete the evaluation
  - September 1, 2005 response – results of evaluations, modification schedules, licensing action requests
- Implementation Inspections (NRC Regions)

PWR Regulatory Approach/Basis
NRC Safety Evaluation (SE)

- Provides NRC approved methodology for evaluation of sump screen performance
- Covers ALL main topics: Break Selection, Debris Generation, Latent Debris, Debris Transport, Head Loss, Alternate Evaluation, Structural Analysis, Upstream/Downstream Effects, & Chemical Effects
- Developed using NEI guidance with Staff evaluation and enhancement (SE)

PWR Regulatory Approach/Basis
Potential Mitigation Strategies

Integrated Plan (addresses ALL major topics)

- Modification of insulation types/jacketing
- Plant cleanliness programs
- Midstream debris interceptors
- Operator actions to secure unnecessary flowpaths
- Larger, Complex, Submerged screens
- Test and approve back-flush to dislodge compacted debris
- Active screen sweep and collection concepts
- Innovative porous media designs on top of existing screens

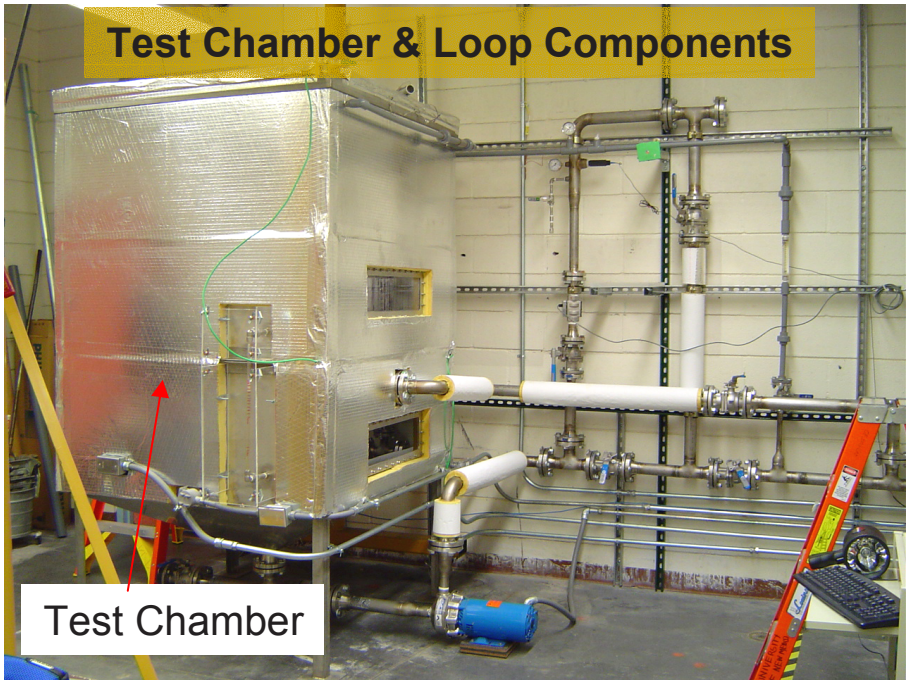
PWR Regulatory Approach/Basis Evaluations & Oversight

- Pilot Program Approach
  - Staff is working with potential pilot plants
  - Meetings to identify issues
  - Permits early problem resolution
- In-Depth Plant Review Program Approach
  - Vendor
  - Methodology used/overall performance
  - Screen design
- Regional Inspections

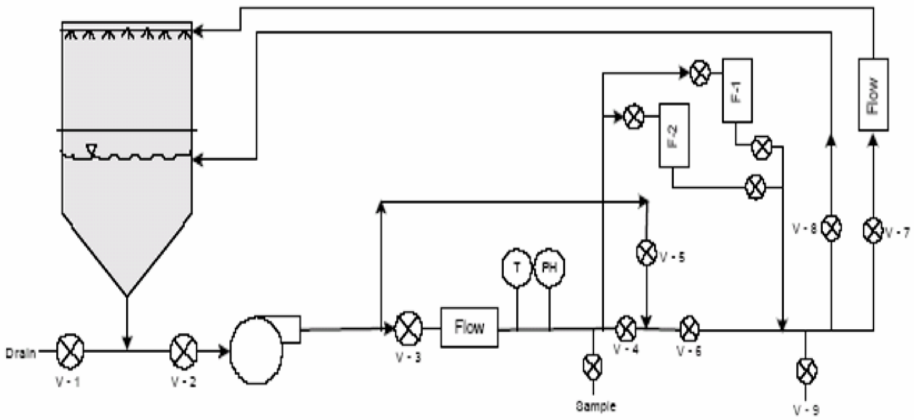
Ongoing Testing
Research Supporting GL 2004-02

- **Chemical effects**: Determine if sump pool environment generates by-products which contribute to sump clogging
- **Debris Transport & Head loss**: Confirmatory research on debris transport of coatings and head losses associated with PWR containment materials with and without chemical effects
- **Downstream effects**: Confirmatory research on the effect of injected debris on HPSI throttle valve performance

Ongoing Testing
Integrated Chemical Effects Testing (ICET)



Test Loop Schematic



- Evaluate corrosion byproducts and the formation of gel-type compounds
- Testing consists of multiple 30-day tests.
- Testing and characterization procedures and requirements were developed jointly by the NRC and industry.
- Testing results are shared between the NRC and industry.

Ongoing Testing
Description of Integrated Chemical Effects Testing

- Tests simulate five unique chemical environments with scaled amounts of containment materials.
- Tests 1 - 4 completed; test 5 is scheduled to begin on 7/26.
- Chemical by-products have been observed in tests 1 - 4.

Test Number	Buffering Agent	Insulation Material
1	Sodium Hydroxide: pH ≈ 10	100% Fibrous (NUKON)
2	Tri-sodium Phosphate: pH ≈ 7	100% Fibrous (NUKON)
3	Tri-sodium Phosphate: pH ≈ 7	80% Particulate (CalSil) 20% Fibrous (NUKON)
4	Sodium Hydroxide: pH ≈ 10	80% Particulate (CalSil) 20% Fibrous (NUKON)
5	Sodium Tetraborate: pH ≈ 8.5	100% Fibrous (NUKON)

Ongoing Testing
Possible Implications of ICET Findings

Chemical product formation

- Tests have shown that small variations in chemical composition may lead to significantly different chemical by-products.
- Products formed in plant-specific environments need to be examined for differences with ICET by-products.

Head loss contributions from chemical effects

- Nature of head loss is likely fundamentally different from typical debris loading.
- International testing has shown that significant head loss is possible under certain conditions.

Downstream Effects

- The possibility of chemical by-products being formed or transported downstream of sump strainer screen and degrading either component performance or ECCS functionality should be examined.
- Blockage or wear of downstream components is another consideration to be examined.

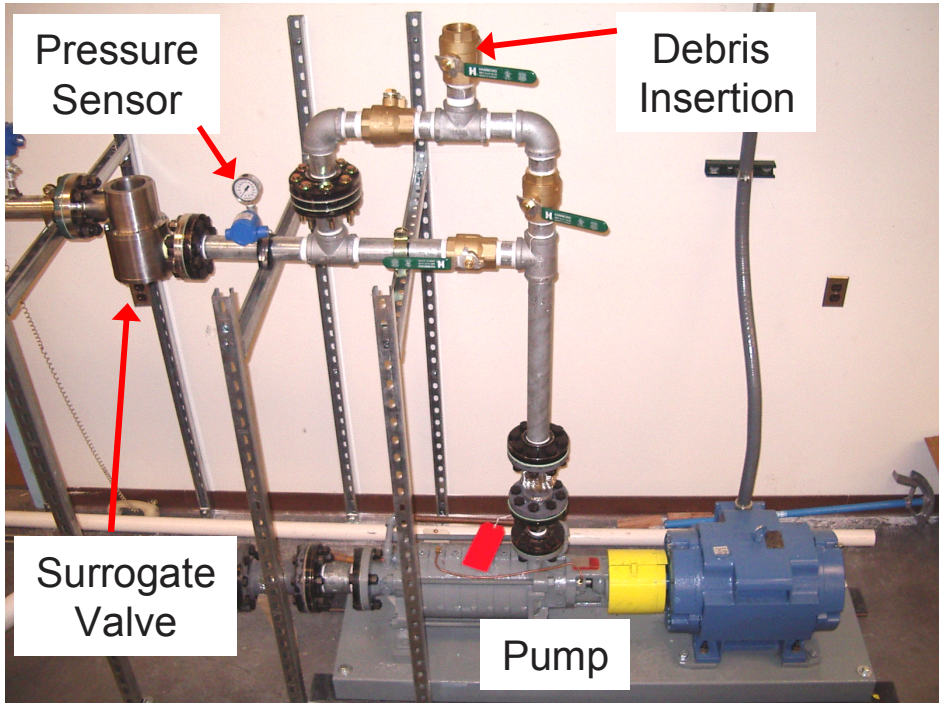
Ongoing Testing
Debris Transport and Head Loss

- **Objectives**:
  - Develop a mechanistic understanding of debris transport and head loss processes.
  - Develop predictive head loss correlations
- **Debris transport and characterization**
  - Testing transportability of “fine” particulate and larger coating chips to the sump screen
- **Head loss testing**
  - PWR fibrous and particulate insulation and coatings in inert environments
  - Focus on lower approach velocities to simulate modified designs
  - Head loss contributions of chemical effects in PWR debris beds
- **Improved analytical head loss model**

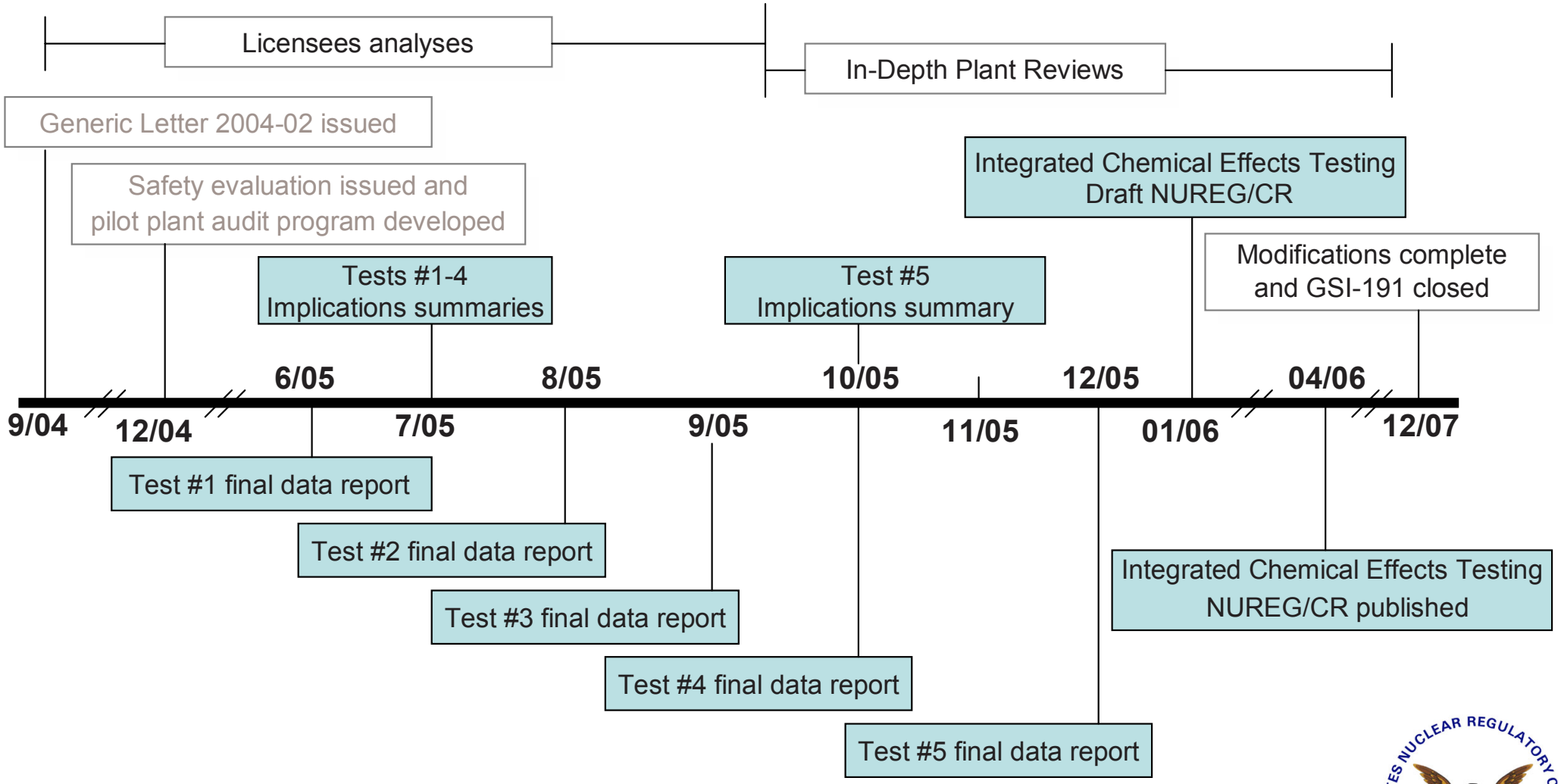
Ongoing Testing
Downstream Effects Testing

- **Objective**: Understand physical characteristics of debris which can pass through sump strainer screens and affect a HPSI throttle valve blockage
- Debris pass-through under PWR conditions
  - Fibrous, particulate, and reflective metal insulations
  - Representative approach velocities
- Two-step throttle valve testing
  - Baseline and single debris type
  - Multiple debris-types

Downstream Effects Loop



Ongoing Testing
Timeline for Chemical Effects Testing



LEGEND:
Shaded boxes – products of research under NRC/EPRI MOU
Final data reports - LANL reports, reviewed by NRC and EPRI/industry
Implications summaries – NRC reports, implications of test results for licensee analyses

NRC Policy Issues
Compliance / Operability

- Regulatory Compliance
  - Existing licensing basis in effect until GSI 191 resolution
- GSI-191 Resolution Date: 12/31/07
  - All plant & licensing basis modifications are to be completed by this date
  - New methodology not “required” until after this date
- Compliance After 12/31/07
  - Based on new licensing basis incorporating new methodology

NRC Policy Issues Resolution Schedule

- Issue identified some time ago (GSI issued in 1996)
- NRC has openly communicated expectations to industry
  - Bulletin 2003-01, GL 2004-02, GSI-191 Safety Evaluation
  - Letter B. Sheron to A. Pietrangelo 8/25/04
  - NEI Workshop 12/1/04
  - Public meetings (1/27/05, 4/13/05, & 6/30/05)
- NRC Expects Industry to maintain schedule (Detailed submittals by Sept. 05, Implementation by Dec. 07)
  - Recent audit & vendor information indicate resolution is achievable

NRC Policy Issues
Issue Resolution

- Industry has responsibility to resolve, NRC responsibility to evaluate
  - Staff is willing to evaluate industry data to relax conservatisms
- Industry needs to show a detailed plan for resolving issues
- Industry has “burden of proof” for any proposed delay (will need to show PRA and financial risk factors)