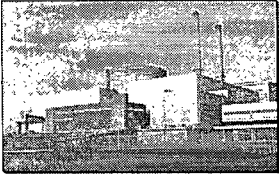



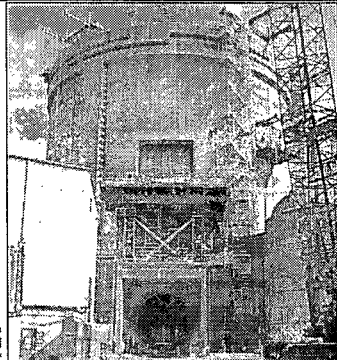
Crystal River Unit #3

**Presentation to PNSC
Containment Update & Discussion
of Repair Options**


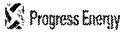
November 16th 2009
Presented by Garry Miller

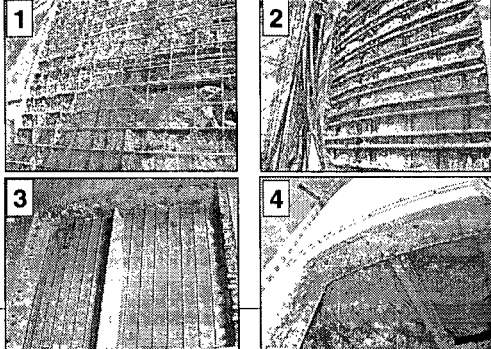
**Steam Generator Replacement (SGR) Opening
(between Buttresses 3 and 4)**



SGR Opening Dimensions
 @ Liner 23' 6" x 24' 9"
 @ Concrete Opening 25' 0" x 27' 0"

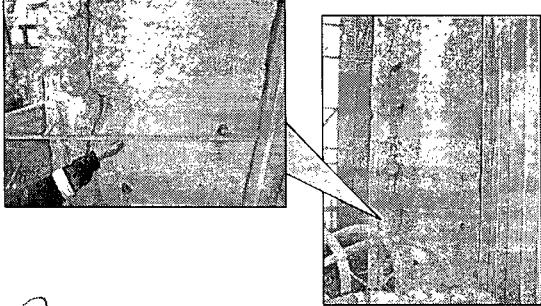





Hydro-Demolition & Liner Removal Sequence



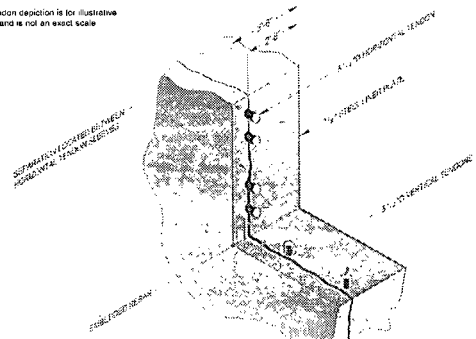
3

Delamination Close-up

Location of the Delamination



Note - Tendon depiction is for illustrative purposes and is not an exact scale



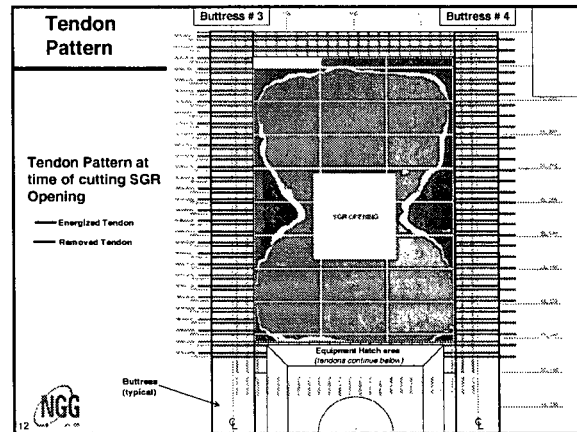
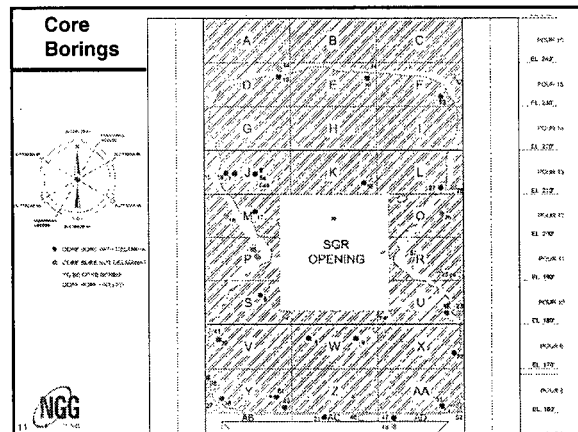
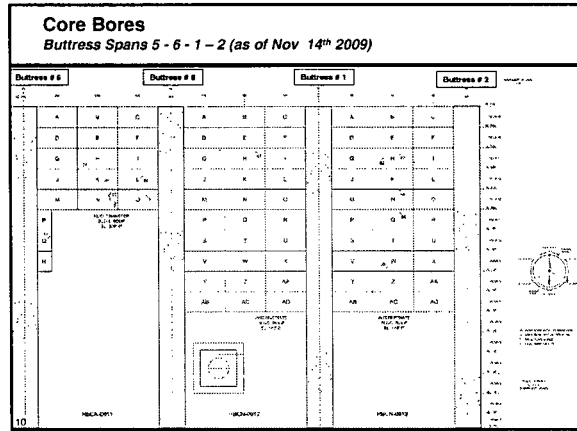
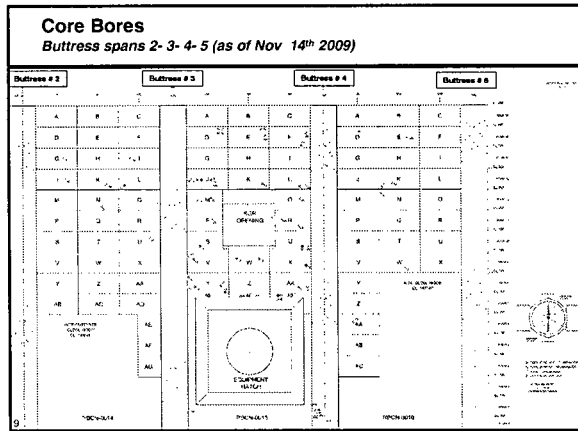
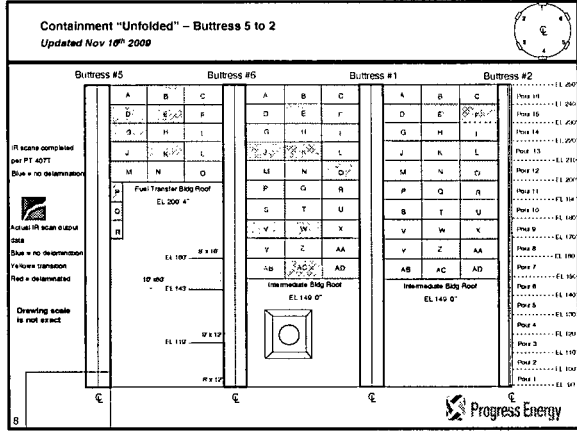
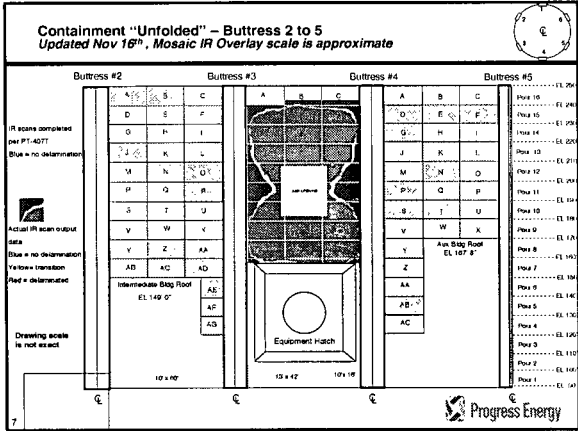
5

**Condition Assessment Techniques
Completed or Planned**

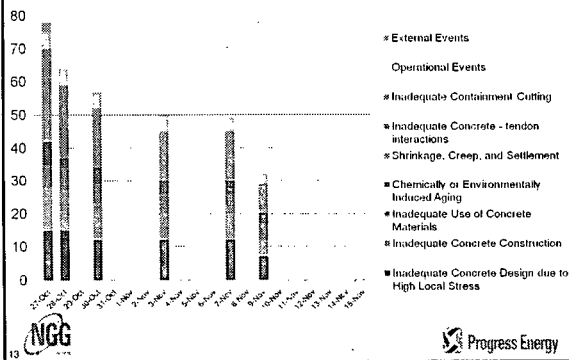
- | Impulse Response (IR) Scanning of Containment Wall Surfaces
 - w Comprehensive on external exposed surfaces
 - w Representative sampling inside buildings
- | Core bores
 - w Use to cross-check IR results
 - w Includes visual inspection/documentation of surface inside the bored hole
- | IWL visual inspection of containment external surface (affected areas)
- | Dome Inspections
 - w IR scans in selected area
 - w Core bore samples in repaired and non-repaired areas
 - w Physical survey (compared to 1976 results)

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Root Cause Analysis – PII Metrics
Un-refuted Failure Modes as of Nov 9th 2009



Root Cause Analysis
Field Data Acquisition

- Impulse Response (IR) Scans
- Boroscopic Inspections
 - Core bore holes
 - Inside the delaminated gap
- Visual inspections
 - Delamination cracks at SGR Opening
 - Larger fragments from concrete removal process
 - Containment external surface

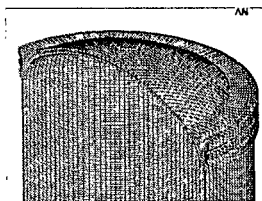
Root Cause Analysis
Field Data Acquisition (continued)

- Nearby energized tendons lift-off (vertical and horizontal)
- Containment ID measurements
- Strain gauge measurements
- Linear variable displacement transducer (LVDT) gap monitoring
- Building Natural Frequency

Root Cause Analysis
Field Data Acquisition (continued)

- | Core bores laboratory analysis
 - w Petrographic Examination
 - w Modulus of Elasticity and Poisson's Ratio
 - w Density, Absorption, and Voids
 - w Compressive Strength, Splitting Tensile Strength, and Direct Tensile Strength

DESIGN BASIS ANALYSIS



MPR 3D FE Model
Model Features

- | 180 degree Symmetric model
 - w Symmetry plane @ 150 degrees midway Between Butress 3 & 4 / 1 & 6
 - w ½ Opening, ½ Damage & ½ Hatch Modeled Explicitly
- | Concrete Model
 - w Brick elements for all components
 - w Dome and Base modeled independently
 - w Simplified ring beam and buttress geometry
 - w Constraint equations used to join dome and ring girder for meshing efficiency
 - w Constraint equation used to model sloped surfaces of the hatch
- | Liner Model
 - w Shell mesh with variable thickness
 - w Shared nodes with containment inner surface
- | Tendon Modeling
 - w Hoop tendons modeled explicitly for release and re-tensioning
 - w Vertical Tendons modeled explicitly for release and re-tensioning
 - w Dome tendons modeled independently with forces ported to global model

MPR 3D FE Model
Model Features (continued)

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MPR 3D FE Model
Load Cases

- | Live and Dead Loads
- | Wind (110mph @ 30' increasing to 179 mph @ 166'10")
- | Tornado Wind (300 mph)
- | Tornado pressure (external pressure of 3 psig)
- | Tornado Missiles (35' utility pole or 1 ton car @ 150 mph)
- | Seismic (OBE – 0.05 and SSE – 0.10)
- | Temperature Loads
- | Accident Pressure (55 psig)
- | Accidental Containment Spray Actuation Press (-2.5 psig)

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MPR 3D FE Model
Specific Analysis to be Performed

<p>Existing Design Cases for Comparison</p> <ul style="list-style-type: none"> w Gravity (.95 G) w Internal Dead Load (200 puff) w Tendons (1635 kips / tendon) <ul style="list-style-type: none"> u Include losses w Internal Pressure (55.0 psi) w Wind Pressure (0.568 psi) w Seismic w Accident Thermal 	<p>Planned Analysis Sequence</p> <ul style="list-style-type: none"> w Dead Load + Tendons w Remove Hoop + Vertical Tendons in SGR Opening w Remove SGR Opening w Delamination⁽¹⁾ w Remove Additional Hoop & Vertical Tendons w Replace the SGR Plug⁽²⁾ w Repair⁽²⁾ w Re-tension Tendons w SAVE Path Dependent Model for Starting point to Run 5 Controlling Design cases
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⁽¹⁾ Root Cause must confirm delamination timing
⁽²⁾ Sequence of replacing SGR concrete plug or repair may be adjusted

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Repair Attributes

- | Incorporates and is compatible with Root Cause Analysis findings
- | **Re-Design Basis Controlling Load Steps**
- | Incorporates Life of Plant Considerations
 - w Long Term Surveillance and/or Maintenance Requirements
 - w License Renewal
- | Constructability

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Repair Alternatives Considered

- | Use-as-Is
- | Anchorage Only
- | Cementitious Grout
- | Epoxy Resin
- | Delamination Removal and Replacement

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Repair Alternatives
"Use-as-Is" and "Anchorage Only"

- | **Use as Is - Rejected**
 - w Degraded safety related structure
 - w Design margins are reduced
- | **Anchorage Only- Rejected**
 - w Containment and delaminated layer will not structurally perform as monolithic shell
 - u Would function as two independent shells pinned together
 - w Detensioning is not expected to close the delamination gap (greater than 2" in some places)
 - u Would require some competent fill material to be added
 - w Anchorage plate washers (acting to distribute the load) would have minimal separation creating difficulty in the field
 - u Tendons are not always equally spaced
 - u Rebar mat interference at targeted anchorage locations

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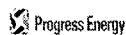
Repair Alternatives
"Cementitious Grout"

I Cementitious Grout - Rejected

- w Will not be able to penetrate all of the fissures observed along the delaminated surface
 - u Creates un-repaired weak planes, affecting tensile capacity

- w Multi-fissure segmented cracking and dislodgement could block adjacent areas from being filled

- w Mock-up testing to simulate all of the in-situ conditions is problematic
 - u Examples - Cleanliness of surfaces, parallel fissures
 - u Would likely require in-situ testing that would be difficult to control in the field



Repair Alternatives
"Cementitious Grout"

I Cementitious Grout - Rejected (continued)

- w Mock-up test needed to validate tendon duct integrity (leak tightness against grouting injection)
 - u Test may indicate leak tightness is not assured

- w Requires anchorage to resist grout injection pressures (≥ 20 psig), and this has all of the same difficulties as detailed in the "Anchorage Only" repair
 - u This anchorage system limits access to effectively perform IR scans to ensure complete grout coverage

- w Physical properties of grout would require detailed evaluation and/or verification to prior to use
 - u Many grouts are blended for geotechnical applications
 - u Tensile strength of typical grouts is significantly lower than epoxy resins



Repair Alternatives
"Epoxy Resin"

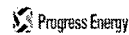
I Epoxy Resins - Rejected

- w Not viable in gaps greater than $\frac{1}{4}$ " due to exothermic reaction
 - u Delamination gaps are well beyond this limit, including > 2 " in some locations

- w May not be able to penetrate all of the fissures observed along the delaminated surface
 - u Creates un-repaired weak planes, affecting tensile capacity

- w Raising the injection pressure to improve penetration in fissures
 - u Anchorage becomes more difficult
 - u Tendon conduit integrity becomes more difficult

- w Mock-up test needed to validate tendon duct integrity (leak tightness against epoxy injection)
 - u Test may indicate leak tightness is not assured



Repair Alternatives
"Epoxy Resin"

I Epoxy Resins - Rejected (continued)

- w Mock-up testing to simulate all of the in-situ conditions is problematic
 - u Examples - Cleanliness of surfaces, parallel fissures
 - u Would likely require in-situ testing that would be difficult to control

- w Requires anchorage to resist epoxy injection pressures (8 to 20 psig), and this has all of the same difficulties as detailed in the "Anchorage Only" repair
 - u This anchorage system limits access to effectively perform IR scans to ensure complete coverage



Repair Alternatives
Repair and Replacement

I Delamination Removal and Replacement - Selected

- w Delamination Removal Challenges
 - u Safe removal of delaminated concrete at elevated heights
 - u Avoiding collateral damage to tendon conduits
 - u Minimize damage to the remaining substrate to minimize concrete bruising and to provide a favorable bonding surface
 - u Requires verification planar fissures are removed

- w Requires new radial reinforcement design (anchored to the substrate)

- w Will require treatment of planar fissures (if encountered) at periphery



Repair Alternatives
Repair and Replacement

I Repair and Replacement - Selected (continued)

- w Need to secure and verify same constituents to use the existing qualified design concrete mix (for the SGR Opening)

- w Concrete Placement
 - u Needs to construct ganged forms for placing the pours
 - u Need to determine method to anchor the forms
 - u Elevations create work execution challenge



Boroscopic Photos
Delamination Gap Dimensions

Buttress 3-4, Cell K, Core #55

Buttress 3-4, Cell H, Core #82

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Boroscopic Photos
Delamination Gap Dimensions

Buttress 3-4, Cell Z, Core #78

Buttress 3-4, Cell X, Core #80

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Boroscopic Photos
Debris in the Delamination Gap

Buttress 3-4, Cell H, Core #81

Buttress 3-4, Cell H, Core #82

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Boroscopic Photos
Debris in the Delamination Gap

Buttress 3-4, Cell Z, Core #78

Buttress 3-4, Cell Y, Core #61

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Boroscopic Photos
Fissures in the Delamination Gap

Buttress 3-4, Cell J, Core #7

Buttress 3-4, Cell M, Core #17

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Boroscopic Photos
Fissures in the Delamination Gap

Buttress 3-4, Top of SGR Opening
Upper Left Corner, Looking West

Buttress 3-4, Top of SGR Opening
Upper Left Corner

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Questions

