North Anna Unit 3 COLA



NRC Meeting - Subsurface Variability



May 19, 2011



Meeting Purpose

Discuss the NRC questions regarding the North Anna Unit 3 site subsurface variability and seismic ground motion analysis methodology, and provide a basis for acceptability of the S-COLA approach



Opening Remarks

- Dominion's evaluation complies with NRC requirements and guidance, specifically SRP 2.5.2 and RG 1.208
- Change in reactor technology had no impact on North Anna 3 site
- Dominion used same methodology for ESBWR R-COLA and US-APWR S-COLA. NRC accepted approach in draft SER for ESBWR R-COLA.
- Change in methodology would require substantial additional resources and is on critical path for our seismic analyses. However, a change in methodology would not be expected to change current design of any structures.



Meeting Agenda

- Introduction
- Background
- Regulatory Requirements
- Site Response Analysis Method and Basis
- Consistency with Regulatory Requirements
- Summary/Conclusion



- NRC Staff issued RAI 5199 (02.05.02-2) on 12/21/2010
 - FSAR Figures show significant variability in competent rock elevation and large V_s variations
 - Site response calculation method based on 1-D subsurface structure approximation
 - Justify assumption of uniformity of layers
 - Describe how GMRS and FIRS analyses adequately capture significant variability



- Dominion provided response 1/28/2011
 - Variation random; rock within each zone is essentially the same (varying degree of weathering)
 - Randomization is appropriate
 - No dipping
 - Addressed by considering different BE V_s profiles, layer thicknesses, and corresponding variations (described in terms of standard deviation) using applicable boring data



- NRC Staff issued RAI 5693 (02.05.02-3) as follow-up on 5/5/2011
 - Vs measurements show considerable variation (up to 100% from 184' El. To 250' El.)
 - Indicates 1-D analysis may not be sufficient for multidimensionality of subsurface
 - Best Estimate (log mean) profile (instead of enveloping) may underestimate site amplification
 - Justify 1-D site response analysis is appropriate
 - Provide site amplification calc input details and explain how Profiles 1 and 2 were developed



- Dominion briefed NRC Project Management in relation to Dominion concern with additional questions on 2.5.2 (mid-April)
- NRC provided feedback in conference call 4/27/2011
 - New borings data indicates site subsurface variability is different than what NRC understood
 - Require additional analyses IAW RG 1.208



• R-COLA (ESBWR)

- Site Characterization
 - 53 soil/rock borings to as deep as 300 ft
 - 3 downhole geophysical borings to measure V_s
- Site Response Analysis Methodology
 - Log mean of V_s profile obtained from the 3 V_s borings
 - 60 randomized profiles generated to simulate variation in soil/rock properties and layer thickness
- Draft SER and ACRS Review
 - Topic had no Open Items draft SER or ACRS review
 - NRC documented acceptance in draft SER; used same methodology for confirmatory analysis



• S-COLA (US-APWR)

- Site Characterization
 - 38 additional soil & rock core borings (60 ft to 200 ft depth)
 - Approx half were in UHSRS area
 - 2 sets downhole V_s tests (200 ft) both in UHSRS area
 - For R/B area, used same three V_s borings as R-COLA
 - Additional borings indicated subsurface conditions (including dynamic properties) consistent with results from previous exploration



- S-COLA (US-APWR)
 - Site Response Analysis Methodology
 - Same as R-COLA
 - Log mean of V_s profile obtained from original 3 V_s borings
 - 60 randomized profiles generated to simulate variation in soil/rock properties and layer thickness





Unit 3 US-APWR Seismic Category I and II Structures

Reactor center line location for US-APWR is same as ESBWR



Locations of 38 Supplemental Borings (highlighted in orange)





Locations of Geophysical Borings



<u>Summary</u>

- Same reactor centerline location
- Same site grade elevation
- Consistent subsurface data
- Same site response analysis method
- NRC accepted method and used for confirmatory analysis



Regulatory Requirements

- SRP 2.5.2, Vibratory Ground Motion
- Applicable RG: RG 1.208 Position 4 and Appendix E:
 - 1-D analysis (or nonlinear analysis that assumes vertical propagation of shear waves) may be appropriate, however:
 - Analyses accounting for inclined waves may be required if:
 - Dipping bedrock surface, topographic effects, other impedance boundaries exist
 - Regional characteristics (such as certain topographic effects) exist
 - Source characteristics (such as nearby dipping seismic sources) exist
 - Multi-dimensional soil models may be needed if:
 - Complex geologic and geotechnical conditions exist



Regulatory Requirements

- Applicable RG: RG 1.208 Position 4 and Appendix E:
 - Monte Carlo (or equivalent procedure) should be used to accommodate the variability in soil depth, shear wave velocities, layer thicknesses, and strain-dependent dynamic nonlinear material properties
 - Need sufficient # of convolution analyses to adequately capture the effect of site subsurface variability and soil properties uncertainty
 - At least 60 to define site response mean and standard deviation



Regulatory Requirements

<u>Summary</u>

- Guidance available for use of 1-D vs. multidimensional analysis
- Guidance available for performing 1-D analysis
- Regulatory guidance seeks the characterization and incorporation of site variability in system response analysis in order to obtain the mean and standard deviation of the site response



Site Response Analysis Method and Basis

- Site Characterization
- Methodology



Site Characterization

• Site Subsurface Variability

- North Anna site typical of Piedmont geology
- Various zones are in different stages of weathering process of same rock
- Subsurface variability results from different local effects of weathering on minerals comprising parent rock. (Ex. Quartz more resistant to weathering and does not alter to clay materials)
- North Anna site does not exhibit complex geotechnical or engineering geologic conditions



Site Characterization

- Soil and rock not deposited as distinct strata
 - All derived from same parent rock weathered in-situ
 - Boundaries between the zones are not distinct
- Undulating site but not dipping site
- The non-systematic variations in the properties of the site is suitable for the Monte Carlo simulation



- Site Response Analysis Methodology
 - 1-D analysis using 60 randomized profiles
 - Bounding profiles 1 and 2 define the range of variation of the boring data
 - Median V_s and coefficient of variation defined from a logaverage of bounding profiles 1 and 2 (statistical analysis of B-901, B-907, and B-909 lead to nearly identical values)
 - Includes simulation of layer thickness and V_s correlation between adjacent layers
 - Dominion methodology is technically reasonable
 - Accounts for soil-profile variability
 - Same soil simulation methodology as R-COLA
 - Same approach used in nearly all COLAs and ESPs



Shear Wave Velocity, V_s (ft/sec)

Shear Wave Velocity **Measurements** and Profiles 1 & 2 in Power **Block Area**

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Comparison of Measured Velocity Data in Power Block Area with Simulated Profiles

The 60 simulated profiles capture the observed variation of shear-wave velocities in the boring data



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Consistency with Regulatory Requirements

- Multi-dimensional analyses and analyses accounting for inclined waves are not required because conditions requiring more detailed analyses do not exist at North Anna:
 - Site does not have dipping bedrock or nearby-dipping seismic sources
 - Site does not contain impedance boundaries
 - Site not considered to possess complex engineering geologic and geotechnical conditions
- 1D soil column analysis and vertically propagating waves were modeled



Consistency with Regulatory Requirements

- Rock zone thickness and V_s variability (due to rock formation weathering) recognized and incorporated in analyses
 - Considers the range in thickness and velocity of various rock layers
 - 60 simulated profiles used to capture variability in depth/thickness of each rock formation and measured variation in the dynamic properties
- Consistent with SRP 2.5.2 / RG 1.208 requirements



Summary/Conclusion

- Demonstrated that Dominion's evaluation complies with NRC requirements and guidance, specifically SRP 2.5.2 and RG 1.208
- Change in reactor technology had no impact on North Anna 3 site
- Dominion used same methodology for ESBWR R-COLA and US-APWR S-COLA. NRC accepted approach in SER for ESBWR R-COLA and performed confirmatory analysis using same methodology.
- Change in methodology would require substantial additional resources and is on critical path for our seismic analyses. However, a change in methodology would not be expected to change current design of any structures.

