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Oconee Flood Protection and the 10 CFR 50.54(f) Response

Background Material

D3

Outline

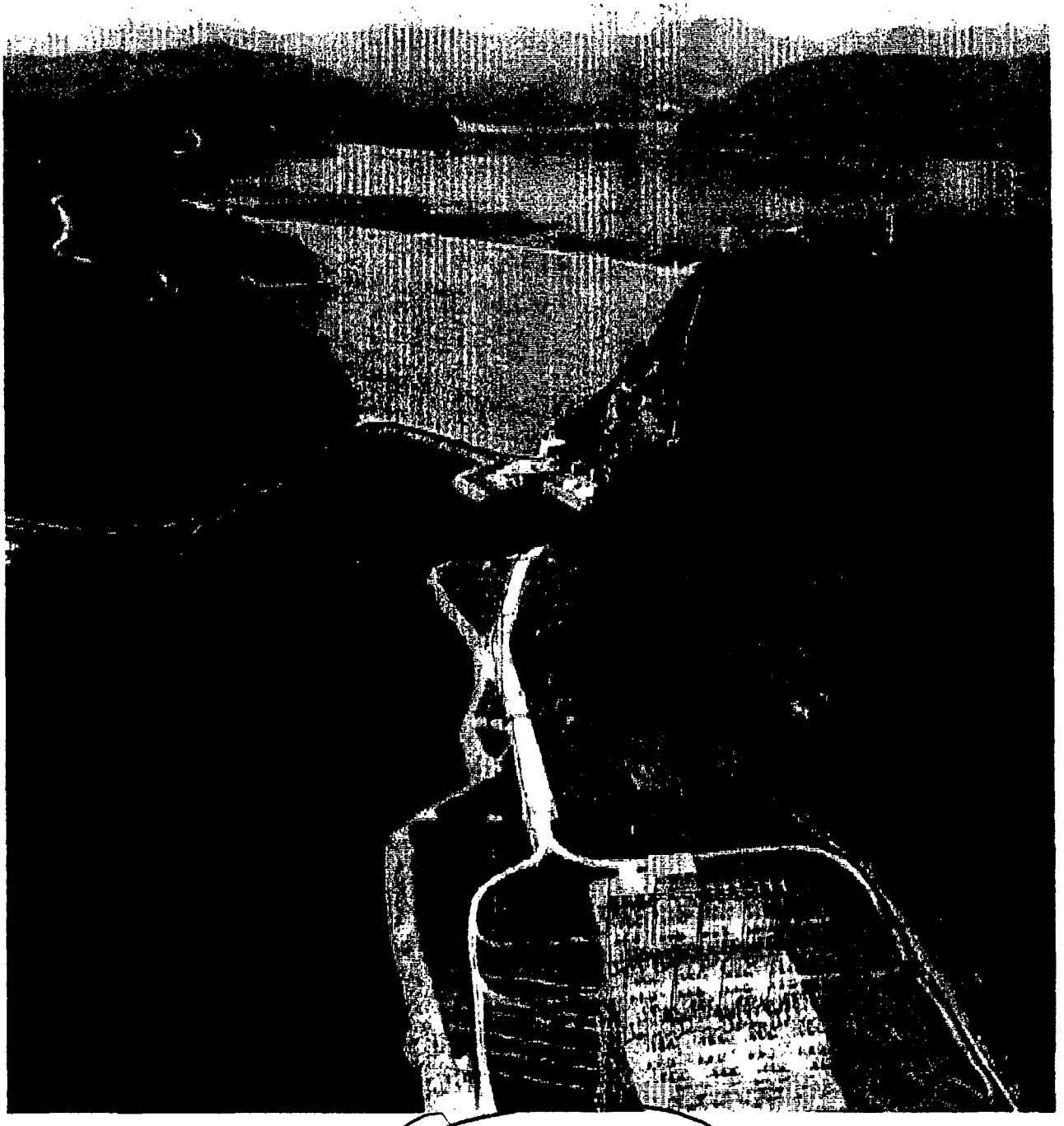
- Site Background
- Issue Background
- 10 CFR 50.109 Backfit
- Principal 10 CFR 50.54(f) Questions Regarding Oconee Flood Protection Issue
- Summary of Licensee Response
- Detailed Summary of Licensee Response to 10 CFR 50.54(f) Letter
- 50.54(f) Letter Review Team
- Team Members
- Principles of Risk-informed Decision Making Process Used
- Summary of Random Dam Failure Frequency of Licensee Response

Site Background

Oconee Nuclear Station

- Three nuclear units located in Seneca, SC
- Operational in 1973-74
- Plant located down river of Lake Keowee and Lake Jocassee
- Only nuclear plant in the United States that relies on hydro-electric generators located in one dam as emergency power source
- Plant relies on the Standby Shutdown Facility (SSF) to maintain reactor shutdown in case of fires, floods, or sabotage events.

The Jocassee Dam



Aerial View of the Oconee Site and Lake Keowee

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Issue Background

- NRC inspection identified flood protection issue with Oconee Standby Shutdown Facility (SSF).
  - Potential lack of adequate flood protection and defense-in-depth upon loss of SSF
  - Five-foot walls constructed over SSF entrances to protect against Jocassee Dam failure based on unavailable inundation study
  - Duke Hydro/FERC Inundation Study completed in early 1990s. Estimated flood heights up to 16.8 ft above SSF grade level
  - Dam random failure frequency was significantly underestimated.
  - White finding on specific deficiency
- Staff response
  - Performed backfit analysis
  - Issued 10 CFR 50.54(f) letter for Duke to address external flooding concerns
  - Evaluation of current fleet for flood vulnerabilities underway
  - Security interface with NSIR and DHS

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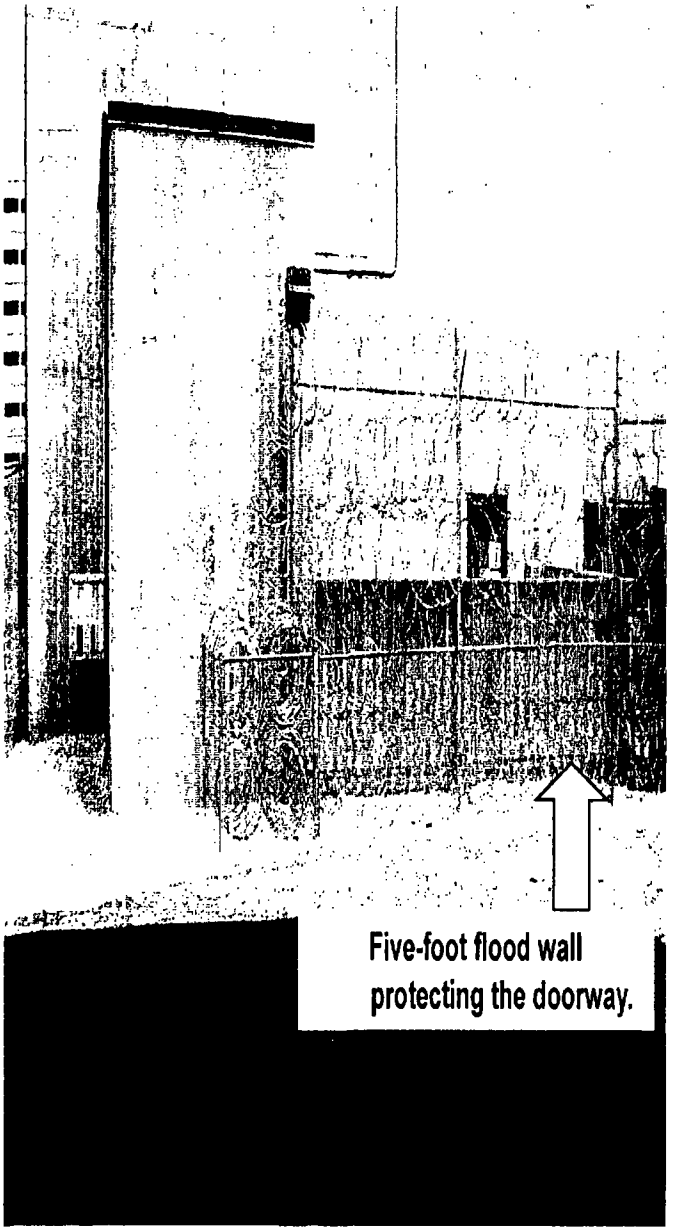
The SSF Flood Barriers



10 CFR 50.109 Backfit Evaluation

- Backfit evaluation: external flooding is within Oconee's licensing basis. Licensee did not address Jocassee dam failure as a source of external flooding.
- Staff determined increased flood protection is a backfit.
- "Adequate Protection" based backfit is best approach.
  - No defense-in-depth: 3-unit core damage event with ultimate failure of each containment.
  - Regulatory expectations for external flood protection includes dam hazards.
- Cost-benefit estimate of $3 million in modifications. Modifications on the order of $13 million justified.

Principal 10 CFR 50.54(f) Questions Regarding Oconee Flood Protection Issue

1. Explain the bounding external flood hazard at Oconee and the basis for excluding consideration of other external flood hazards, such as those described in the Inundation Study, as the bounding case.
2. Provide your assessment of the Inundation Study and why it does or does not represent the expected flood height following a Jocassee Dam failure.
3. Describe in detail the nuclear safety implications of floods that render unavailable the SSF and associated support equipment with a concurrent loss of all Alternating Current power.

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Summary of Licensee Response

Tidbits to be added in package

- Duke offered to increase entrance wall heights by 2.5 feet.
- Question of whether to perform 1D vs. 2D study from Duke telecon
- Duke telecon on discussion of frequency
- Maintenance of Jocasse Lake levels as interim fix.
- NRC staff still has questions on the total inventory from Bad Creek and Jocassee during conditions of PMP.
- FERC report and the condition of Jocassee Dam embankment leakage
- Discussion of Duke's reliability approach over a statistical approach on failure frequency

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Detailed Summary of Licensee Response to 10 CFR 50.54(f) Letter

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50.54(f) Letter Review Team

- Scope
  - Review submittal as if NRC is reconstituting a design basis flood for Oconee
  - All modes/events causing external flooding will be assessed
  - All modes/events causing Jocassee dam failure will be assessed
- Diverse team of SES and senior technical staff with expertise in:
  - Engineering
  - Risk Assessment
  - Seismology
  - Hydrology
  - Project Management

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Team Members

SES - Management

Melanie Galloway (DD/DRA)
David Skeen (DD/DE)
Sam Thomas (DD/DORL – acting)

DRA – Risk Assessment and Dam Failure Frequency

Mike Franovich (BC/APOB)
Jeff Circle (APOB)
James Vail (APOB)

DE - Structural

Kamal Manoly (BC/EMCB)
Raman Pichumani (EMCB)

NRO – Seismic

Goutam Bagchi (SL:NRO/DSER)

NRO - Hydrology

Kenneth See (NRO/DSER/RHEB)

DORL – Project Management

Melanie Wong (BC/LP)
Leonard Olshan (LP)
Jon Thompson (LP)

Contributing SES Members

Mike Case (D/DPR)
Timothy McGinty (DD/DORL)
Sher Bahadur (DD/DE – acting)

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Principles of Risk-informed Decision Making Process Used

- Risk insights are integrated with considerations of defense in depth and safety margins.
- Traditional engineering analysis provides insight into available margins and defense in depth
- Topics considered in support of options
  - Likelihood of dam failure
  - Flood analysis (nominal and PMP lake levels)
  - Seismic analysis
  - Basis for continued operation
  - Security

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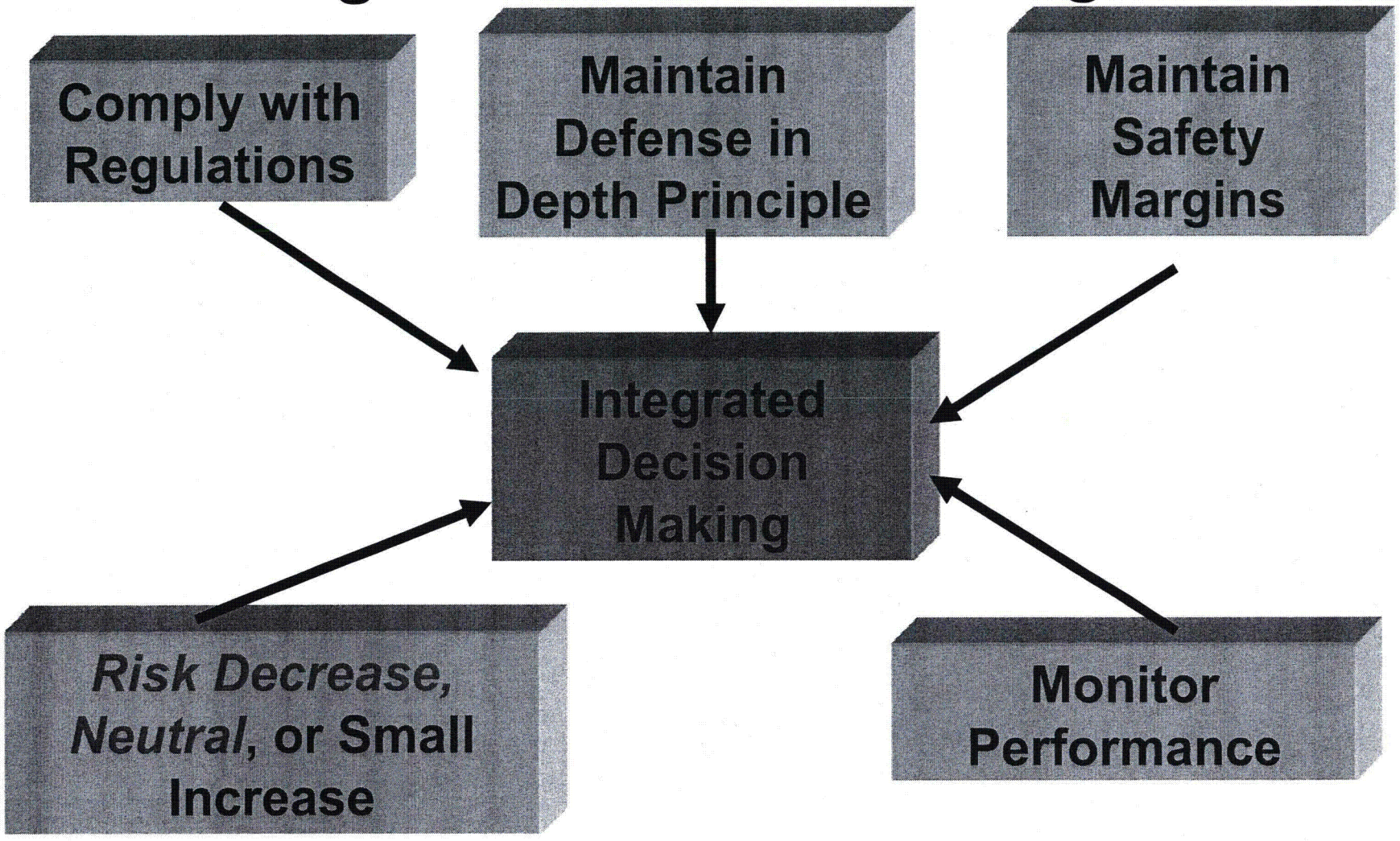
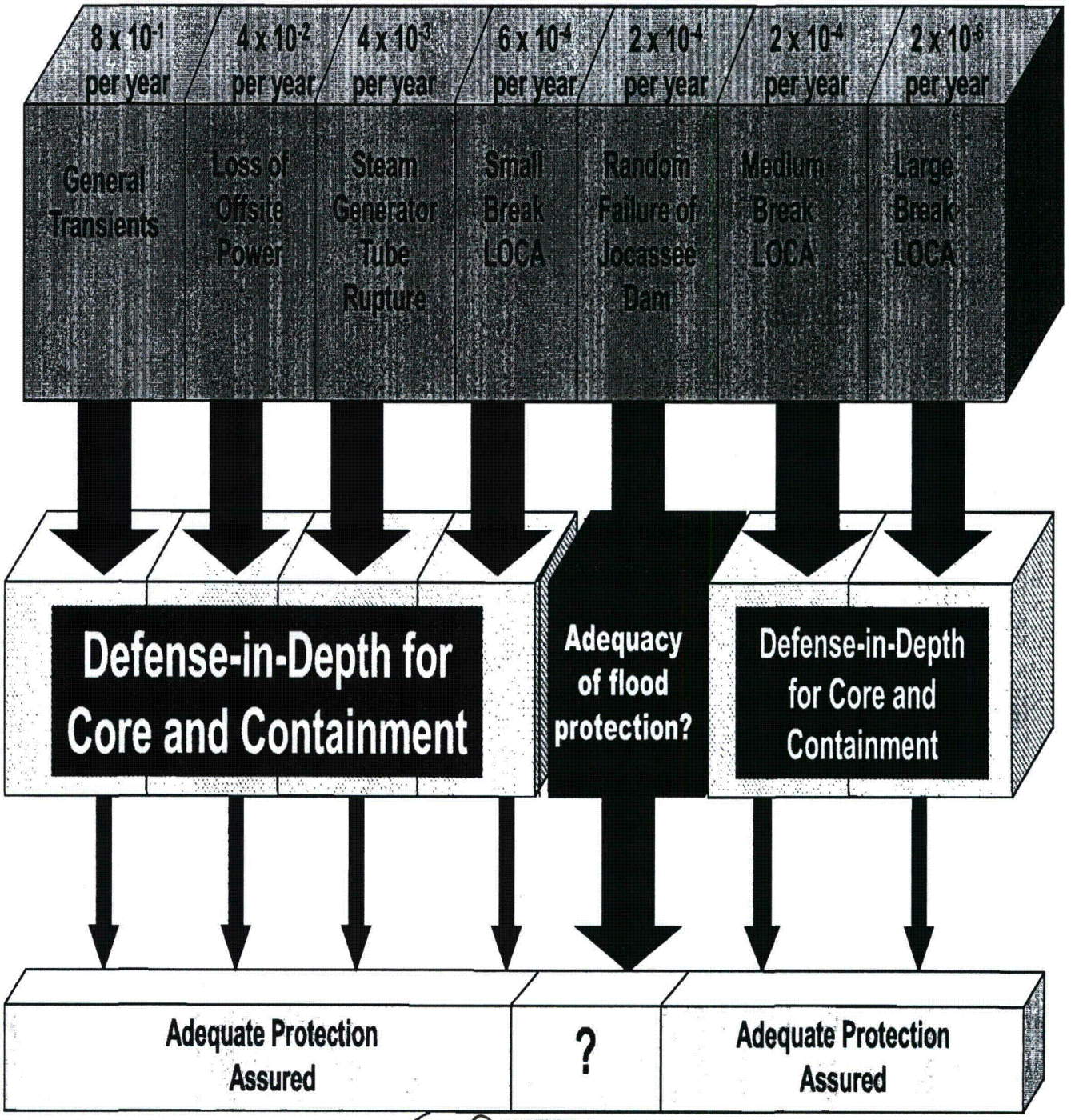
Integrated Decision Making

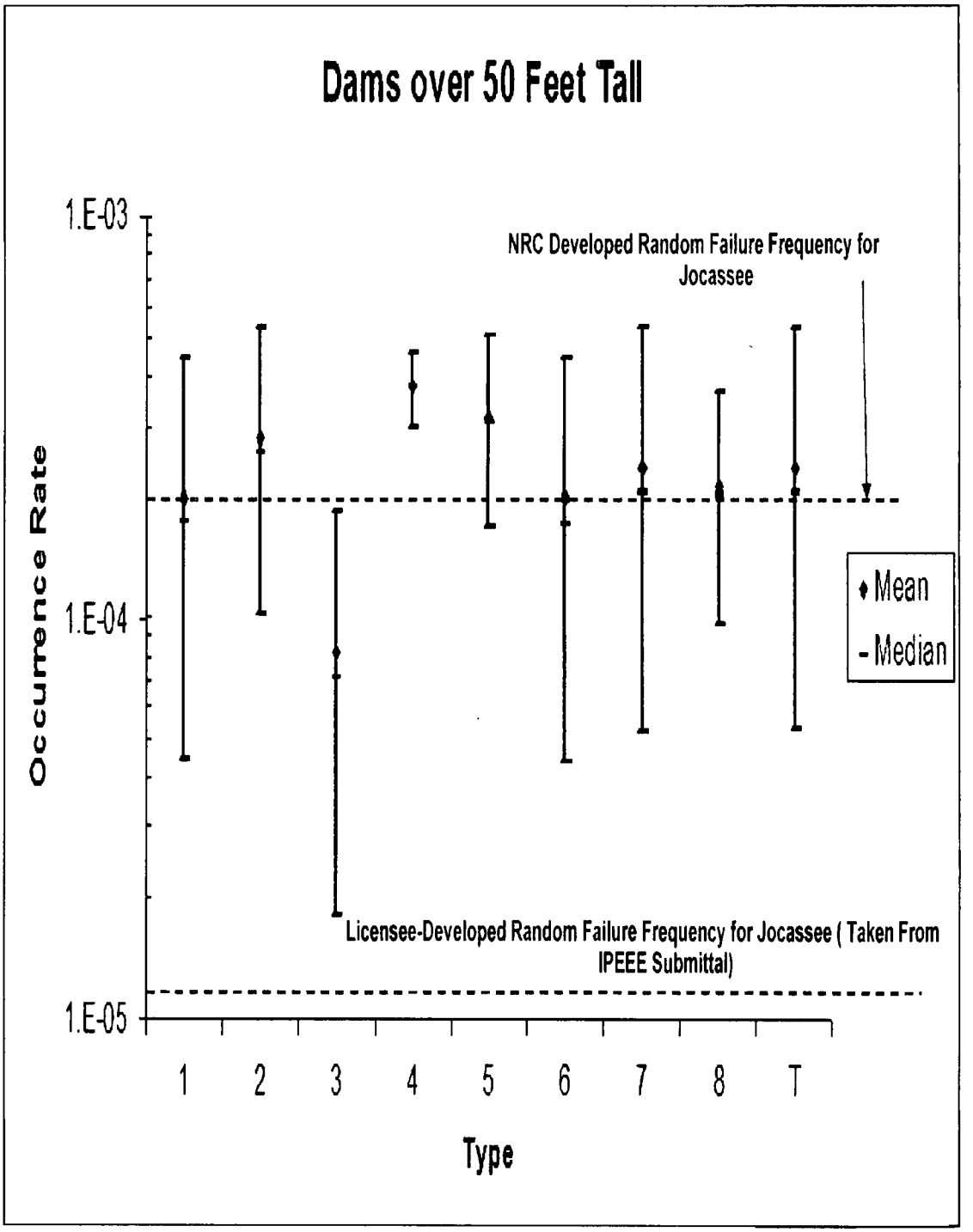


Perspective of Oconee Credible Event Protection



Summary of Random Dam Failure Frequency of Licensee Response

1	Buttress Dams Over 50 Feet High
2	Arch Dams Over 50 Feet High
3	Concrete Dams Over 50 Feet High
4	Earth Dams Over 50 Feet High
5	Gravity Dams Over 50 Feet High
6	Masonry Dams Over 50 Feet High
7	Multi-Arch Dams Over 50 Feet High
8	Rockfill Dams Over 50 feet high
T	Total



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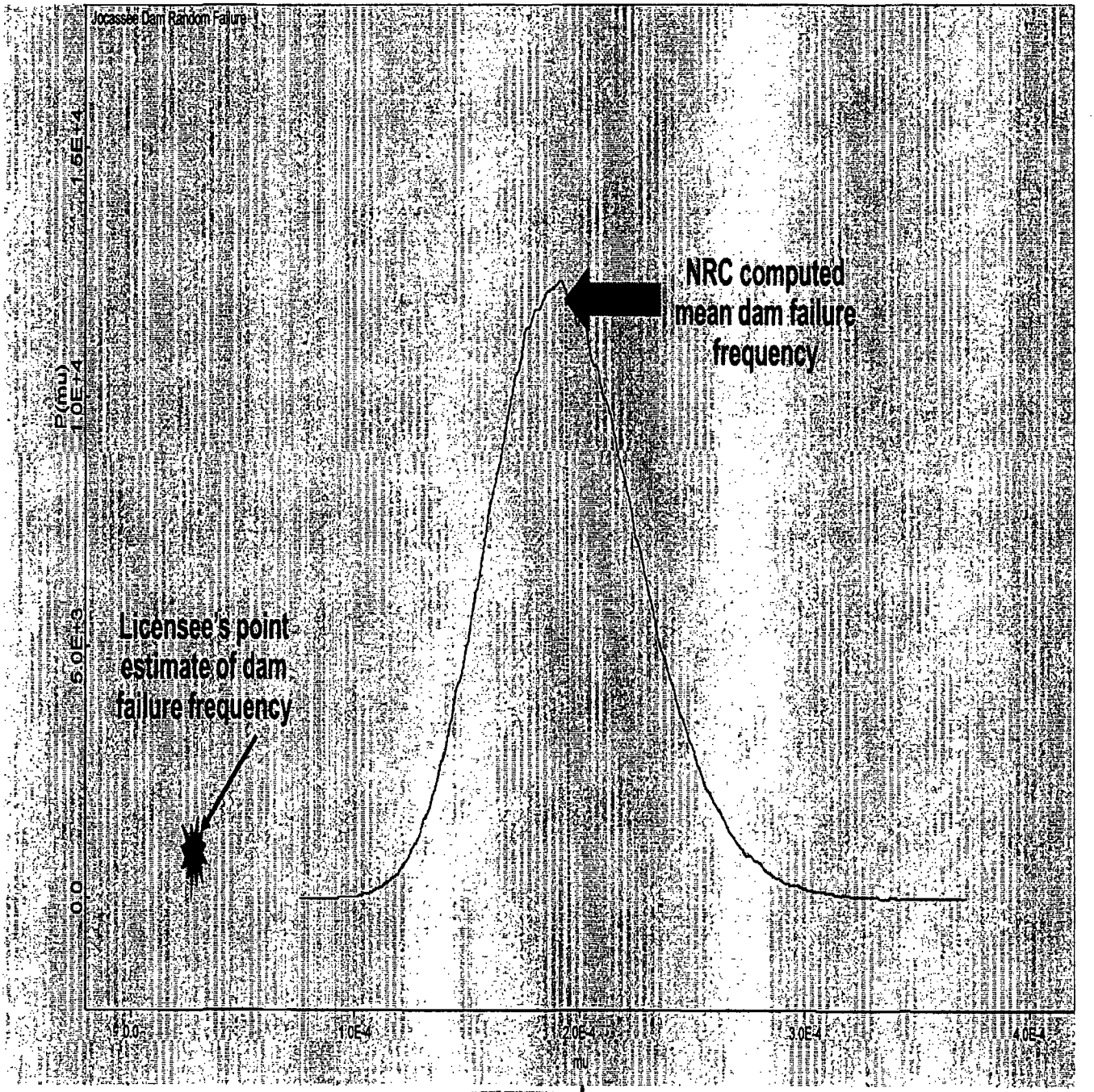
Probability Density of Jocassee Dam Failure Frequency



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Summary of Hydrology Aspects of Licensee Response

Flood Analysis for Oconee Nuclear Station

- The licensee proposed to use the Hydrologic Engineering Center River Analysis System (HEC-RAS) to model and estimate the flood depth at the ONS.
- HEC-RAS is a one-dimensional hydraulic model used to model networks of canals and reaches of rivers.
  - Typically, one-dimensional models are not appropriate near complex topography and submerged structures
  - Limitations of using a one dimensional model:
    - Flow path is parallel to stream path
    - Quantities such as velocity are uniform across the river.
    - Quantities such as velocity are uniform with depth.

Flood Analysis for Oconee Nuclear Station.

Site Topography at Oconee Nuclear Station.

Flood Analysis for Oconee Nuclear Station.

Two dimensional (Depth Averaged) hydraulic models allow for modeling unusual flow patterns over complex topography. Two-dimensional models are applicable under the following circumstances

- Flow varies in 2 dimensions
- Cross-stream
- Circulations
- Split flow around objects or topography
- Complex floodplains

Two-dimensional models are capable of investigating areas near submerged structures and over complex topography.

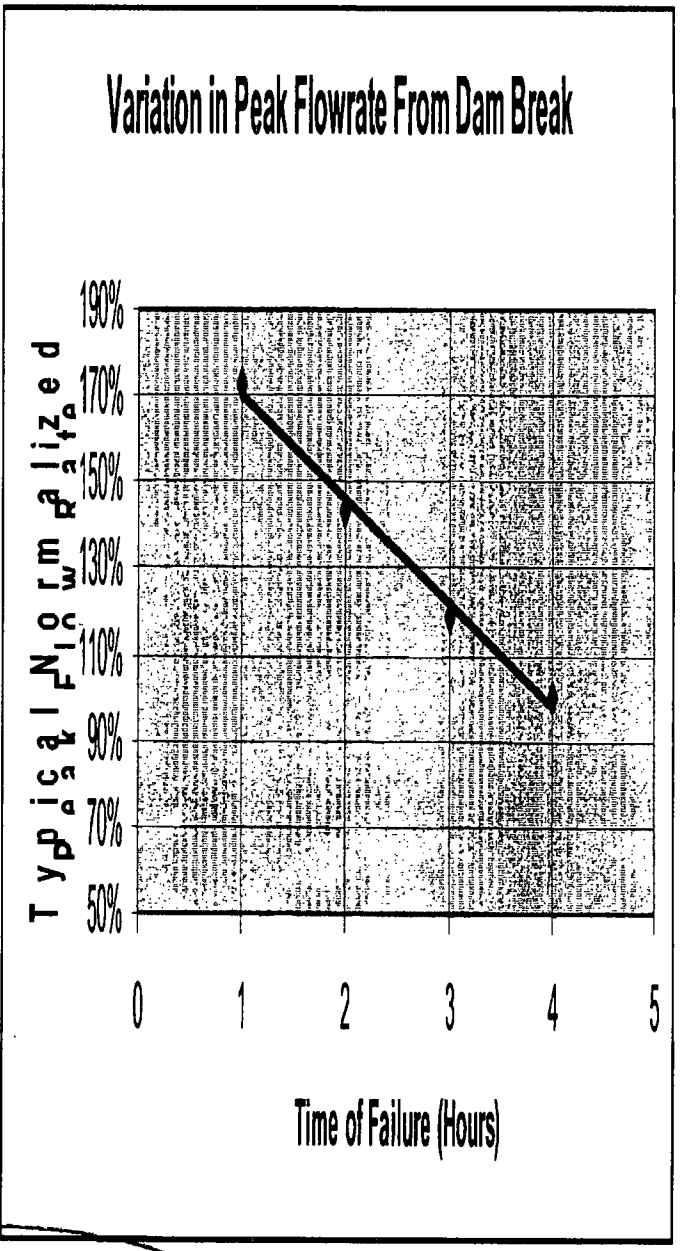
Since the topography in the immediate vicinity of the ONS is complex and in close proximity of the Keowee dam a two-dimensional model is needed to adequately represent the complex flow at the site.

Flood Analysis for Oconee Nuclear Station

- 1983 Study (Case 1) (Documented by KA Anthony in Memo)
  - Failure time of 2 hours
  - Median breach width of 575 ft
  - Maximum flood height of 4.7 ft (Sunny Day Failure)
  - PMF not considered
  - Licensee responded by building a 5 ft flood wall
- 1992 Study (Study Requested by FERC)
  - Failure time of 4 hours
  - Median breach width of 575 ft
  - Maximum flood height of 12.5 ft (Sunny Day Failure)
  - Maximum flood height of 16.8 ft (PMF with dam failure)
  - Predicted flood overtops SSF after 5 hours
  - Licensee took no action
- No explanation was given for adjusting failure time from the 1983 value (2 hours) to the 1992 value (4 hours).
  - The licensee claims that their chosen value of 4 hours for the failure time is conservative based on the time of failure for Hell Hole dam (18 Hours).

Sensitivity of Flood Analysis

- Any reduction in the failure time for Jocasseee dam will directly reduce the amount of response time. For example, a reduction in the failure time from 4 hours to 2 hours would mean the SSF would overtop in 3 hours not 5 hours, causing core damage to occur 2 hours earlier.
- Also any reduction in the time of failure for Jocassee dam would increase the maximum flow rate and flood height



Summary of Seismic Aspects of Licensee Response

Inadequacies of Jocassee Dam Seismic Fragility Based on Duke 2007 Submission

- Updated seismic hazard curves are not current
- Liquefaction analysis of sandy material was not done by Duke
- Assumed failure modes do not include catastrophic failure surface
- Increased vertical settlement over time implies probability of soft material at base of dam which may have a liquefaction potential

Decision-making Factors

Overall Staff Conclusions

- The NRC staff met to assess the Licensee's response.
- Two options emerged:

  -- an engineering solution of installation of watertight doors to the SSF

  -- an analytical approach of further analysis by the licensee
- Further regulatory action will be required.
- Interim operation appears feasible with an additional licensee commitment.
- The presentation will provide background to options and pros and cons to each.