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Oconee Flood Protection and the Jocassee Dam Hazard

NRR LT Meeting
October 21, 2008

10/5/2012

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Objectives

- Purpose
 - To discuss the specific questions raised
 - summarize the licensee's responses
 - discuss the staff's evaluation
 - discuss possible paths forward
 - To receive LT feedback on
 - staff's evaluations
 - merit of possible paths forward

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Agenda (not to be included)

- Review of issue and site background
- Prior staff work in backfit evaluation
- 10 CFR 50.54(f) Letter
- Evaluation of Licensee's Response
- Team members
- Overview of options based on review of 50.54(f) response
- Risk-informed decision making process
 - Assessing the licensee's response to the 10 CFR 50.54(f) letter
 - Topics considered in support of decision
 - Likelihood of dam failure
 - Flood analysis (nominal and PMP lake levels)
 - Seismic analysis
 - Security
 - Basis for continued operation
- Conclusions and Recommendations
 - Pros and cons of options
- Summary

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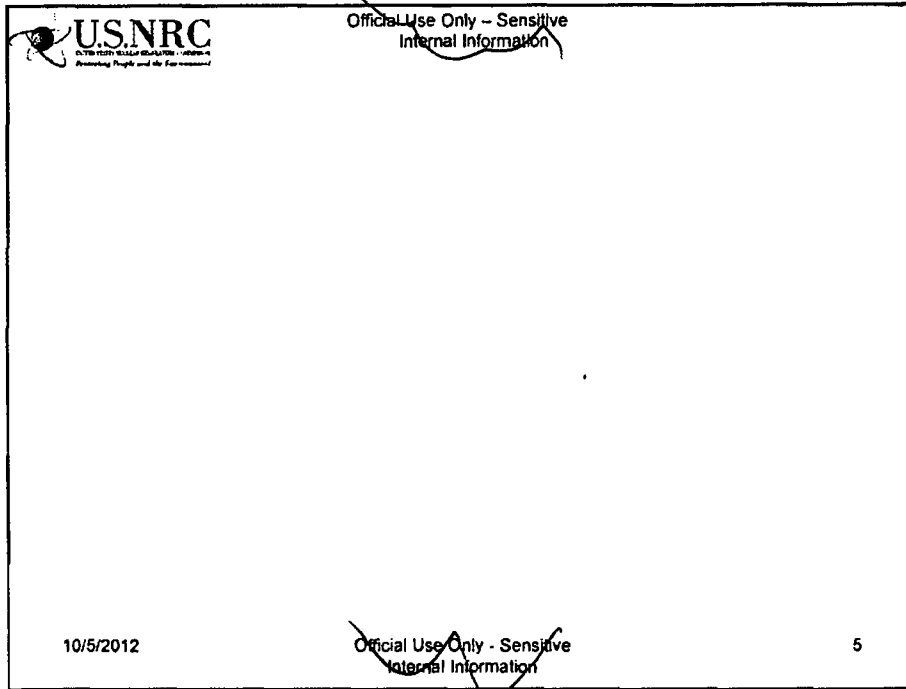
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Summary

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Site Background

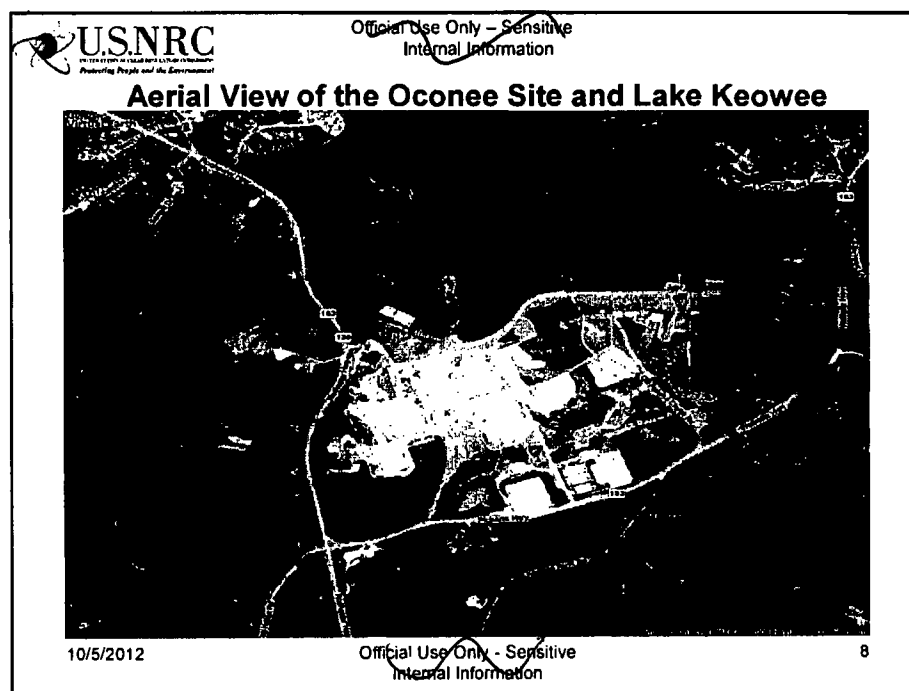
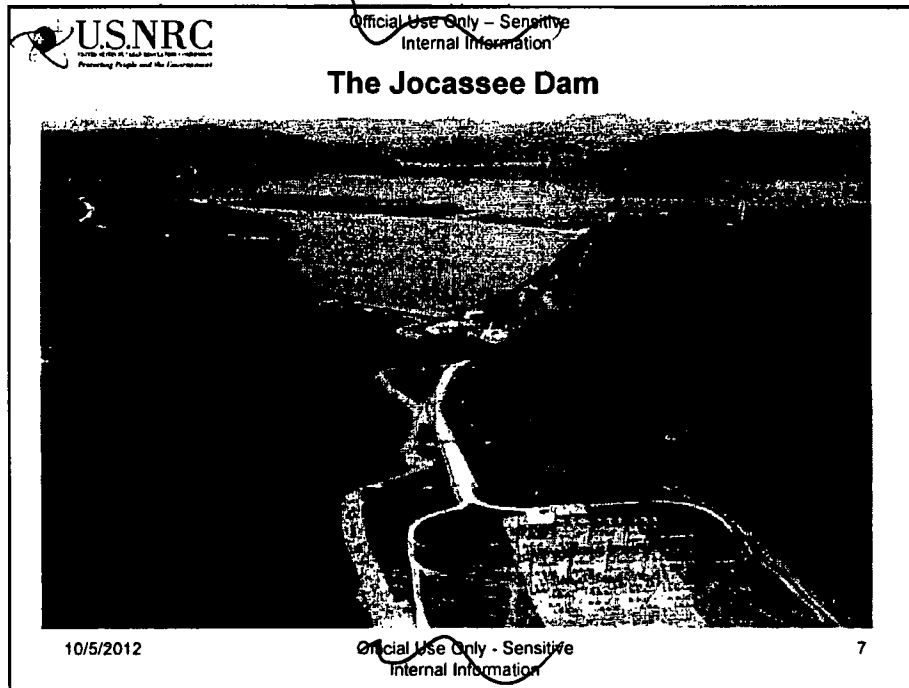
Oconee Nuclear Station

- 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 to maintain reactor shutdown in case of fires, floods, or sabotage events.

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Issue Background

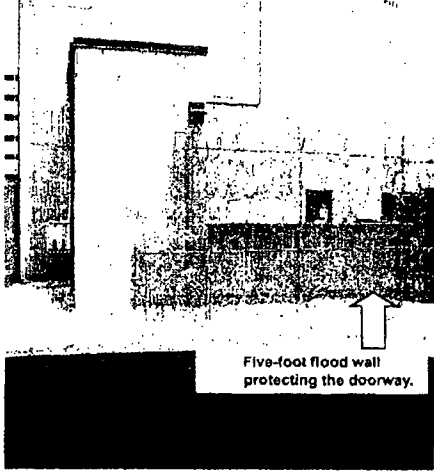
- NRC inspection identified flood protection issue with Oconee Standby Shutdown Facility (SSF).
 - Potential lack of adequate flood protection and defense-in-depth upon loss of SSF
 - Five-foot walls constructed over SSF entrances to protect against Jocassee Dam failure based on unavailable inundation 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



Five-foot flood wall protecting the doorway.

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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.

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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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Licensee Response to 10 CFR 50.54(f) Letter Question 1

- Dams are constructed with adequate freeboard to accommodate the effects of probable maximum precipitation (PMP).
- Design of Jocassee was to the same seismic input as Oconee site.
- FERC study was not to assess credible flood heights for Oconee site.
- Random "sunny day" failure of Jocassee not credible due to design, construction, and inspections conducted.
- Embankment failures should be excluded.

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Licensee Response to 10 CFR 50.54(f) Letter Question 2

- The FERC Inundation study is the only study on record.
- Licensee feels that it is not applicable to Oconee since it was developed to determine evacuation plans.
- Piping failure of Jocassee Dam was not considered credible and of low frequency based on response to question 1.
- Questions on timing of Keowee Dam failure after overtopping.

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Licensee Response to 10 CFR 50.54(f) Letter Question 3

- Licensee states that SSF will survive flood based on assumption that Jocassee Dam failure will produce flood heights of less than 5-ft.
- For floods greater than 5-ft, the SSF will be unavailable leading to early core damage.
- Licensee assumes reactor shutdown in 1 hour with floodwater reaching site in 5 hours.
- Core damage will occur in 8 to 9 hours with containment failure in 59 to 68 hours.

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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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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.

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LIC-504 Risk-informed Decision Making Process [create new title w/o ref to 504]

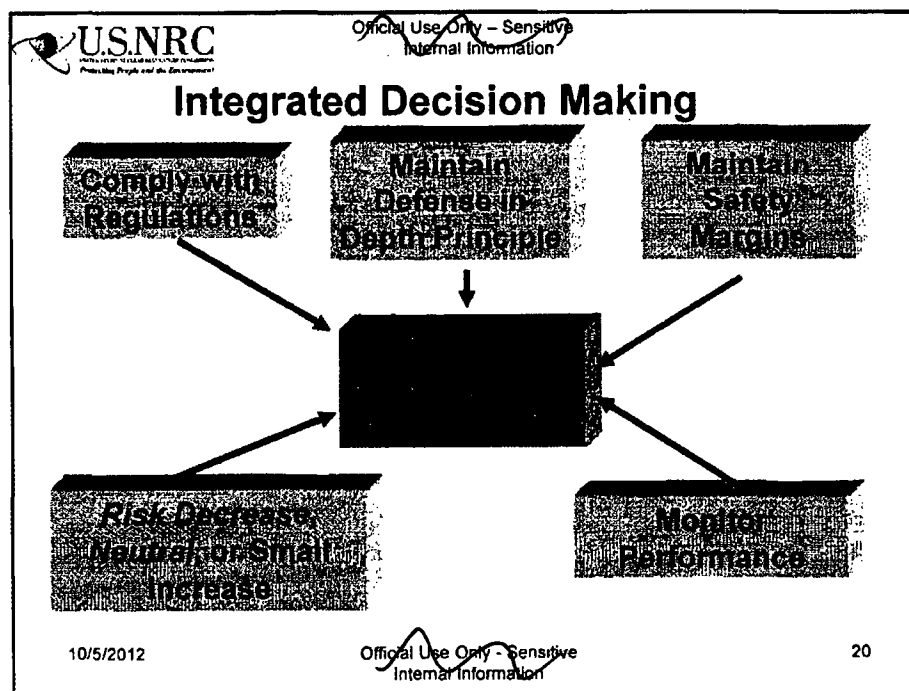
- Assessing the licensee's response to the 10 CFR 50.54(f) letter and supporting information
- Topics considered in support of options
 - Likelihood of dam failure
 - Flood analysis (nominal and PMP lake levels)
 - Seismic analysis
 - Security
 - Basis for continued operation

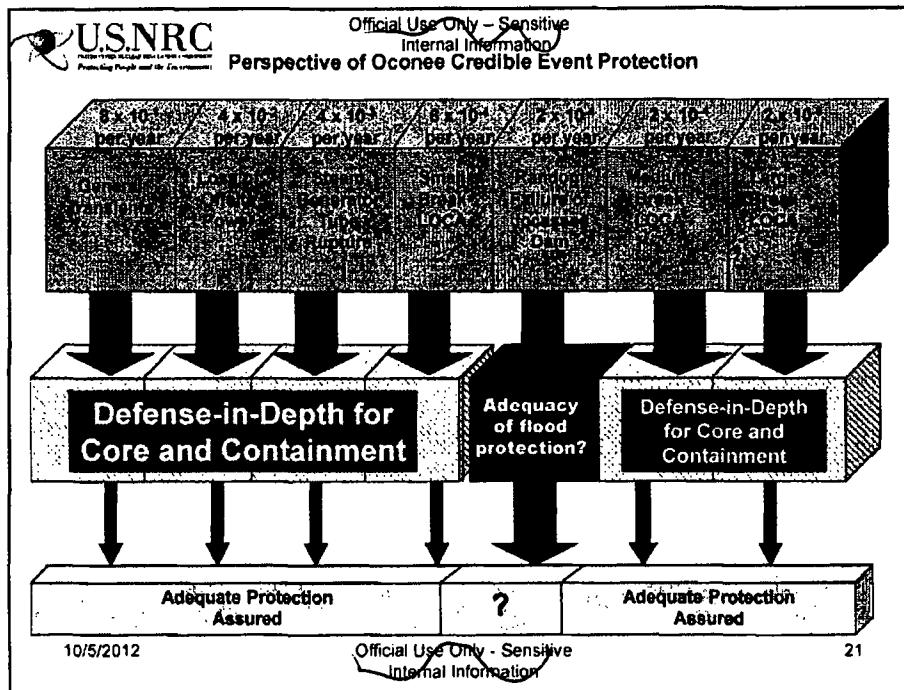
Note : THIS IS A PLACEHOLDER

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Summary of Licensee's Response to 50.54(f) Questions

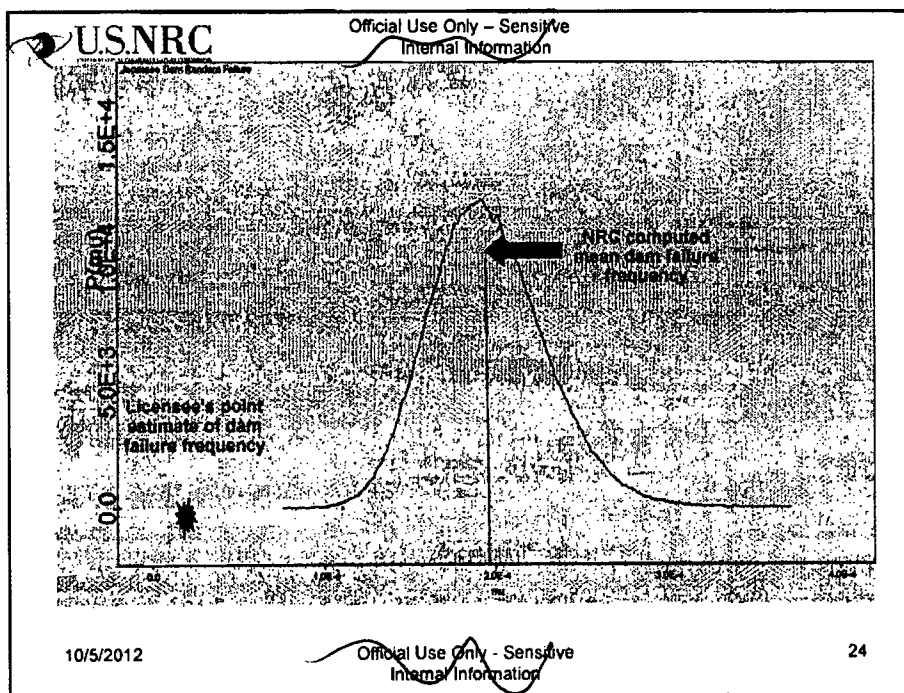
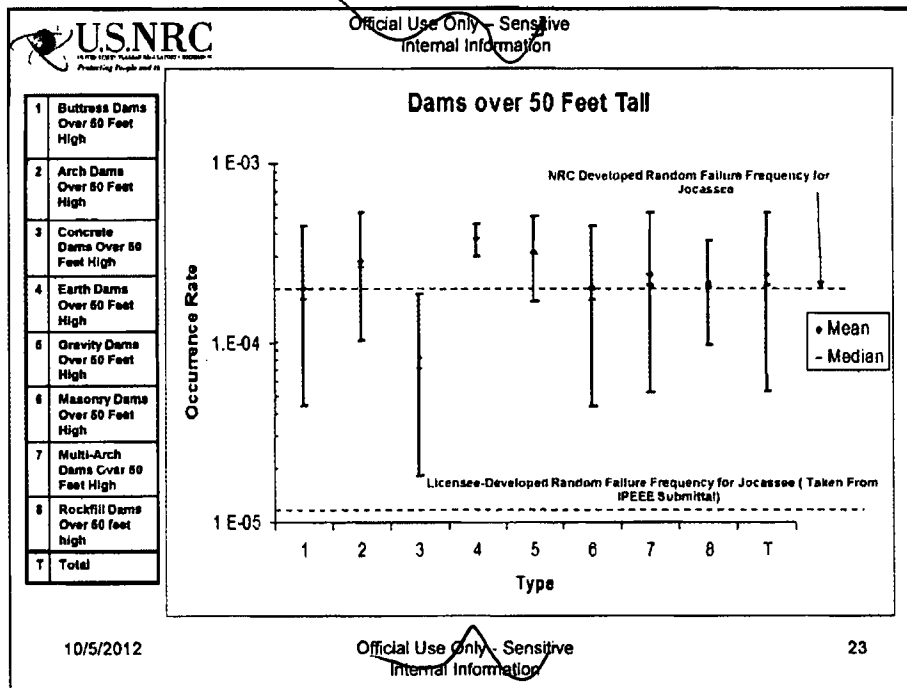
- Inundation levels based on current drought conditions.
- Commitment to increase current flood walls to 7.5 feet by February 2009.
- Further analysis by February 2010.
- Heavy reliance on test and inspection of dam.
- Seismic failure is not credible
- Other dam failure modes (i.e., overtopping) not credible.

*****UNDER DEVELOPMENT*****

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Flood Analysis for Oconee Nuclear Station

Choice of Hydraulic Model [consolidate 21-27 into 2 slides—points to make—time to failure not conservative, breach size not conservative, adequacy of 1-D model indeterminate due to complex site topography; keep slide 22]

In their 50.54(f) response letter, 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. One-dimensional models are limited to situations where the following are true.

- Flow path is parallel to stream path
- Quantities such as velocity are uniform across the river.
- Quantities such as velocity are uniform with depth.

Typically, one-dimensional models are not appropriate if the area of interest is located near complex topography and submerged structures because the fluid structure interactions tend to violate the assumptions given above.

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Flood Analysis for Oconee Nuclear Station.



Site Topography at Oconee Nuclear Station.

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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.

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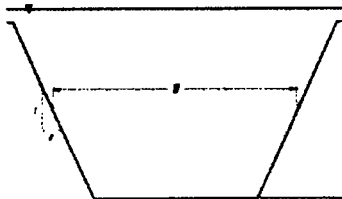
Flood Analysis for Oconee Nuclear Station.

Choice of Dam Breach Parameters

Definitions

Breach width, B – The maximum size of opening that develops in the dam over a specified period of time. Typically the opening is assumed to be trapezoidal in shape. The opening can be characterized by its side slope and the bottom or median width (See Figure).

Time of failure – the time for the breach opening to fully develop. The development is typically assumed develop linearly in time.



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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

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Flood Analysis for Oconee Nuclear Station.

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).

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Flood Analysis for Oconee Nuclear Station.

Any reduction in the failure time for Jocassee 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 (See Figure).

Variation in Peak Flowrate From Dam Break

Time of Failure (Hours)	Typical Normalized Peak Flow Rate (%)
1	175
2	150
3	125
4	100

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Inadequacies of Jocassee Dam Seismic Fragility Based on Duke 2007 Submission

- Scaled input motion with Factor of Safety. Updated seismic hazard is 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 (i.e., liquefaction potential)
- [this slide needs to be clearer]

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Jocassee Dam Seismic Fragility

FERC 2004 Part 12 Report [delete this slide]

- FERC 99 to 04 report shows a 5-year steadily higher vertical settlement
- There may be soft material near the base of dam

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