Oconee SSF Flood Barrier Breach SDP – Lessons Learned

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Purpose

- To inform DRA personnel of the lessons learned from the disposition of the Oconee Standby Shutdown Facility (SSF) wall SDP finding.
- To help encourage and foster a questioning attitude by staff on regulatory and enforcement processes.

Discussion Topics

- Background of finding.
- Technical lessons learned.
- Process lessons learned.
- Actions taken.
- Considered future actions.

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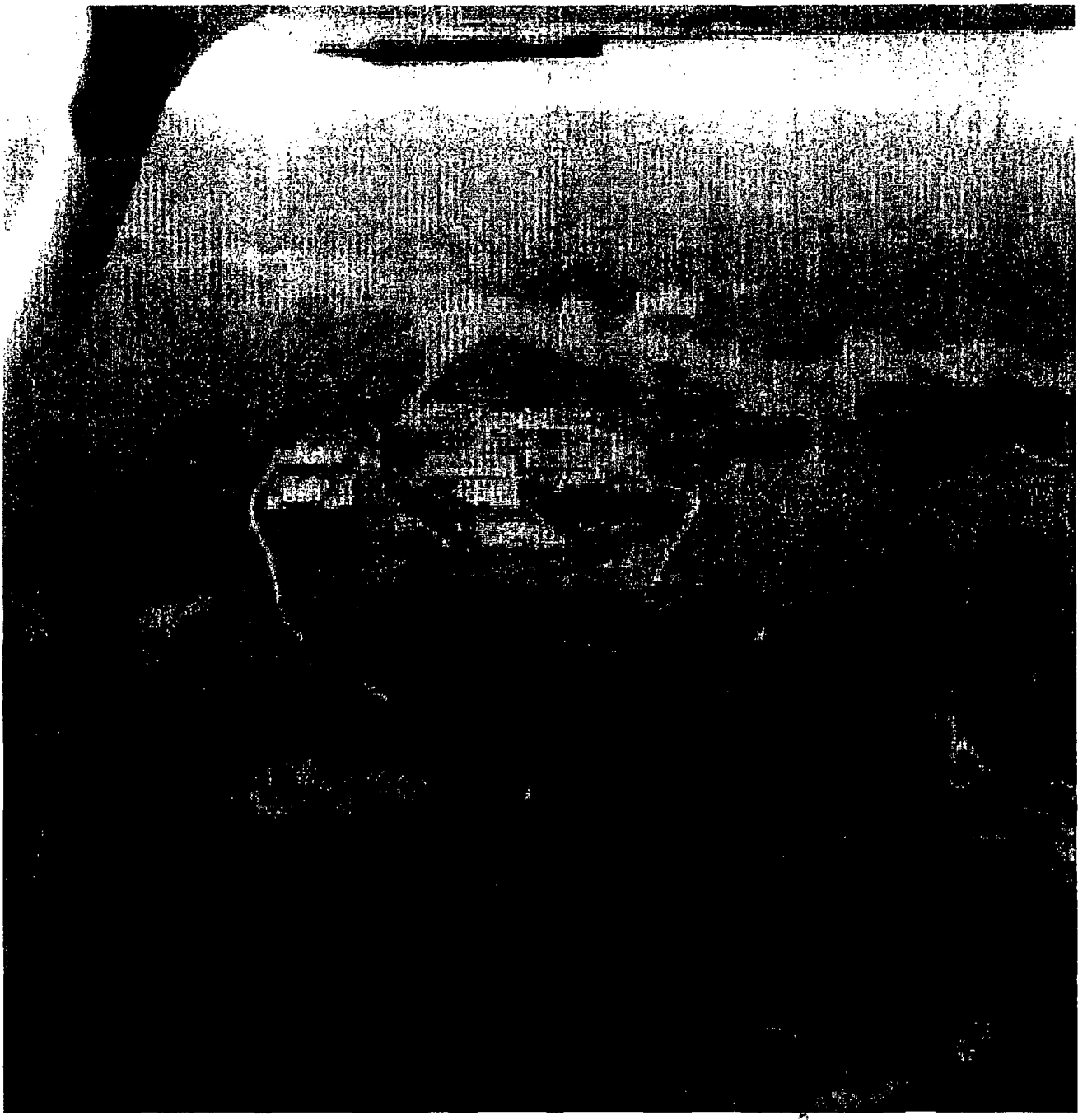
Importance of the SSF at Oconee

- The SSF contains the only means to shut all three units down following a station blackout induced by catastrophic flood, fire, or other external events.
- The Oconee site does not have emergency diesel generators.
  - On-site emergency ac power is provided by two hydro-electric generators at the Keowee dam.
- Catastrophic flooding to the site can render all the switchyards and Keowee dam unavailable thus blacking out all three units.
  - Under these conditions, the additional failure of the SSF function results in core damage.

Aerial View Showing The Relationship of the Oconee Site Environment and Lake Keowee



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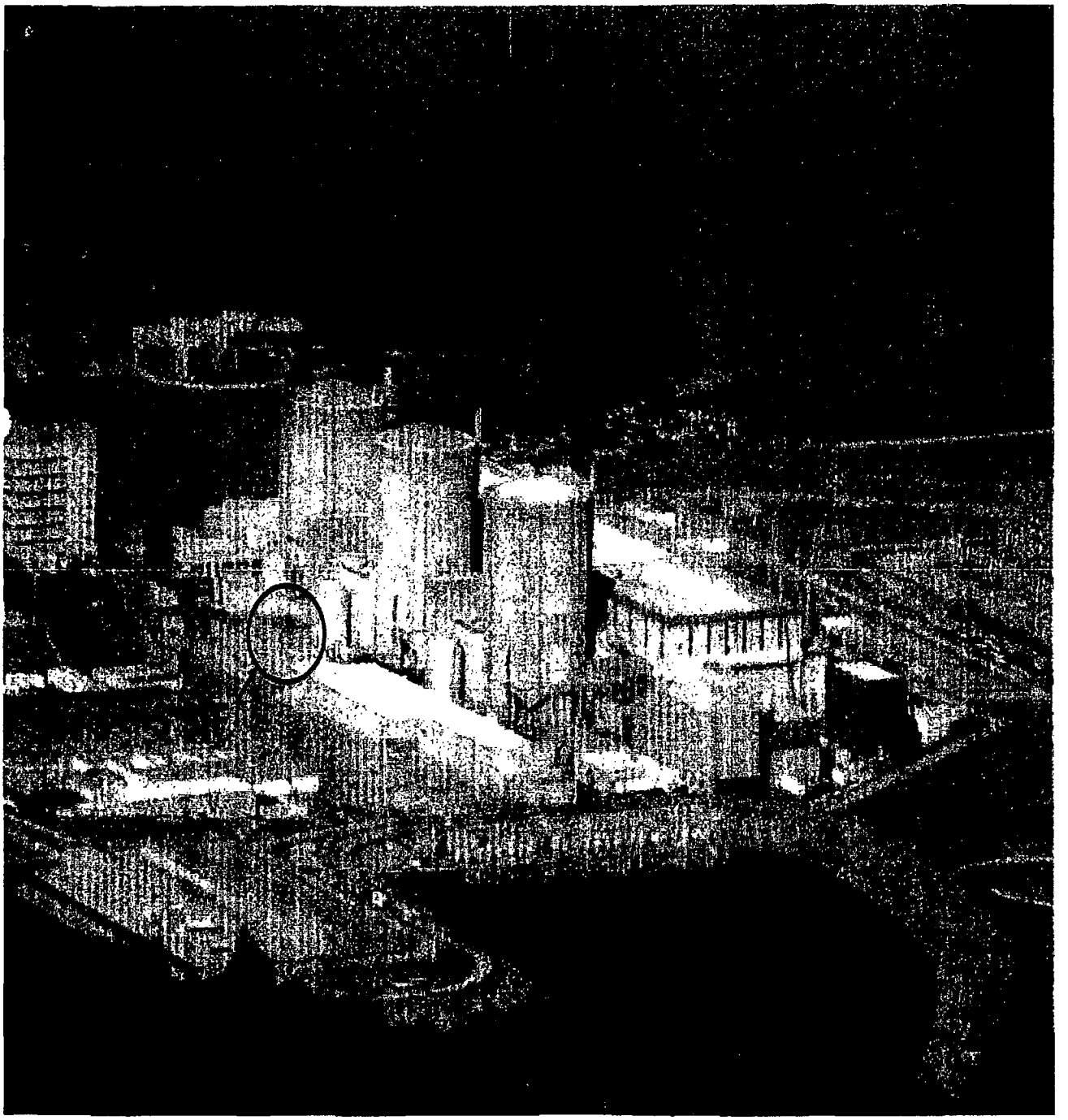
Aerial View of the Oconee Site



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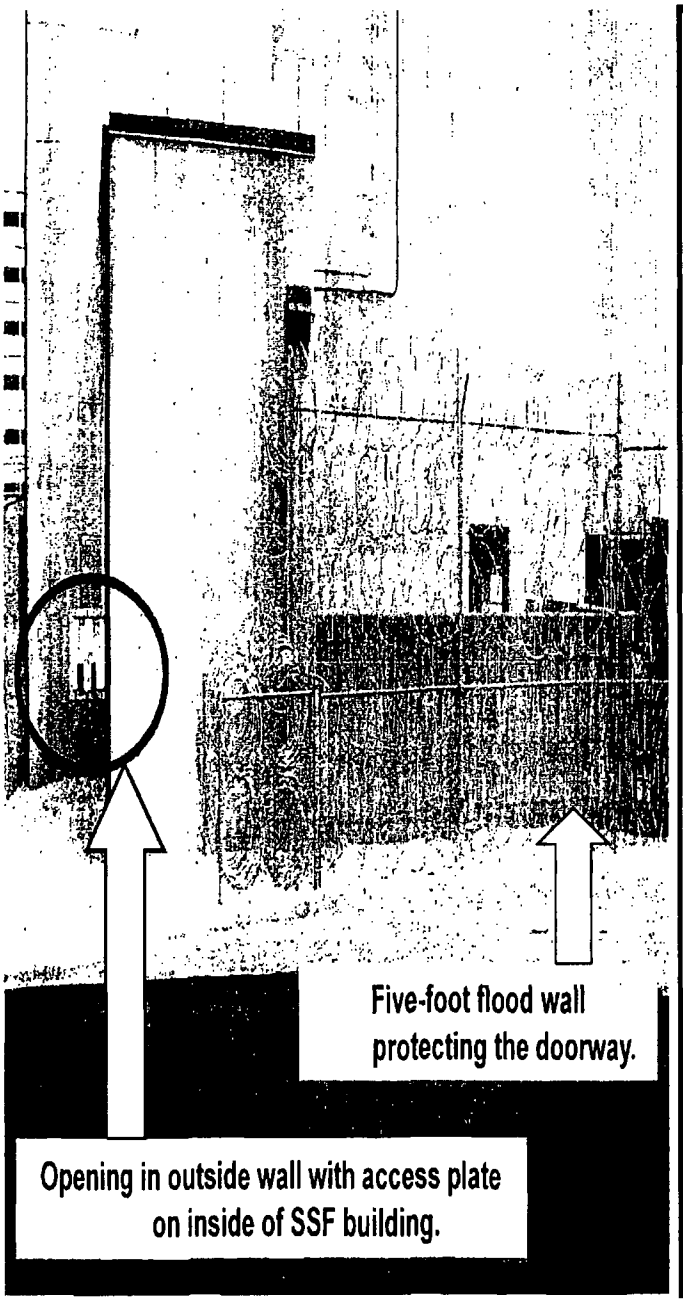
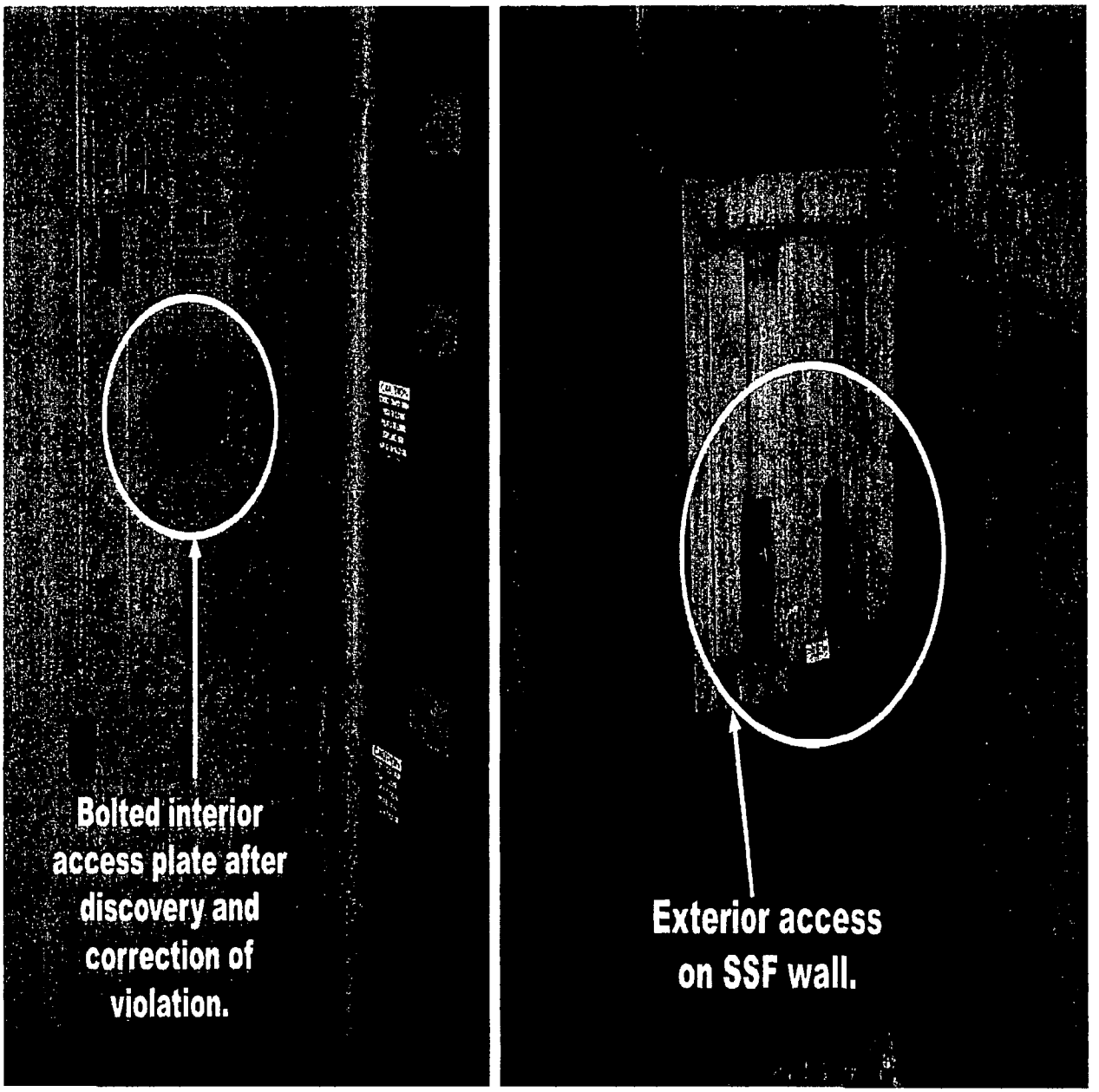
The Flood Barrier Finding



- Licensee opened an access cover uncovering a previously cut hole in the wall on August 13, 2003.
  - Should have done a 10CFR50.65 (a)(4) assessment immediately.
  - Should have done a 10CFR50.59 evaluation after 90 days.
- Licensee opportunities to identify issue
  - June 2, 2005 NRC inspectors notified the licensee of condition. Licensee issued PIP (condition report in their corrective action system). Corrective action not taken.
  - August 3, 2005 NRC inspectors questioned lack of corrective action and licensee issued a further PIP.
- Opening sealed on August 3, 2005.

Interior and Exterior Walls of SSF



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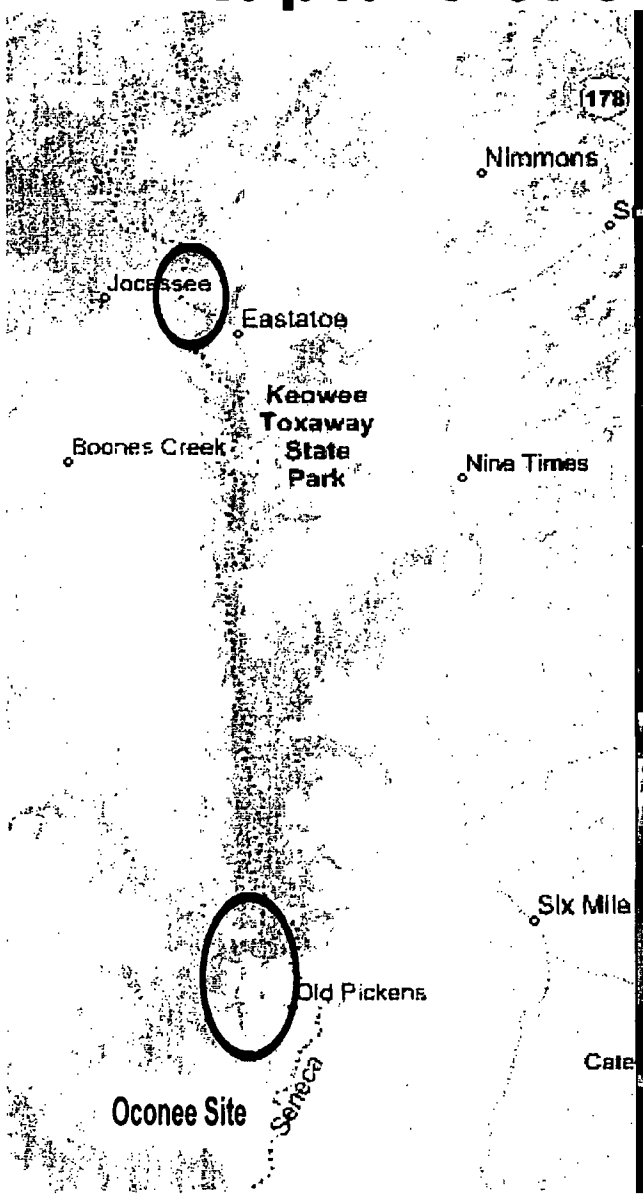
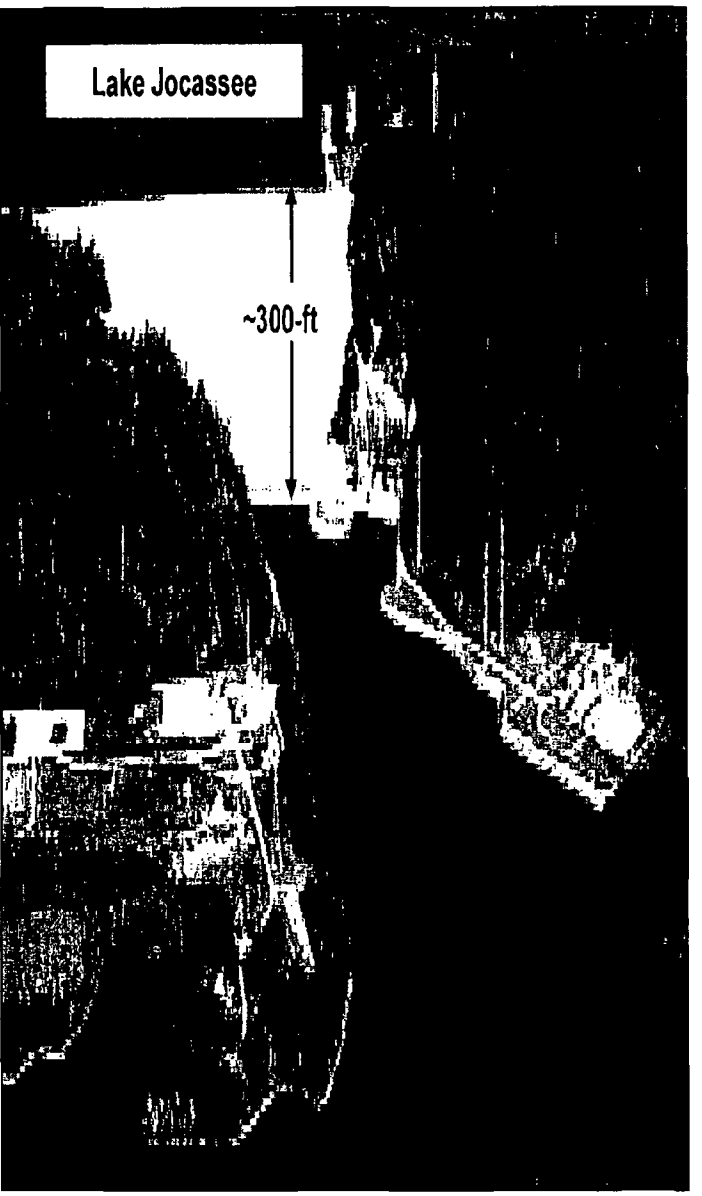
The Flood Scenario
Rupture of Jocassee Dam





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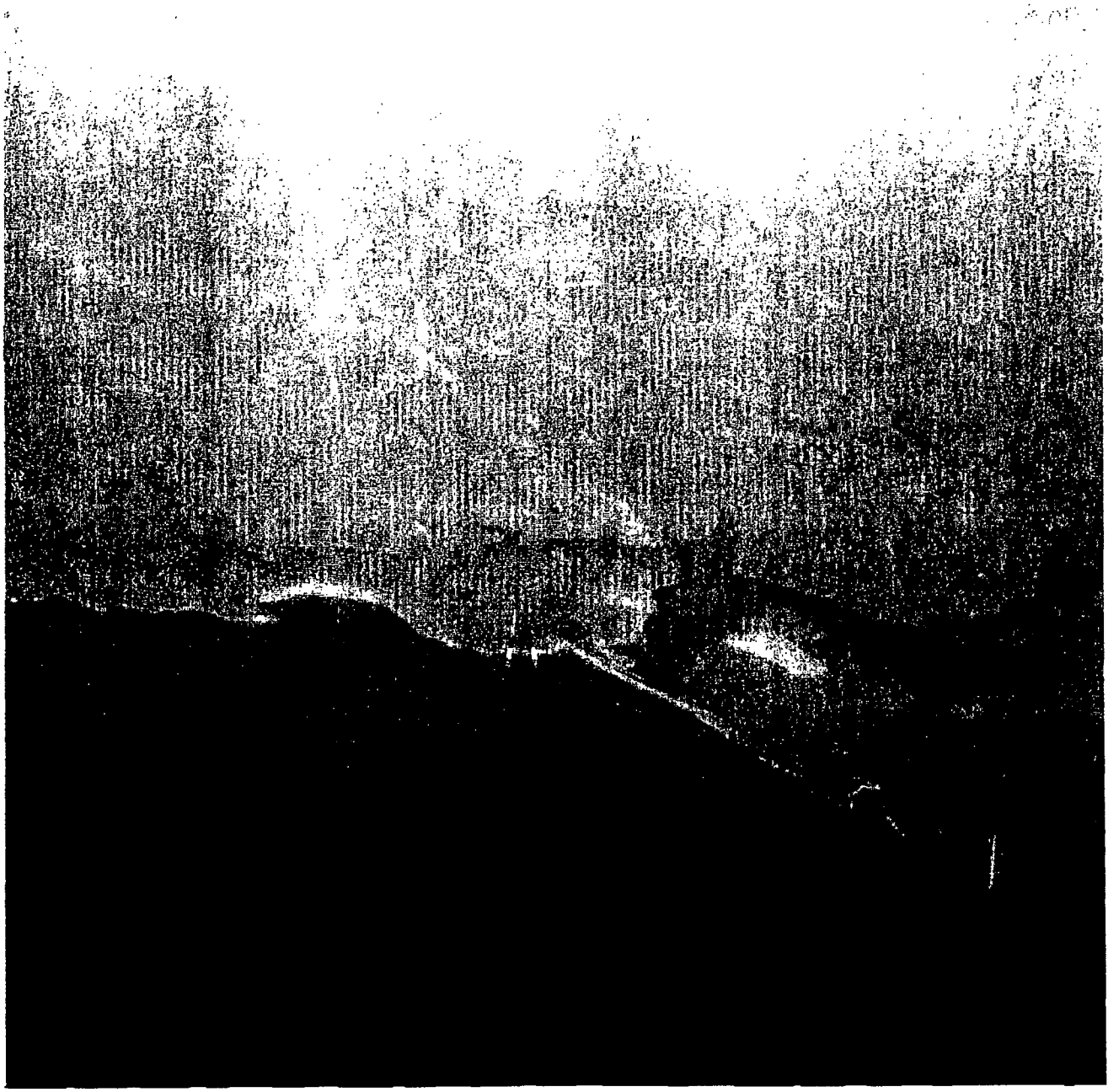
Aerial View of Jocassee Dam - Upstream of the Oconee Site



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SSF Catastrophic Flood Heights Given Rupture of Jocassee Dam

- Licensee study in 1980s established a resultant flood height of approximately 5 feet.
  - Justification for erection of the 5-ft wall around the doorway.
  - Study is unavailable.
  - Flood height almost matches that of overtopping of Keowee dam.
- Licensee commissioned additional study by FERC in 1992.
  - Established a higher resultant flood height range of 12-16 feet.
  - Licensee still used the 5-ft height for their IPEEE submittal developing a 20% split fraction apportioning the Jocassee Dam rupture frequencies to account for these higher FERC flood heights.

Background Summary

- August 17, 2006 - SERP meeting assessed as preliminary WHITE based on a blended qualitative and quantitative risk-informed approach (pre-IMC 0609 App M).
- August 31, 2006 - Choice letter sent to licensee.
- October 5, 2006 – Licensee provided written response to choice letter and waived regulatory conference.
- Nov. 22, 2006 - Final significance determination issued. WHITE based on qualitative erosion of defense-in-depth, but includes quantitative CDF based on apportioning flood frequency to flood height.
- December 20, 2006 - Licensee appeals the final significance determination. Requests NRC to accept incomplete, un-docketed new information on Jocassee dam seismic failure.
- Appeal panel convened on January 9, 2007.
- Licensee contractor seismic fragility analysis of Jocassee issued January 29, 2007.
- March 1, 2007 – Appeal panel upholds WHITE finding.
- May 3, 2007 – Licensee requests reassessment of final significance determination.
- June, 2007 – Assembled a team to review new information. Flooding expert review of data on random dam failure.
- June 28, 2007 - Follow up telecom with Licensee on dam failure questions and comments.
- July 17, 2007 - Licensee response to analysis questions by email.
- September 5, 2007 – Final SERP split vote forces upper management resolution.
- November 20, 2007 - Final determination letter released to licensee.

Jocassee Dam Random Failure Frequency

- Licensee developed random dam failure frequency for IPEEE submittal based on rockfill dam failures per population of earthen, rockfill, and composite dams.
  - Severely underestimated frequency by an order of magnitude at 1.4E-5 per year.
- As part of the second appeal, DRA/APOB investigated the derivation of this frequency.
  - (b)(7)(F)

Dam and Dike Failure

- Dam failure is well documented and can be characterized by type of dam.
- Of the 79,777 dams in the US, 72% are embankment type and 28 % are concrete.
- Nineteenth century dams would fail at 5% in the first five years after construction but would settle out to a 1 to 4% additional failure by 20 years of life.
- This failure rate was reduced to 2% in the first 5 years for dams built after 1930.
- By 1960, dam failure rates were less than 0.01% due to better engineering.
- Whatever the era, half of all dams that ever fail, do so in the first five years. This high infant mortality is often due to piping in the soil around the dam or underneath it. Even concrete dams are not immune. However, dam construction dropped dramatically after 1980 so that nearly all dams are older than 5 years.

Technical Lessons Learned
Investigation of Dam Failure Frequencies

http://crunch.tec.army.mil/nid/webpages/nid.cfm

http://npdp.stanford.edu/index.html

	Failures	Dam-years	Mean
All Arch Dams	2	9101	2.1E-04
All Buttress Dams	2	9819	1.9E-04
All Concrete Dams	10	110227	9.3E-05
All Earth Dams	366	2240403	1.6E-04
All Gravity Dams	28	122798	2.3E-04
All Masonry Dams	5	21692	2.2E-04
All Multi-Arch Dams	0	240	1.5E-04
All Rockfill Dams	7	55872	1.3E-04
All Stone Dams	2	11365	1.7E-04
All Timber Crib Dams	3	6536	3.6E-04
Total	425	2605987	1.6E-04

	Failures	Dam-years	Mean
Buttress Dams Over 50 Feet	0	1876	2.0E-04
Arch Dams Over 50 Feet	2	5667	2.8E-04
Concrete Dams Over 50 Feet	0	19215	8.2E-05
Earth Dams Over 50 Feet	56	144810	3.8E-04
Gravity Dams Over 50 Feet	7	19542	3.2E-04
Masonry Dams Over 50 Feet	0	1987	2.0E-04
Multi-Arch Dams Over 50 Feet	0	77	2.4E-04
Rockfill Dams Over 50 feet	4	19900	2.1E-04
Total	69	213184	2.4E-04

Licensee Evaluations

- Only two IPEEEs addressed dam failure floods quantitatively – Ft Calhoun and Diablo Canyon. Everyone else only addressed probable maximum precipitation and screened out dam failure as low probability.
- Unfortunately, there were few dam failure data sources around back then, so many plants used the estimate published in NUREG/CR-5042. The data source for the estimate in NUREG/CR-5042 was the Oconee PRA - NSAC/60. The estimate of 2.5E-05/dam-year in NSAC/60 was done in error by an order of magnitude and it propagated throughout the industry.
- **References**:
  - NUREG/CR-5042, "Evaluation of External Hazards to Nuclear Power Plants in the United States.
  - NSAC/60, "Oconee PRA"

SPAR Considerations for External Flood

- Dams as far up or downstream as 300 miles should be considered for both flood and loss of heat sink. It is noteworthy that all forms of dams have a failure rate between 1E-4 and 4E-4, even for blue sky events.

- Determining flood levels, however, is a complex matter. The USACOE has software named HEC RAS that when combined with GIS geographical data will model river flow and flooding in great detail.

- Weather based floods remain in the deterministic world because the input conditions are always from the same source as was used in the original plant design basis. Besides, the growth of the maximum precipitation only increases about 20% when a 100 year interval is compared to a 1000 year interval. With only 100 years of data available in many locations, projecting beyond a 1E-3/yr event is very uncertain anyway.

Process Lessons Learned

- Process did not account for situations where licensee did not communicate to the regional office and waived participation in a regulatory conference.
- Process did not accept new information prior to final determination.
- Without a regulatory conference, communication was impacted to program office and regional management of potential greater-than-green SDP findings.

Actions Taken

- IMC0609 in draft revision to account for:
  - Licensees may present new information provided that they informed the agency either during a regulatory conference or in writing before the final significance determination is made.
  - New information has to be submitted within the 30-day appeal period.
  - Using best available information to determine final significance in a timely manner.
  - NRR concurrence with regional management on accepting an appeal.

Actions Taken (cont'd)

- Training conducted to regional Senior Reactor Analysts (SRAs) in recent counterparts meeting.
- Met with NSIR to inform DHS on potential dam and other outside infrastructure vulnerability.

Considered Future Actions

- NRR Program Office Director and/or Deputy Director should be informed of all greater-than-green findings.
- Exploration of licensing and potential backfit requirement for protection against most likely flood.
- Generic communication to licensees on flooding.