Oconee Nuclear Station Regulatory Conference

East Penetration Room Blowout Panels/Auxiliary Building Flood Mitigation

NRC Region II Office
Atlanta, Georgia
May 17, 2006

Agenda

- Introductions
- Opening Remarks
- Background / History
- Licensing Basis Discussion
- Risk Analysis Input Differences
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- Closing Remarks

Duke Participants

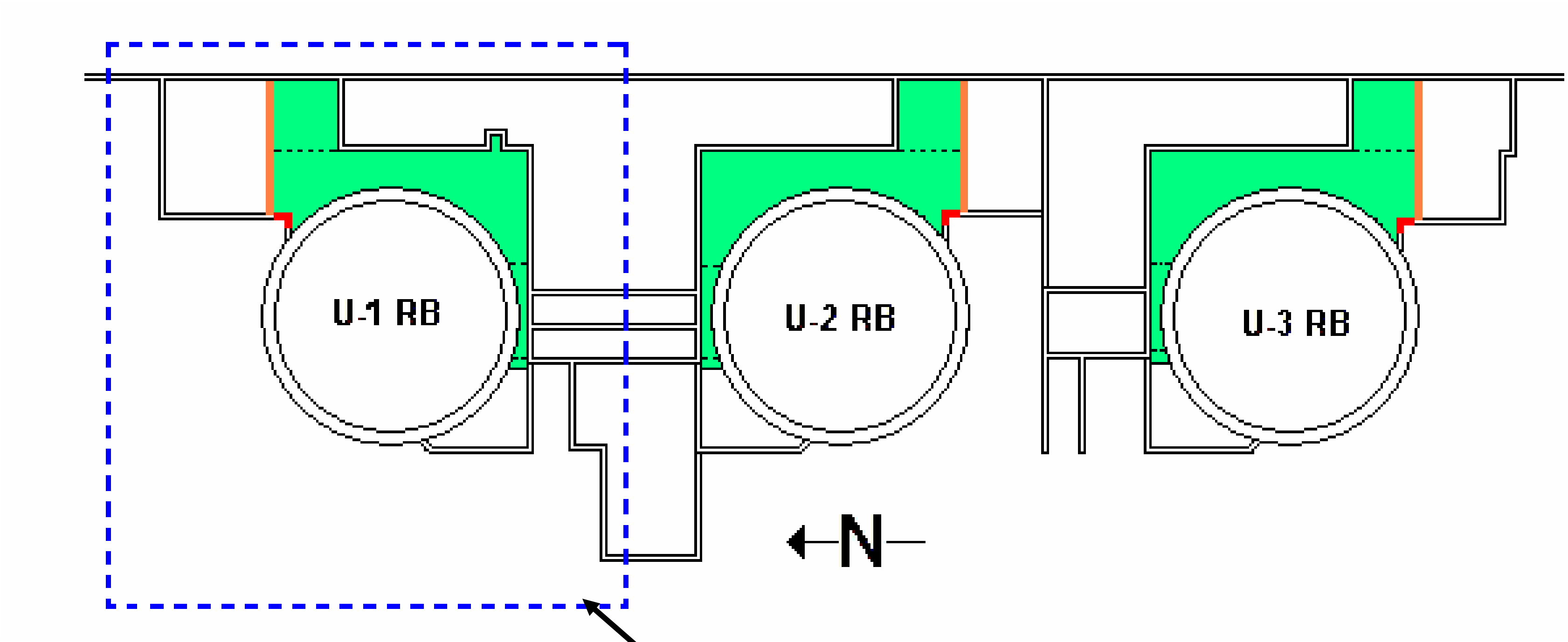
- Bruce Hamilton, Oconee Site Vice President
- Mike Glover, Oconee Engineering Manager
- Rich Freudenberger, Engineering Supervisor
- Graham Davenport, Oconee RCG Manager
- Tim Brown, Oconee Tornado/HELB Team
- Allen Park, Oconee Tornado/HELB Team
- Lee Kanipe, Duke PRA Engineer

Opening Remarks

- The Auxiliary Building (AB) flood associated with a HELB event is included in the scope of the ongoing Oconee HELB Reconstitution Project.
- Oconee remains safe today because of the low probability of HELB events in the East Penetration Room (EPR)
- Duke quantitative analysis supports this conclusion.
  - Overall change in core damage frequency (ΔCDF) less than 1E-6.

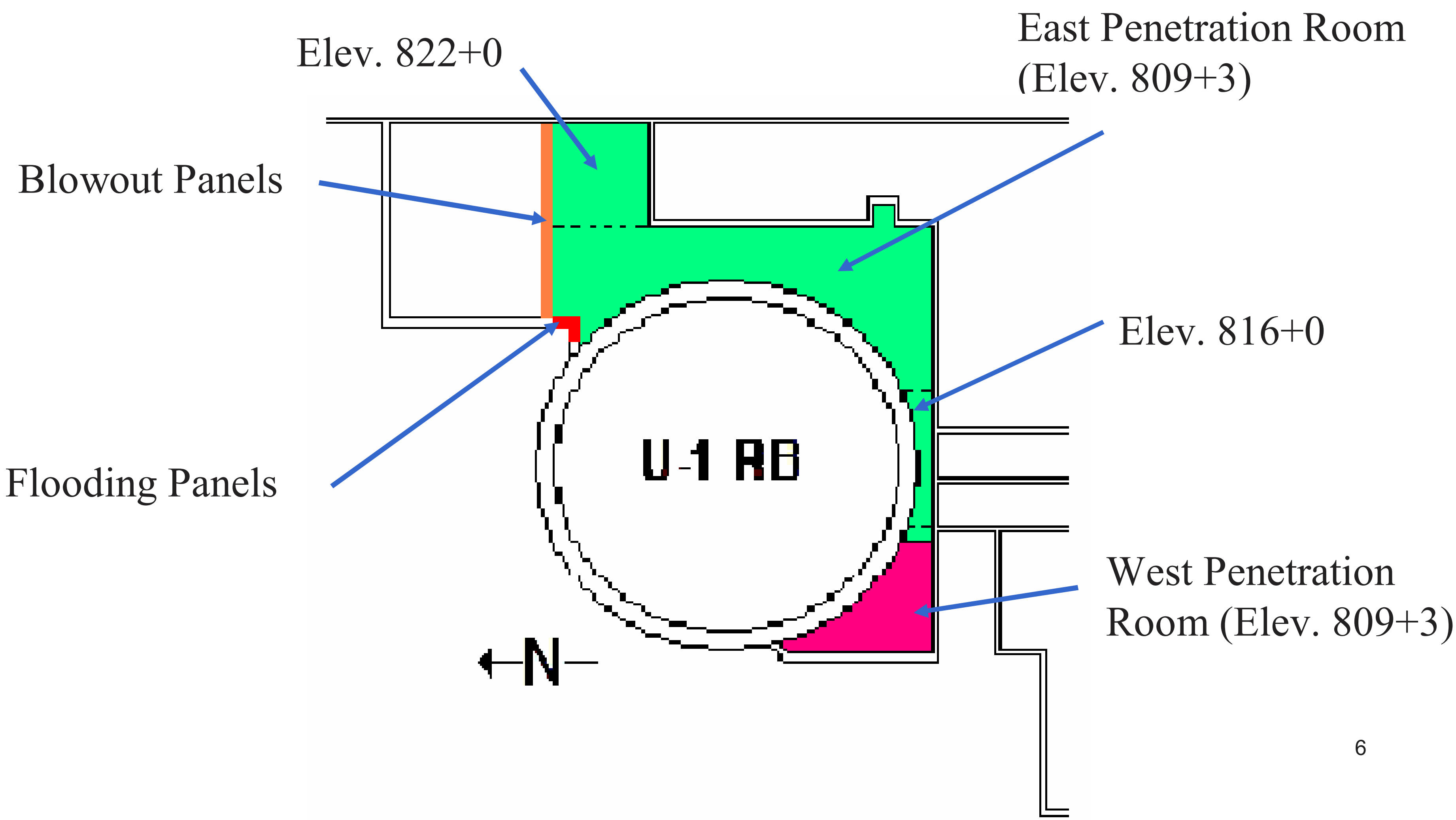
Plant Layout

Turbine Building



See Detail on Next Slide

Plant Layout
Typical Unit



Background / History

- Blowout panels installed in each Oconee Units EPR are designed to relieve pressure following postulated Main Steam Line Breaks (MSLBs) and Feedwater Line Breaks (FWLBs).
- Prior modifications strengthened the panels beyond that described in the UFSAR.
- Issue was first identified in 2001,
  - Some repairs made upon discovery but these did not restore the panels to their CLB configuration.
- Although the strengthened panels would impede the flow of water to outside of the room, several of the 'flooding panels' were shown by analysis to fail and release water following a FWLB.
- Initial risk significance found to be Green,
  - Documented in NCV 2002004-02 issued on October 28, 2002.

Background / History *(continued)*

- In August 2004, it was identified that certain masonry walls in the EPR could fail during a FWLB, allowing water to enter the AB regardless of the blowout panel relief pressure.
- As of September 2005, no modifications had been made to prevent flooding of the AB.
- NRC identified "new information" as having a potential affect on the risk significance of this prior finding,
  - Issued as NCV 2005004-07 on October 28, 2005.

Duke Energy[SM]

Licensing Basis Discussion

- Oconee HELB CLB is based on report OS-73.2, submitted to AEC Staff in April 1973,
  - This report responded to the December 1972 AEC Staff HELB letter from Giambusso,
  - Later supplemented by a letter from Schwencer in January of 1973.
- AEC issued an SER in July 1973 signifying acceptance of Duke submittal. In this SER, the AEC stated in part:
  - ***"The staff has evaluated the assessment performed by the applicant and has concluded that the applicant has analyzed the facilities in a manner consistent with the intent of the criteria and guidelines provided by the staff. The staff agrees with the applicant's selection of pipe failure locations and concludes that all required accident situations have been addressed appropriately by the applicant."***

Licensing Basis Discussion *(continued)*

- The CLB, as defined in OS-73.2, analyzes 2 Main FWLBs in the EPR, one at each of the two terminal ends,
  - Stress criteria was used to eliminate all intermediate break/crack locations,
  - The FWLB analysis assumed that the break flow would be a homogeneous mixture that would flow out through the EPR pressure blow out panels,
  - AB flooding was considered to be negligible,
  - Certain masonry walls were fortified to protect the Battery Rooms and Cable Spreading Rooms. Other masonry walls surrounding the EPR were not fortified.

Licensing Basis Discussion *(continued)*

- A 1998 Duke HELB self-assessment revealed issues with the original OS-73.2 report,
  - Duke decided to fully revalidate/reconstitute the HELB CLB.
- In late 1999, Duke initiated a study to determine scope of LB reconstitution efforts. On several occasions since 1999, Duke has met with the NRC Staff to report progress.

Risk Analysis Input Differences

- Number of Welds.
- Length of MFW Piping.
- Potential Loss of Emergency Feedwater (EFW).
- SG Pressure Indication and Automatic Feedwater Isolation System (AFIS) operation.

Risk Analysis Input Differences: Welds and Piping Lengths

- A significant number of the NRC weld count are either attachment, gamma plugs (1⅛") , or small-bore nozzle welds (≤ 1" drain/vents).
- Only girth welds (circumferential full penetration welds of the MFDW piping material) are applicable to the TR-111880 methodology.
- The other weld types pose far less risk of failure, and consequences of a failure would be minimal.
- Piping lengths taken from Duke's review of Oconee piping drawings and field walkdowns.

Risk Analysis Input Differences: Number of Welds

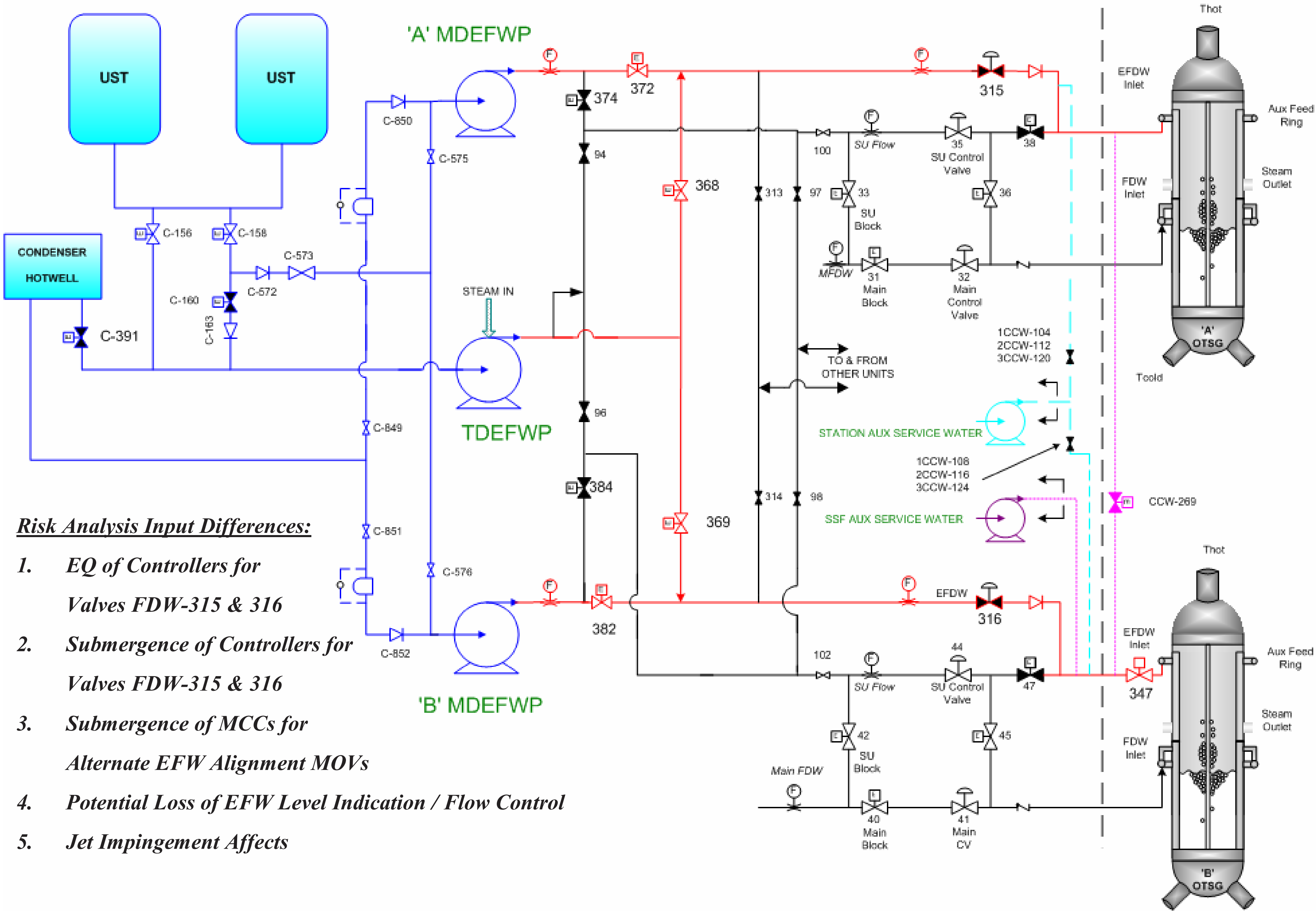
	NRC Phase III			Duke Evaluation (Girth Welds Only)[1]		
Location	Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3
Downstream Piping	17	17	10	9	9	2
Upstream Piping	28	28	35	10	10	8
Auxiliary Building	3	3	3	2	2	6
Total	48	48	48	21	21	16

[1] Per EPRI TR-111880 Methodology

Risk Analysis Input Differences: Piping Lengths (in feet)

	NRC Phase III			Duke Evaluation		
Location	Unit 1	Unit 2	Unit 3	Unit 1	Unit 2	Unit 3
Downstream Piping	50	50	15	29	35	35
Upstream Piping	95	95	37	77	71	46
Auxiliary Building	50	50	50	46	46	59
Total	195	195	102	152	152	140

Oconee Emergency Feedwater System Drawing



Risk Analysis Input Differences:

1. ***EQ of Controllers for Valves FDW-315 & 316***
2. ***Submergence of Controllers for Valves FDW-315 & 316***
3. ***Submergence of MCCs for Alternate EFW Alignment MOVs***
4. ***Potential Loss of EFW Level Indication / Flow Control***
5. ***Jet Impingement Affects***

Risk Analysis Input Differences: Potential Loss of EFW

- ***Environmental Qualification of Controllers for EFW Flow Control Valves FDW-315 & 316:***
  - NRC's qualitative analysis of EFW failure probability assumed that the controllers for FDW-315 & 316 were Fisher Model 546 and not environmentally qualified (EQ).
  - Duke confirmed that these controllers are EQ:
    - Controllers confirmed to be QA-1 Fisher Model 546 NS,
    - Testing included exposing the controller to a 320°F steam environment for 14 hours with no failure noted,
    - The peak temperature in the EPR following a FWLB event was calculated to be less than 217°F.
  - EFW controllers will remain functional under FWLB environmental conditions in the PRs.

Risk Analysis Input Differences: Potential Loss of EFW *(continued)*

- ***Potential submergence of Controllers for EFW Flow Control Valves FDW 315 & 316:***
  - Units 1, 2, & 3 FDW-316 are located in WPR and will not be affected by flooding of the EPR,
  - Units 2 & 3 FDW-315 will not be subjected to flooding in the EPR since both are approximately 5 to 6 feet above the floor,
  - Unit 1 FDW-315 may be subjected to submergence since it is located approximately 2 feet above the floor,
    - Evaluated as not being a significant risk contributor:
      - If EFW is lost, HPI forced cooling is available,
      - If HPI room is flooded, EFW remains available.

Risk Analysis Input Differences: Potential Loss of EFW *(continued)*

- ***Potential submergence of MCCs for Alternate EFW Alignment.***
  - NRC's qualitative analysis included loss of EFW because of potential failure of 'EFW motor operated valves used to align and realign EFW' because of flooding of the associated MOV motor control centers (MCC).
  - Duke confirmed the normal (safety related) EFW path is unaffected,
    - Automatic initiation and control of EFW does not rely upon the MCCs located inside the EPR,
    - The MOVs are not required to change position to meet the EFW safety function (automatic initiation and control),
  - For Unit 1 only, the "A" alternate EFW path remains available because the MOV power supply is not located in the EPR,
  - These factors are incorporated into the Duke Risk Analysis.

Risk Analysis Input Differences: Potential Loss of EFW *(continued)*

Potential Loss of EFW Level Indication / Flow Control

- NRC's qualitative analysis assumed that all four (4) SG level instruments were located in the EPR and would be impacted by spray/leakage through top openings in the electrical penetration panels.
- Duke confirmed that 2 trains of EFW flow control exists for each SG; 1 routed through the EPR, 1 through the WPR as follows:

Level Transmitter	***S/G***	***Penetration U1***	***Penetration U2***	***Penetration U3***
FDW LT-0080	A	1EC4	2EA13	3EA13
FDW LT-0081	B	1EC4	2EA13	3EA13
FDW LT-0082	A	1WA13	2WA1	3WA1
FDW LT-0083	B	1WA13	2WA1	3WA1

Note:

"E" designates East PR;

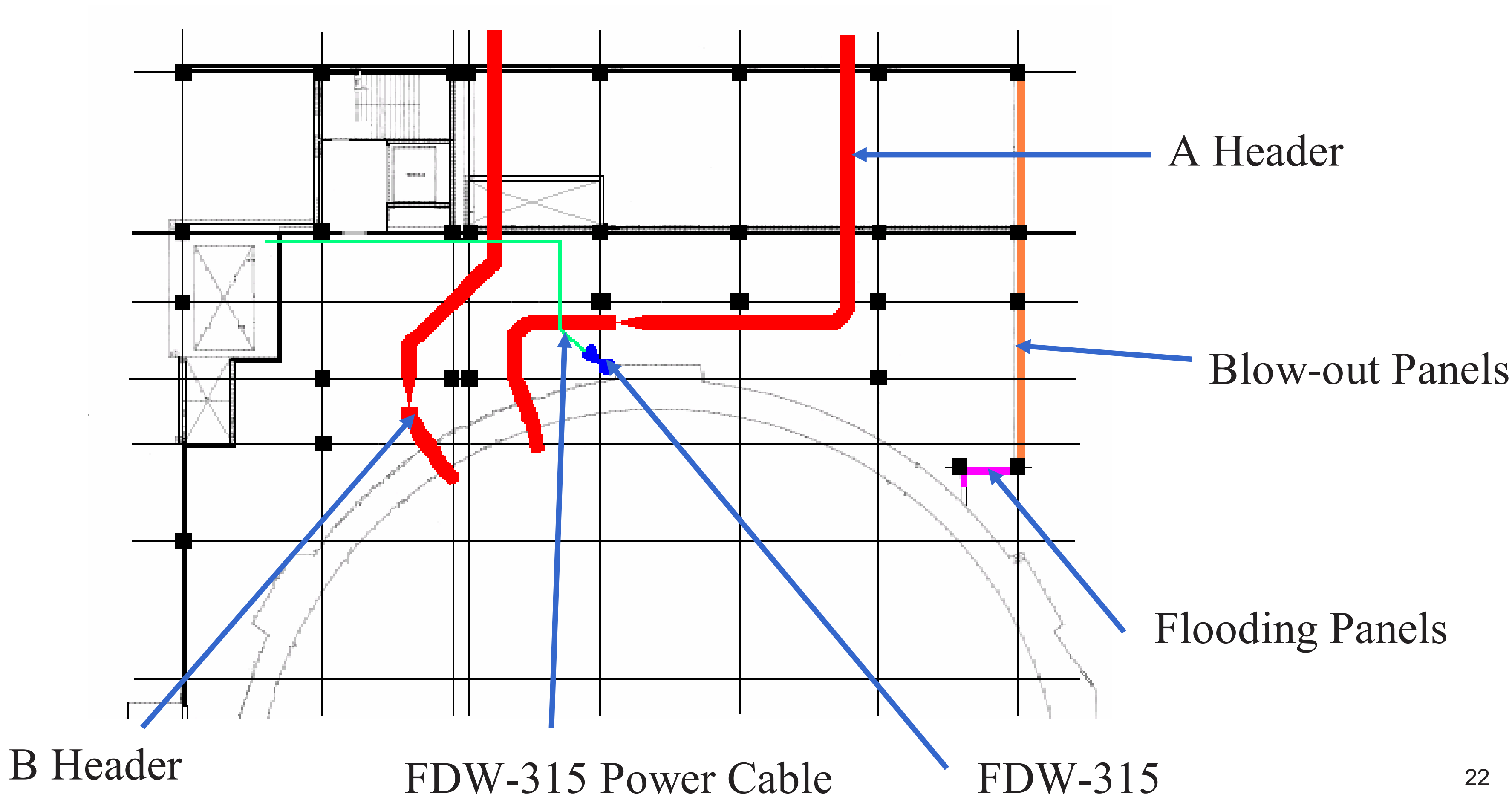
"W" designates West PR

- Even with failure of the electrical penetrations during a HELB, one train of SG level control will remain operational via the WPR electrical penetrations.

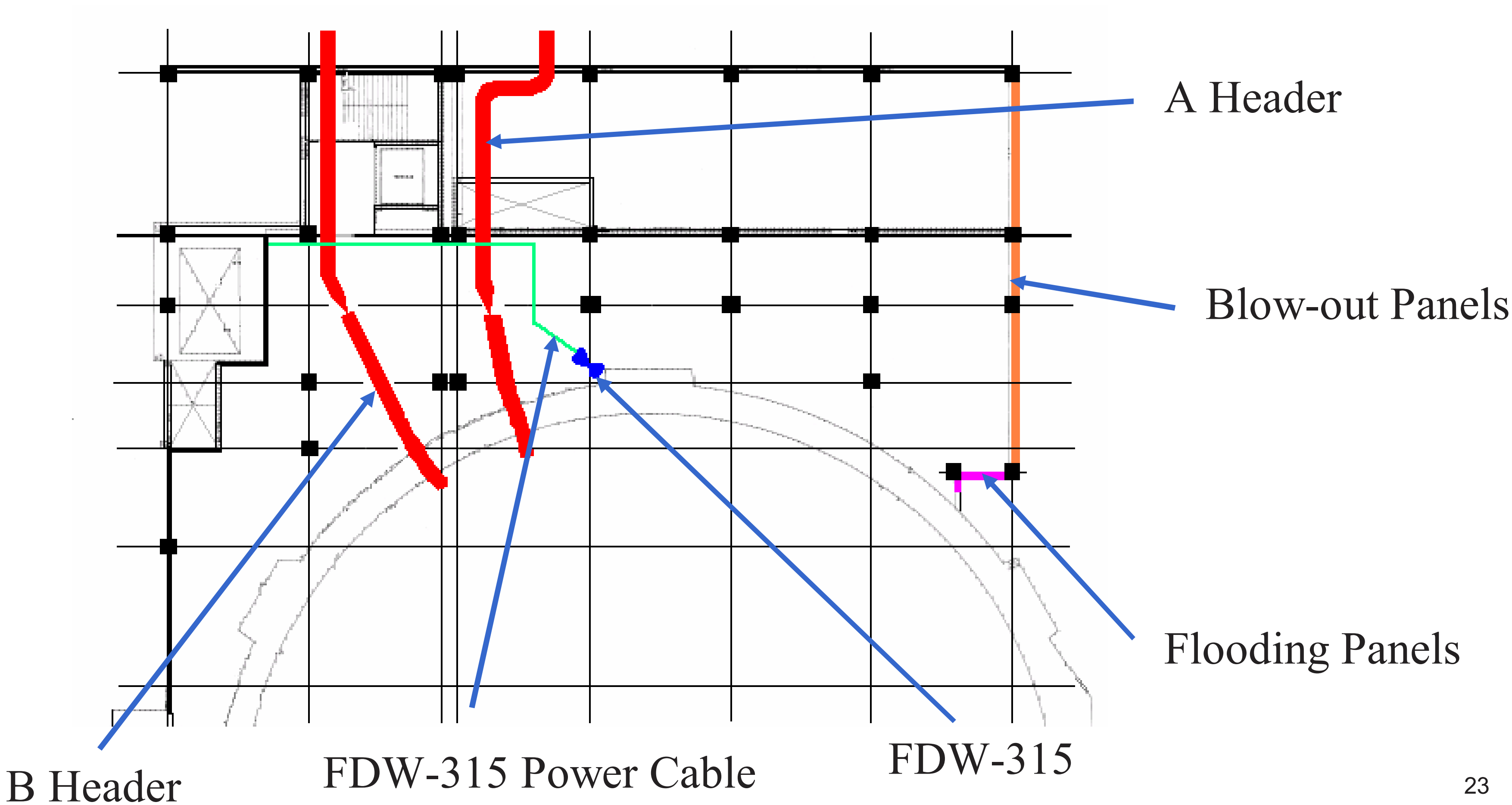
Risk Analysis Input Differences: Potential Loss of EFW *(continued)*

- ***Potential direct jet impingement affects:***
  - NRC's qualitative analysis assumed a loss of EFW due to jet impingement on FDW-315.
  - Duke evaluated the potential affects from jet impingement of a FWLB downstream of the isolation check valve(s) on EFW:
    - Jet impingement analysis based on NUREG CR/2913, "Two Phase Jet Loads,"
    - Maximum jet length considered is 20 feet based on criteria of L/D = 10.

Risk Analysis Input Differences: Layout of MFDW and EFW - Unit 2
(Unit 1 mirror image)



Risk Analysis Input Differences: Layout of MFDW and EFW - Unit 3



Risk Analysis Input Differences: Potential Loss of EFW *(continued)*

- ***Potential direct jet impingement affects (cont.):***
  - Duke results of downstream break analysis concluded:
    - For Units 1, 2, & 3, "A" MFDW header breaks do not affect components for "B" EFW (FDW-316),
    - For Units 1 & 2, "B" MFDW header breaks do not affect components for "A" EFW (FDW-315),
    - For Unit 3 only, FWLBs in the "B" MFDW header may affect the power cable to 3FDW-315,
      - The break size necessary to cause the interaction with the 3FDW-315 power cable is relatively large (greater than 0.56 ft^2),
      - Breaks of this magnitude activate AFIS and prevent potential flooding of the HPI pump room.

Risk Analysis Input Differences: SG Pressure Indication and AFIS

- NRC's qualitative analysis assumed that the 4 SG pressure instrument lines, routed in electrical penetrations EF3 and EF4, could be affected and result in the loss of AFIS.
- Duke confirmed that AFIS will actuate and be able to perform its safety function after a HELB event since:
  - there are 8 pressure transmitters per unit (4 per SG) that provide input to AFIS,
  - 4 of these transmitters are located in the Reactor Building (RB) with cables routed through the EPR,
  - the remaining transmitters MS PT1006, 1007, 1008, and 1009 are located in the Turbine Building (TB),
    - this may result in a loss of AFIS system redundancy. However, AFIS remains functional.

Risk Analysis Input Differences: SG Pressure Indication and AFIS

(continued)

- NRC's quantitative analysis concluded that AFIS would not be effective in isolating large FWLBs to prevent flooding of HPI pumps.
- Duke confirmed the minimum break size required for direct jet impingement of 3FDW-315 power cable is large enough to cause AFIS to actuate and isolate MFDW in time to prevent loss of HPI.
  - Breaks of 0.54 ft^2 and larger were evaluated to determine integrated volume of water released into Auxiliary Building,
    - Based on expected RPS, ICS, and AFIS response, the total volume released is less than 24,000 gallons.
  - Based on a new detailed calculation, the volume of water required to flood out the HPI pumps is higher than previously estimated,
    - Unit 1 & 2 HPI Pump Room Flood Volume = 41,058 gallons,
    - Unit 3 HPI Pump Room Flood Volume = 25,624 gallons.

Duke Energy

PRA Highlights: Initiating Event Inputs for EPRI TR-111880 Methodology

Unit 1	Downstream "A" MFW	Downstream "B" MFW	Upstream	Aux Bldg
Number of Girth Welds	7	2	10	2
Section Length (ft)	24	5	77	46

Unit 2	Downstream "A" MFW	Downstream "B" MFW	Upstream	Aux Bldg
Number of Girth Welds	7	2	10	2
Section Length (ft)	31	4	71	46

Unit 3	Downstream "A" MFW	Downstream "B" MFW	Upstream	Aux Bldg
Number of Girth Welds	1	1	8	6
Section Length (ft)	16	19	46	59

PRA Highlights: Methods and Assumptions

- EPRI TR-111880 used to estimate pipe rupture frequency.
- Conservatively, piping failure rates were not updated to reflect weld and piping base metal inspections:
  - ~ 40 % of girth welds in all units have been inspected,
  - 4 base metal locations in each unit receive periodic thickness examinations for flow accelerated erosion/corrosion concerns,
  - Completed inspections have found no degradation.
  - This implies that actual failure rates are significantly lower.

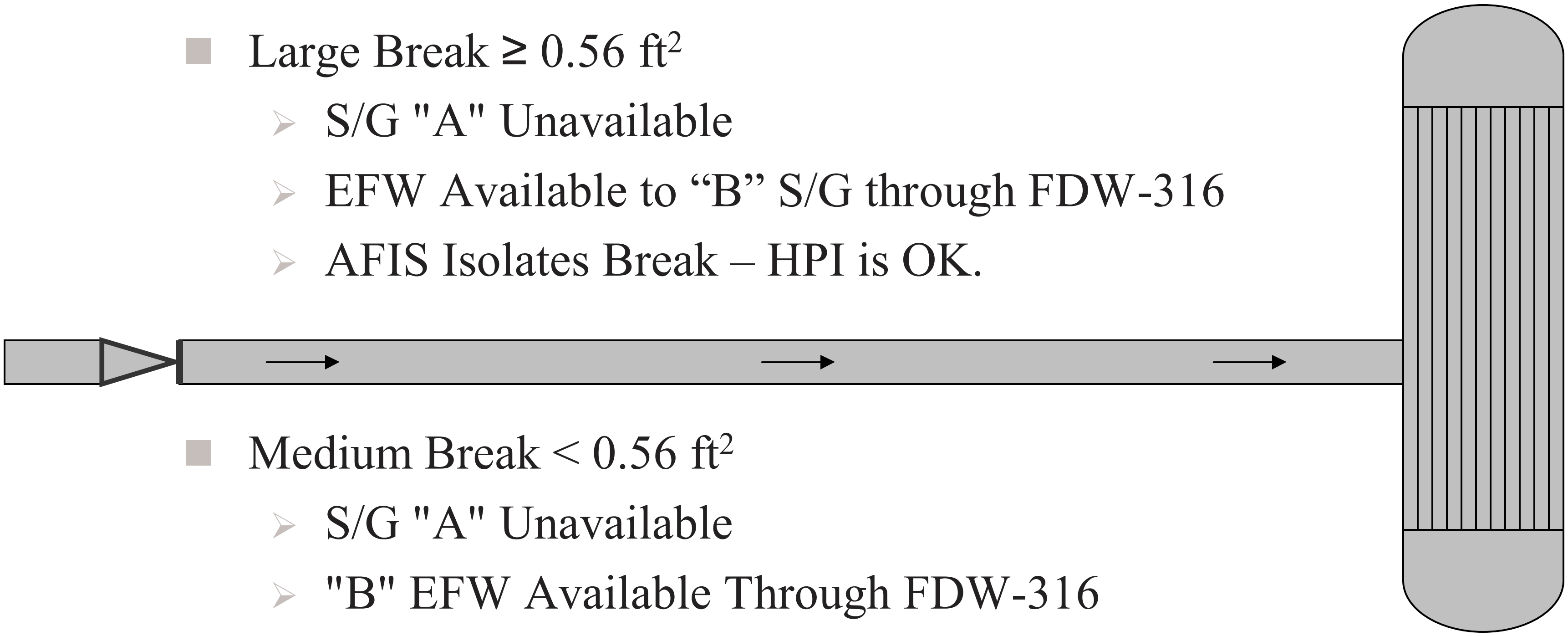
PRA Highlights: Break Size Definitions

- Initiating Event Break sizes (large/medium) based on potential impact on EFW rather than on HPI flood isolation.
- Equipment less than 10 pipe diameters (~20') from MFDW headers are considered vulnerable to jet impingement.
  - Minimum distance was used to define minimum break size required to damage equipment,
  - Large Breaks are defined as those large enough to damage FDW-315 or cables,
  - Medium Breaks are defined as too small to damage FDW-315 or cables.
- Note: There are other minor differences from the Phase III analysis contained in the details of Duke's risk analysis report.

PRA Highlights: Unit 3 Breaks Downstream

Header "3A"

- Large Break ≥ 0.56 ft²
  - S/G "A" Unavailable
  - EFW Available to "B" S/G through FDW-316
  - AFIS Isolates Break – HPI is OK.

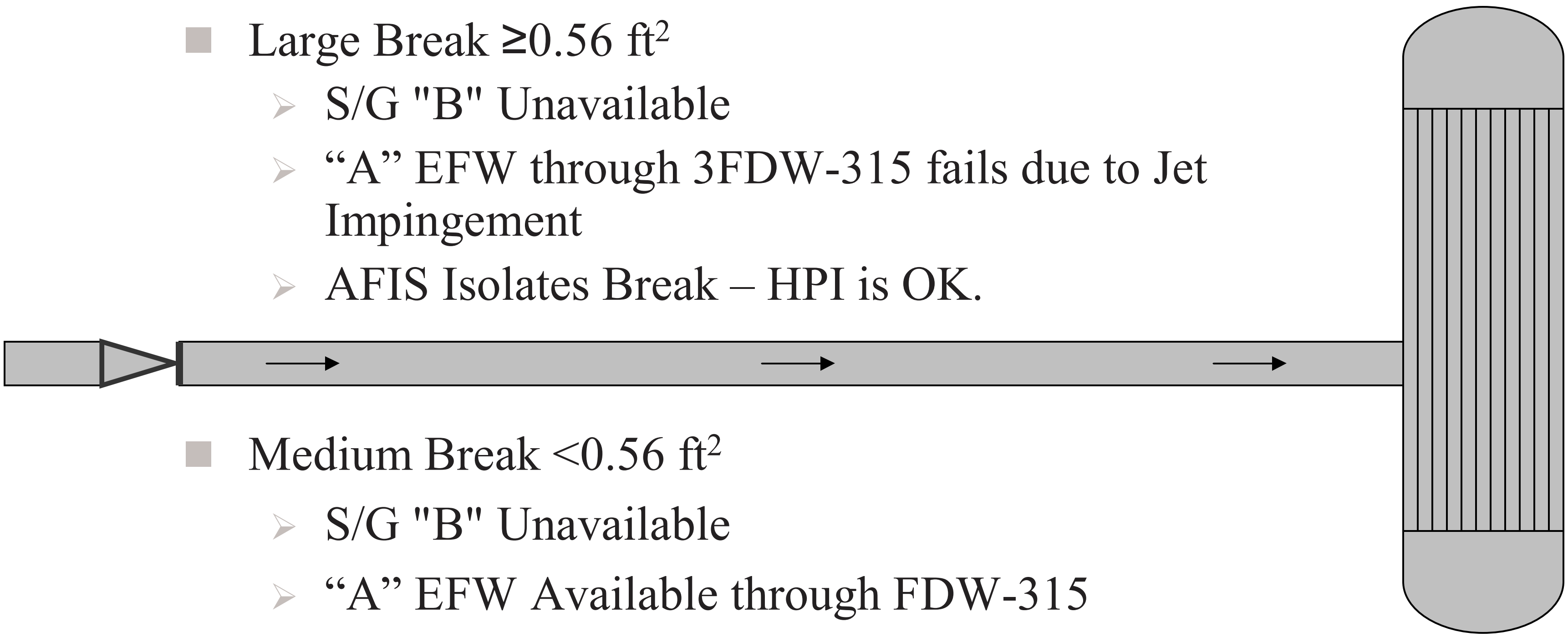


- Medium Break < 0.56 ft²
  - S/G "A" Unavailable
  - "B" EFW Available Through FDW-316
  - AFIS Isolation is assumed to be too late – HPI is flooded.

PRA Highlights:
Unit 3 Breaks Downstream

Header "3B"

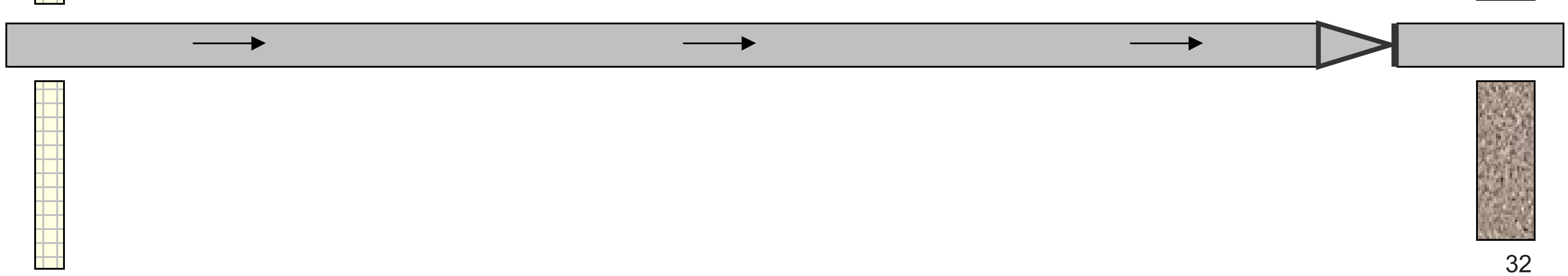
- Large Break ≥0.56 ft^2
  - S/G "B" Unavailable
  - “A” EFW through 3FDW-315 fails due to Jet Impingement
  - AFIS Isolates Break – HPI is OK.



- Medium Break <0.56 ft^2
  - S/G "B" Unavailable
  - “A” EFW Available through FDW-315
  - AFIS Isolation is assumed to be late – HPI is flooded.

PRA Highlights: Unit 3 Breaks Upstream

- S/G pressure boundary integrity is maintained.
- No AFIS Isolation – HPI Assumed Flooded
- Main Feedwater Is Available
- "B" EFW Available through FDW-316
- Large Breaks ($\geq$0.18 ft^2)
  - Loss of "A" EFW through 3FDW-315 due to jet impingement on cables
  - Loss of "A" S/G Level Indication for S/U Path



PRA Highlights: Event Summary

Units 1 & 2

Break Location	Size	Main Feedwater	EFW "A"	EFW "B"	HPI	EFW Recovery	SSF ASW
"A" Downstream	**Large**	X	X	OK	OK	B S/G	OK
	Medium	X	X	OK	X	B S/G	OK
"B" Downstream	**Large**	X	OK	X	OK	A S/G	OK
	Medium	X	OK	X	X	A S/G	OK
Upstream	**Large**	1 S/G	X	OK	X	1 S/G	OK
	Medium	1 S/G	OK	OK	X	2 S/G	OK
Aux Bldg	Any Size	1 S/G	OK	OK	X	2 S/G	OK

PRA Highlights: Event Summary

Unit 3

Break Location	Size	Main Feedwater	EFW "A"	EFW "B"	HPI	EFW Recovery	SSF ASW
"A" Downstream	**Large**	X	X	OK	OK	B S/G	OK
	Medium	X	X	OK	X	B S/G	OK
"B" Downstream	**Large**	X	X†	X	OK	A S/G	OK
	Medium	X	OK	X	X	A S/G	OK
Upstream	**Large**	1 S/G	X	OK	X	1 S/G	OK
	Medium	1 S/G	OK	OK	X	2 S/G	OK
Aux Bldg	Any Size	1 S/G	OK	OK	X	2 S/G	OK

†Note: This box is different than Unit 1 or 2 due to potential jet impingement.

PRA Results: Incremental Risk

EFW Recovery Case				SSF Recovery Case		
	Core Damage	Large Early Release			Core Damage	Large Early Release
Unit	ΔCDF	ΔLERF		Unit	ΔCDF	ΔLERF
1	2.36E-08	4.05E-10		1	5.66E-08	9.10E-10
2	2.65E-08	4.84E-10		2	6.90E-08	1.26E-09
3	3.15E-08	1.39E-09		3	8.20E-08	3.62E-09

PRA Results: Conservatisms

- Conservative Risk Analysis Assumptions:
  - Piping failure rates were not updated to reflect piping inspections which found no indication of erosion or corrosion degradation.
    - Use of EPRI TR-111880 is very conservative.
  - All breaks assumed at the minimum distance for upstream break locations and Unit 3 downstream locations.
  - Only 1 feedwater recovery action was credited for each sequence. Pursuit of EFW and SSF strategies in parallel is possible and is trained on for other non-HELB scenarios.
  - No credit for operator action to isolate small breaks.
  - All break flow is assumed to reach the HPI Pump Room.

PRA Results: Conclusions

- Risk impact is very low (Green).
  - ΔCDF: ~ 8.2E-08 (highest – Unit 3)
  - ΔLERF: ~ 3.6E-09 (highest – Unit 3)
- Dominant risk contribution is from large breaks on the Unit 3 "B" header downstream of the feedwater check valves.
- Duke risk assessments were conservative.

Closing Remarks

- Duke is implementing modifications to address flooding following east PR HELB events:
  - Installation of Flood Outlet Devices (FOD) began in April 2006 on Unit 3,
  - FOD installation will be complete on all units by December 2006,
  - Flood impoundment modifications to be completed on all units by May 2007,
  - Completion of these modifications restores full compliance with the CLB relative to PR HELB events.
- HELB LB reconstitution efforts are ongoing with additional enhancements planned.