PMTurkeyCOLPEm Resource

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To: Comar, Manny
Cc: TurkeyCOL Resource; Maher, William; Orthen, Richard
Subject: [External_Sender] PTN 6&7 ACRS Subcommittee Slides - Day 2
Attachments: FPL_ACRS_Presentation_Day_2_Combined_20160809.pdf

I have attached the final version of our slides for ACRS Day 2. We plan no further changes.
Any questions, please call.

Thanks
Steve Franzone
NNP Licensing Manager - COLA
“The road to success is dotted with many tempting parking places." –Unknown
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Turkey Point Nuclear Power Plant

Units 6 & 7

Combined License Application

August 19, 2016

Turkey Point Nuclear Plant Units 6 & 7
Day 2

- Section 2.5 Geology, Seismology, and Geotechnical Engineering
- Chap. 3 Design Of Structures, Components, Equipment and Systems
- Section 13.3 Emergency Planning
- Chap. 19 Probabilistic Risk Assessment
- Chap. 20 Requirements Resulting from Fukushima Near Term Task Force Recommendations
- Chap. 21 Design Changes Proposed in Accordance with ISG-11

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Turkey Point Nuclear Plant Units 6 & 7
Day 2

- **Section 2.5 Geology, Seismology, and Geotechnical Engineering**
- Chap. 3 Design Of Structures, Components, Equipment and Systems
- Section 13.3 Emergency Planning
- Chap. 19 Probabilistic Risk Assessment
- Chap. 20 Requirements Resulting from Fukushima Near Term Task Force Recommendations
- Chap. 21 Design Changes Proposed in Accordance with ISG-11

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Turkey Point Nuclear Plant Units 6 & 7

Section 2.5 – Geology, Seismology, and Geotechnical Engineering

Paul C. Rizzo
President
Paul C. Rizzo Associates, Inc.

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Section 2.5 – Geology, Seismology, and Geotechnical Engineering

- Site-Specific Geology Investigations
- Settlement Analyses
- Bearing Capacity
- Liquefaction Analysis
- Evaluation of Karst Conditions
- Grout Plan/ITAAC
- Regional Geology & Tectonics
- Surface Deformation
- Seismicity/Seismic Source Characterization
- Ground Motion Model
- Probabilistic Seismic Hazard Analysis
- Shear Wave Velocity Profiles
- Ground Motion Response Spectra
- CEUS SSC Sensitivity Analysis

Site Specific Evaluations

- **Site geology investigations, including evaluation of potential for karst conditions**
- **Foundation condition, soil/rock parameters, and geotechnical analyses**
  - Index properties, rock mass characterization, shear wave velocity profiles, strength properties, dynamic properties, stiffness characterization
  - Settlement, bearing capacity, liquefaction potential, site uniformity, etc.
- **Section 2.5.4 analyses (settlement, bearing capacity, etc.) use updated material properties [initial (2008) and supplemental (2013) investigations]**
- **Analyses in Section 2.5.2 and 3.7 (SSI, site response) consider updated material properties by performing sensitivity analyses**

Turkey Point Nuclear Plant Units 6 & 7

Site Stratigraphy

EL (ft)	Formation	Lithology
	Muck/Peat	elastic silt and peat
-5	Miami Limestone	sandy, oolitic limestone (Pleistocene)
-27	Key Largo Limestone	coralline, vuggy limestone (Pleistocene)
-49	Ft. Thompson	limestone w/ moldic porosity, shells, sand (Pleistocene)
-115	Upper Tamiami	silty sand with gravel (Pliocene)
-168	Lower Tamiami	sandy silt with silty clay (Upper Miocene to Pliocene)
-218	Peace River	silty sand (Middle to Upper Miocene)
-455	Arcadia	wackestone, packstone, mudstone (Oligocene to Lower Miocene)

Foundation
~EL -16 ft

Depth to 2B
(~EL -336)
Approximate
Depth of Influence

Adapted from FSAR Table 2.5.4-209

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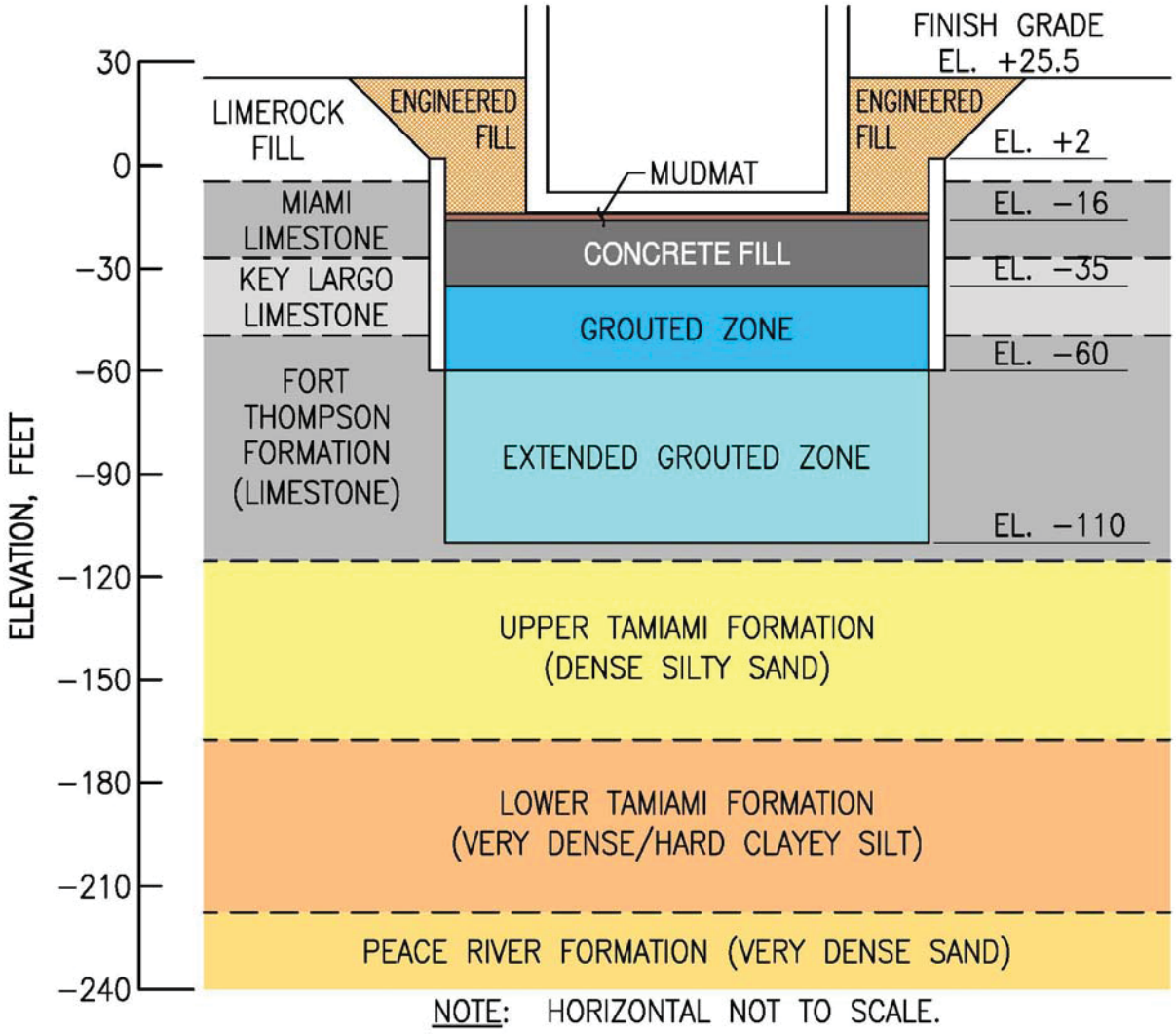
Foundation Conditions



Adapted from FSAR Appendix 3KK Figure 3.1-2

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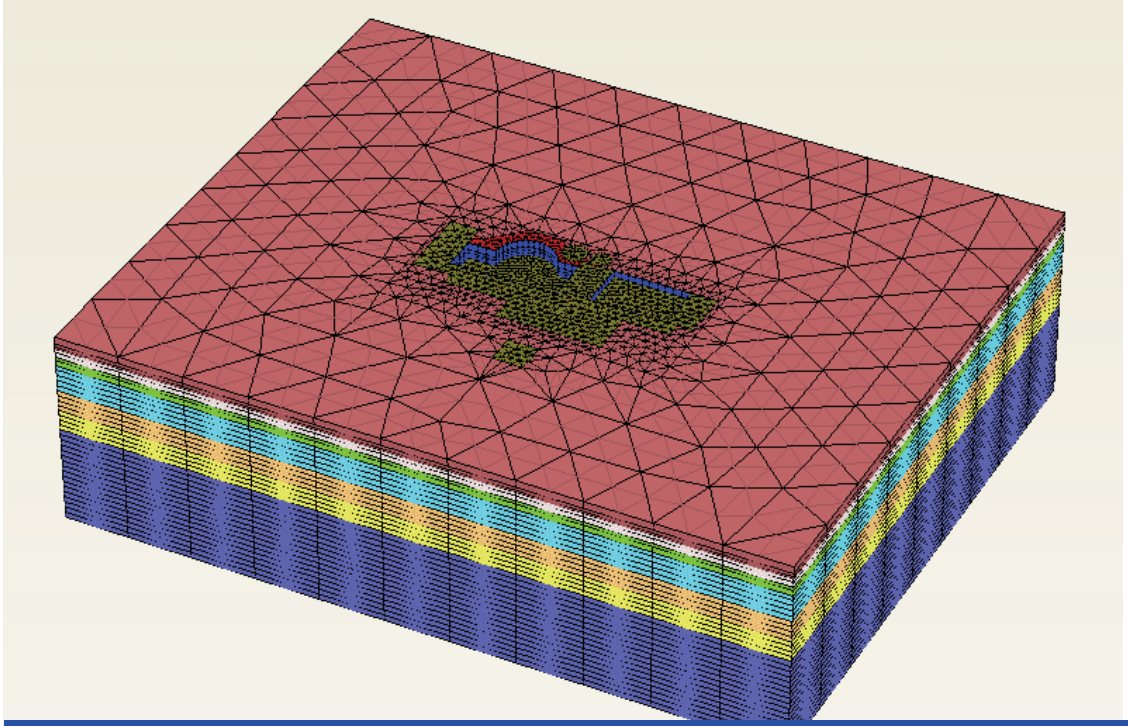
Settlement Analyses



- Finite Element Models
- Classical Hand Calculations

DCD Criteria Met:

Predicted settlement estimates are within the limits provided by AP1000 DCD (6-inch total settlement, 3-inch differential settlement, and 0.5 in/50 ft tilt)

Adapted from FSAR Figure 2.5.4-260

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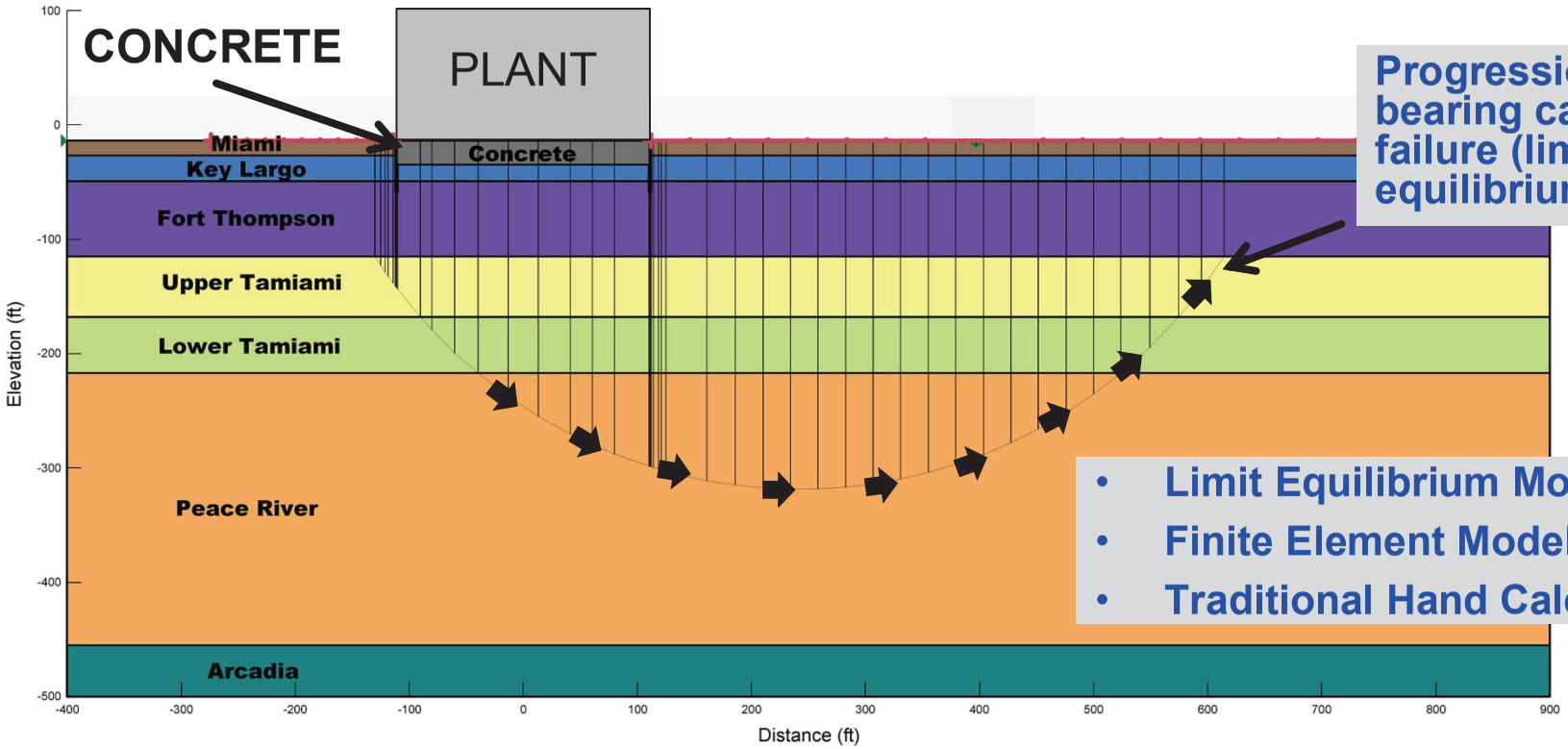
Turkey Point Nuclear Plant Units 6 & 7

Bearing Capacity



Progression of bearing capacity failure (limit-equilibrium model)

- Limit Equilibrium Models
- Finite Element Models
- Traditional Hand Calculations

Adapted from FSAR Figure 2.5.4-257

DCD Criteria Met:

39 ksf static and 41 ksf dynamic bearing capacity are larger than DCD minimum requirements (8.9 ksf static and 35 ksf dynamic)

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Liquefaction Analysis

- **No liquefaction based on SPT, CPT, and V_s data**
- **Conservative Assumptions:**
  - No credit for age, over-consolidation or cementation
  - Input Mw (7.3) - highest EQ magnitude from controlling EQ magnitudes
  - Input PGA (0.1g) – higher than GMRS PGA (0.06g)

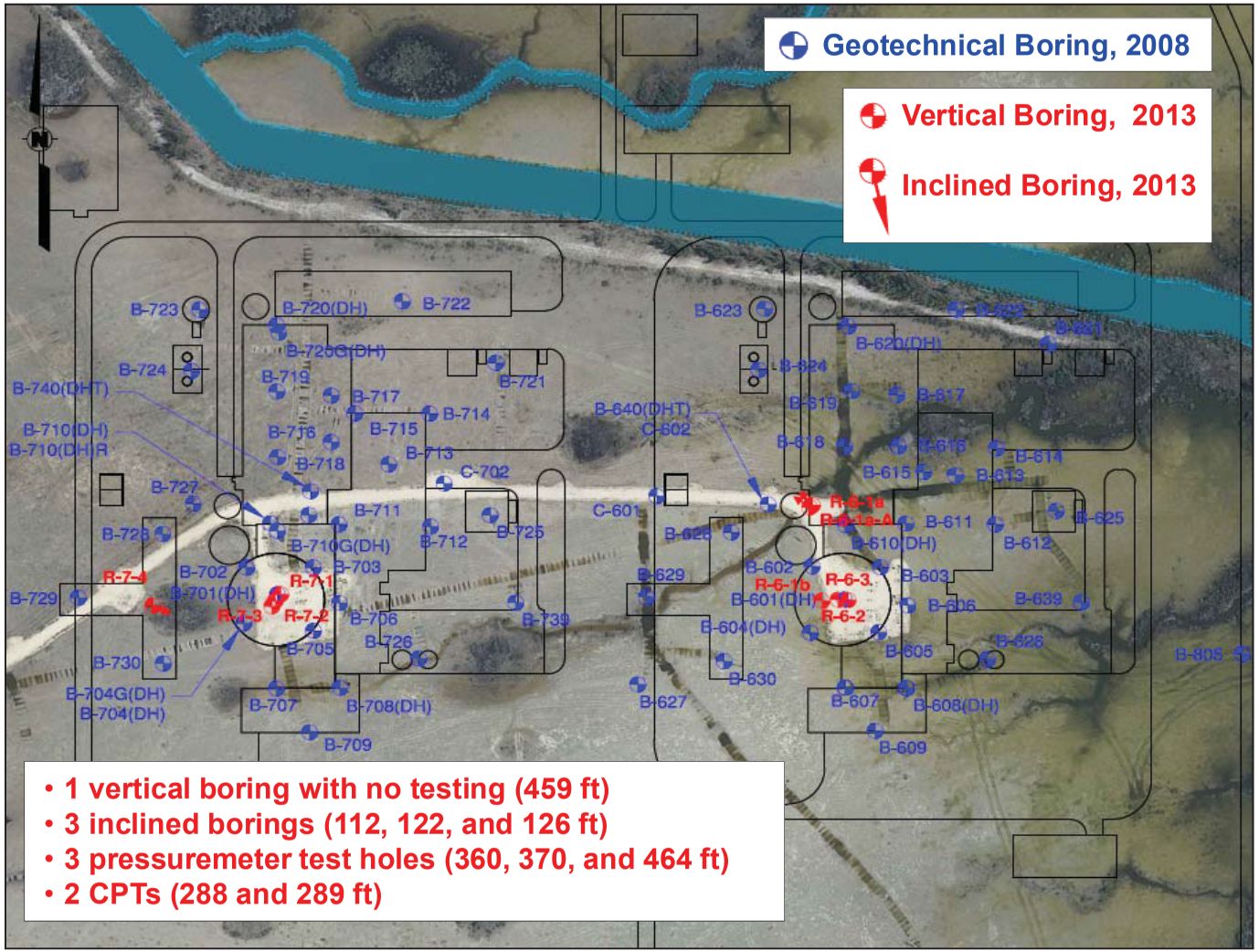
Liquefaction is not a concern.

Evaluation of Karst Conditions

- Only relevant geologic hazard to be addressed is postulated karst deformation
- No karst deformation (cavities/voids or collapses) shown on isopach or structure contour maps
- No caves, surface sinkholes, springs, or paleo-collapse/sag features at the site

Turkey Point Nuclear Plant Units 6 & 7

Site Investigation, 2008 and 2013



Adapted from FSAR Figure 2.5.4-202

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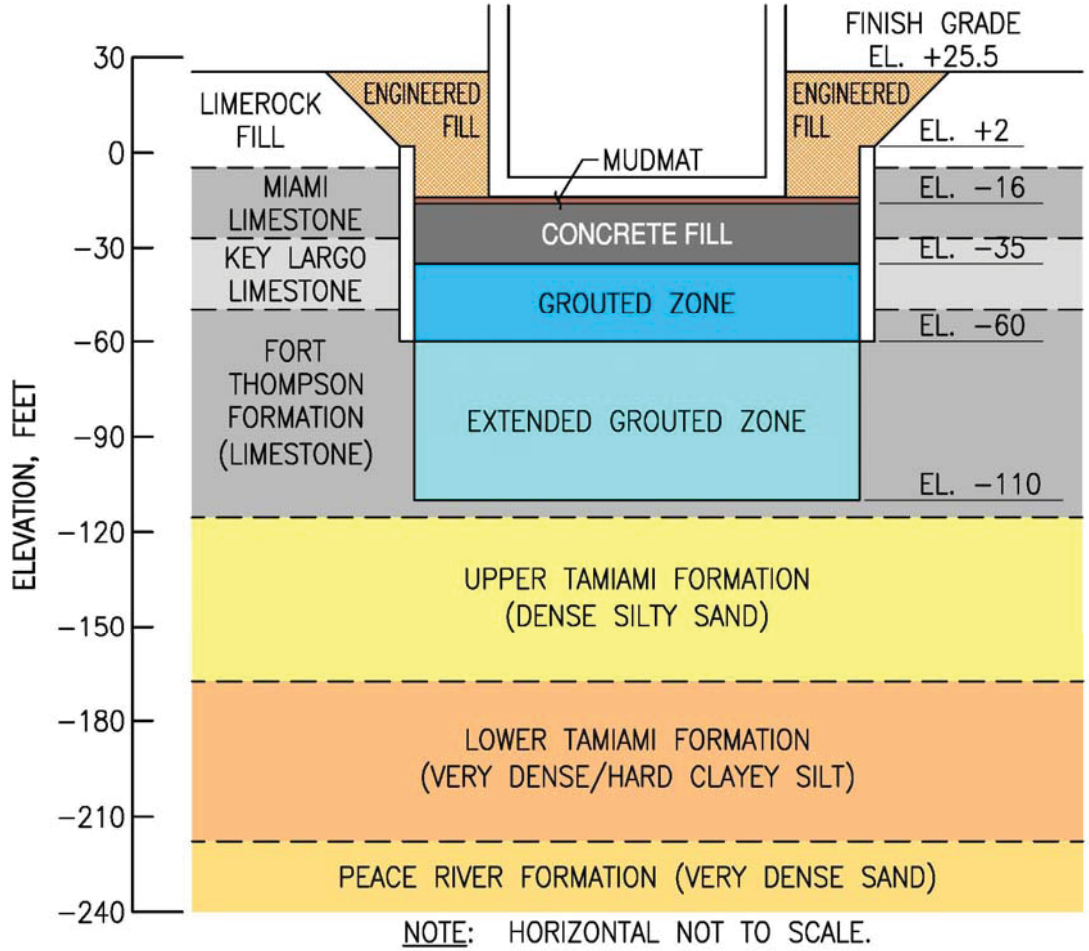
Evaluation of Karst Conditions

- **Observations in Vertical Borings:**
  - Tool/rod drops = 0.3% (20 ft cumulative) of 7,918 ft of core
  - Individual tool/rod drops = 0.4 ft to 4 ft on Site
  - Individual tool/rod drops ≤ 1.5 ft within Unit 6 and 7 footprints
- **Observations in 3 Inclined Borings (2013):**
  - Inclined borings designed to find cavities/voids under the vegetated depressions and drainage channels at the site
  - Tool/rod drops = 4% (15 ft cumulative) of 356 ft of core
  - Individual tool/rod drops = 0.3 to 2.5 ft

Tool drop size is limited to 1.5 ft within Unit 6 and 7 building footprints. Frequency of total drops is < 0.5% site wide.

Grout Plan/ITAAC Table 3.8-6

- Minimizes dewatering effort
- Provides barrier to upward flow
- Minimizes flow through vugs, joints, fractures, and bedding planes in the Key Largo and Fort Thompson



Adapted from FSAR Appendix 3KK Figure 3.1-2

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Grout Test Program

- Validate grouting design/techniques
- Confirm closure criteria for individual grout stages
- Confirm acceptance criteria (residual hydraulic conductivity) for completed areas of the Grouted Zone and Extended Grouted Zone

Grout Plan/ITAAC Table 3.8-6

Primary holes spaced ≤ 20 feet on center, secondary and higher order holes split-spaced

Grouted Zone (El. -35 ft to El. -60 ft)	Extended Grouted Zone (El. -60 ft to El. -110 ft)
• Primary & Secondary holes • Tertiary & Quaternary holes (if necessary)	• Primary holes • Secondary holes (if necessary)
• Any remaining voids structurally insignificant	• Any remaining voids ≤ 20 ft

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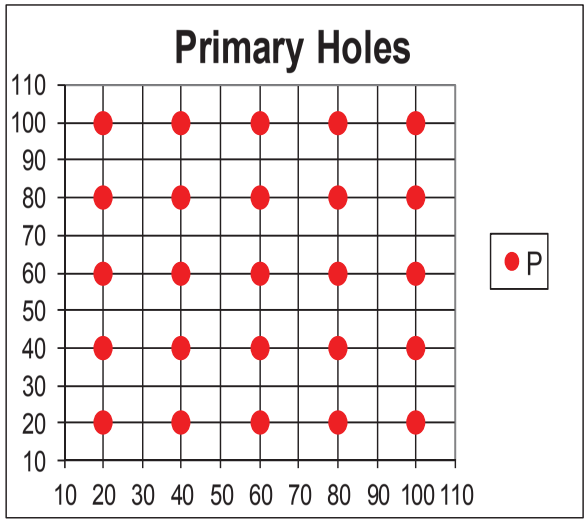
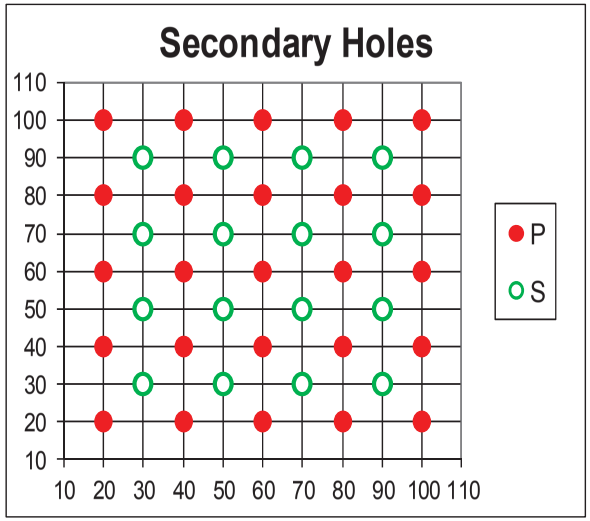
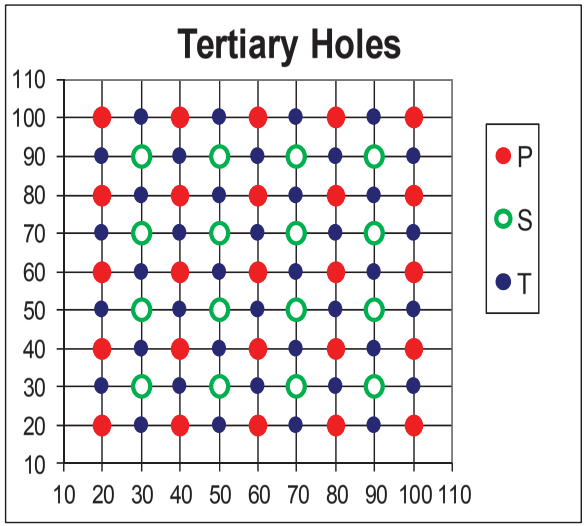
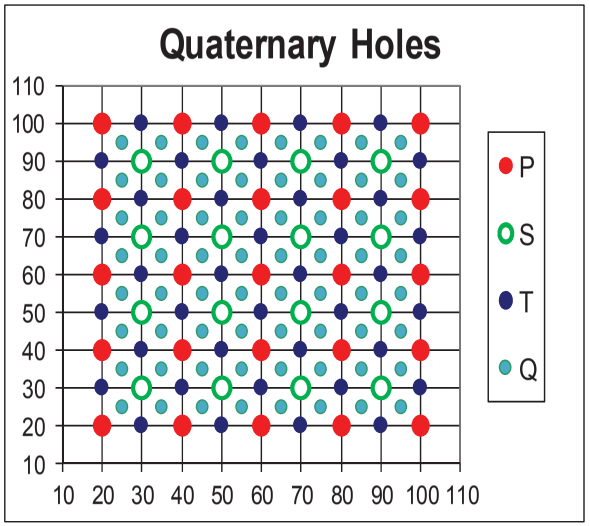
Turkey Point Nuclear Plant Units 6 & 7

Grout Plan/ITAAC Table 3.8-6 (Cont.)









Adapted from FSAR Appendix 2CC Figure 2CC-239

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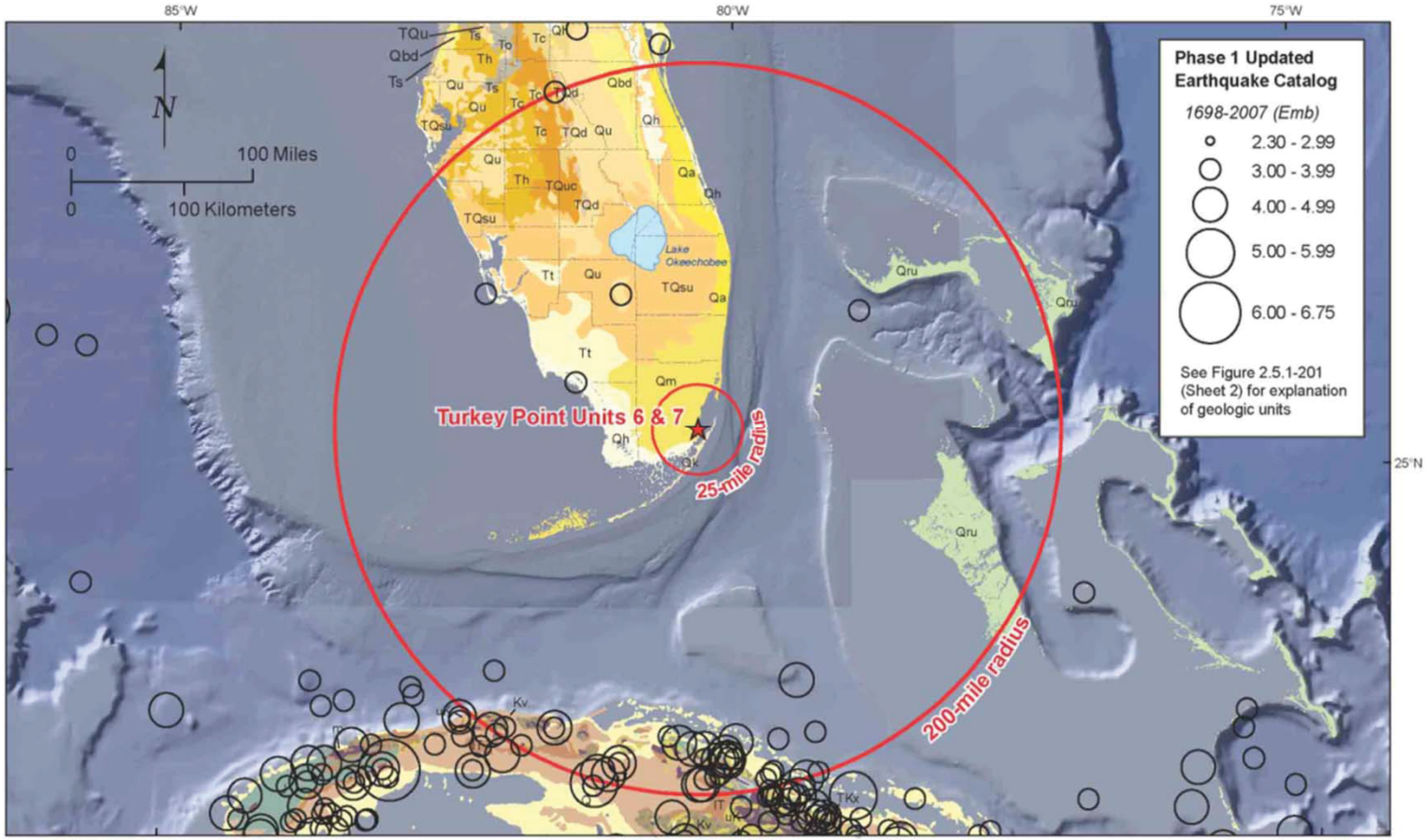
Regional Geology & Tectonics

- **200-mile site region includes:**
  - Southern portion of the Florida Peninsula and offshore Platforms
  - Northern Cuba
- **Significant differences exist between the physiography, geologic history, and current seismotectonic setting of these two areas.**
  - Southern Florida
    - -- Passive continental margin
    - -- Generally flat-lying and undeformed limestones, mudstones, and sandstones deposited over crystalline basement rocks
    - -- Rates of seismicity are very low
  - Northern Cuba
    - -- Complex geologic and tectonic history recorded by faulted and deformed metamorphic, volcanic, and carbonate rocks
    - -- Plate boundary shifted from north to south of Cuba by the Oligocene Epoch. Modern North America-Caribbean plate boundary is located >400 miles from Turkey Point Nuclear Power Plant
    - -- Rates of seismicity in northern Cuba are low to moderate. Rates of seismicity south of Cuba along the modern plate boundary are very high

Turkey Point Nuclear Plant Units 6 & 7

Site Regional Geology and Seismicity



FSAR Figure 2.5.3-203 Site Region Seismicity

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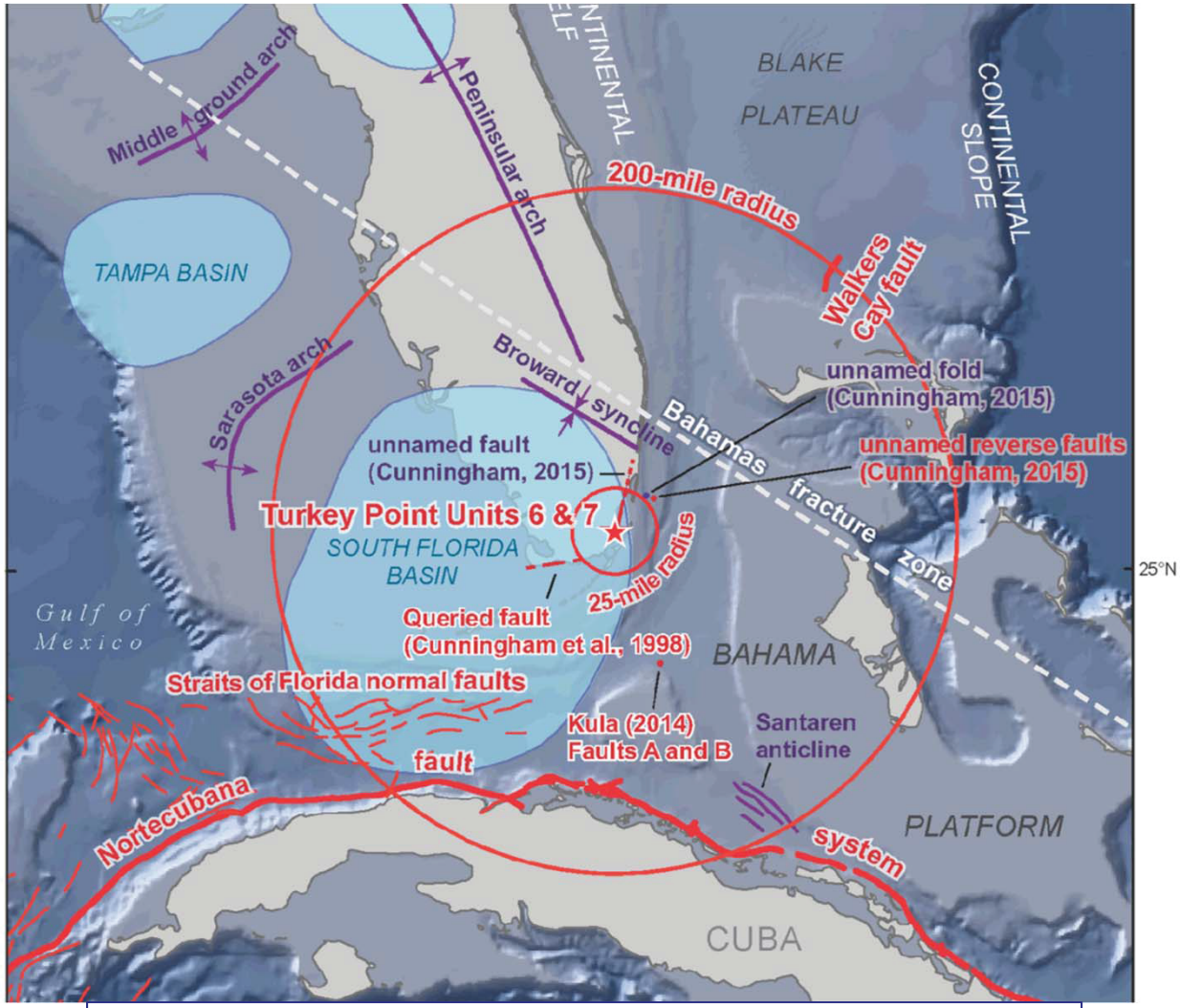
Turkey Point Nuclear Plant Units 6 & 7

Regional Tectonic Map (200-mi.)



Adapted from FSAR Figure 2.5.1-229 Regional Tectonic Features

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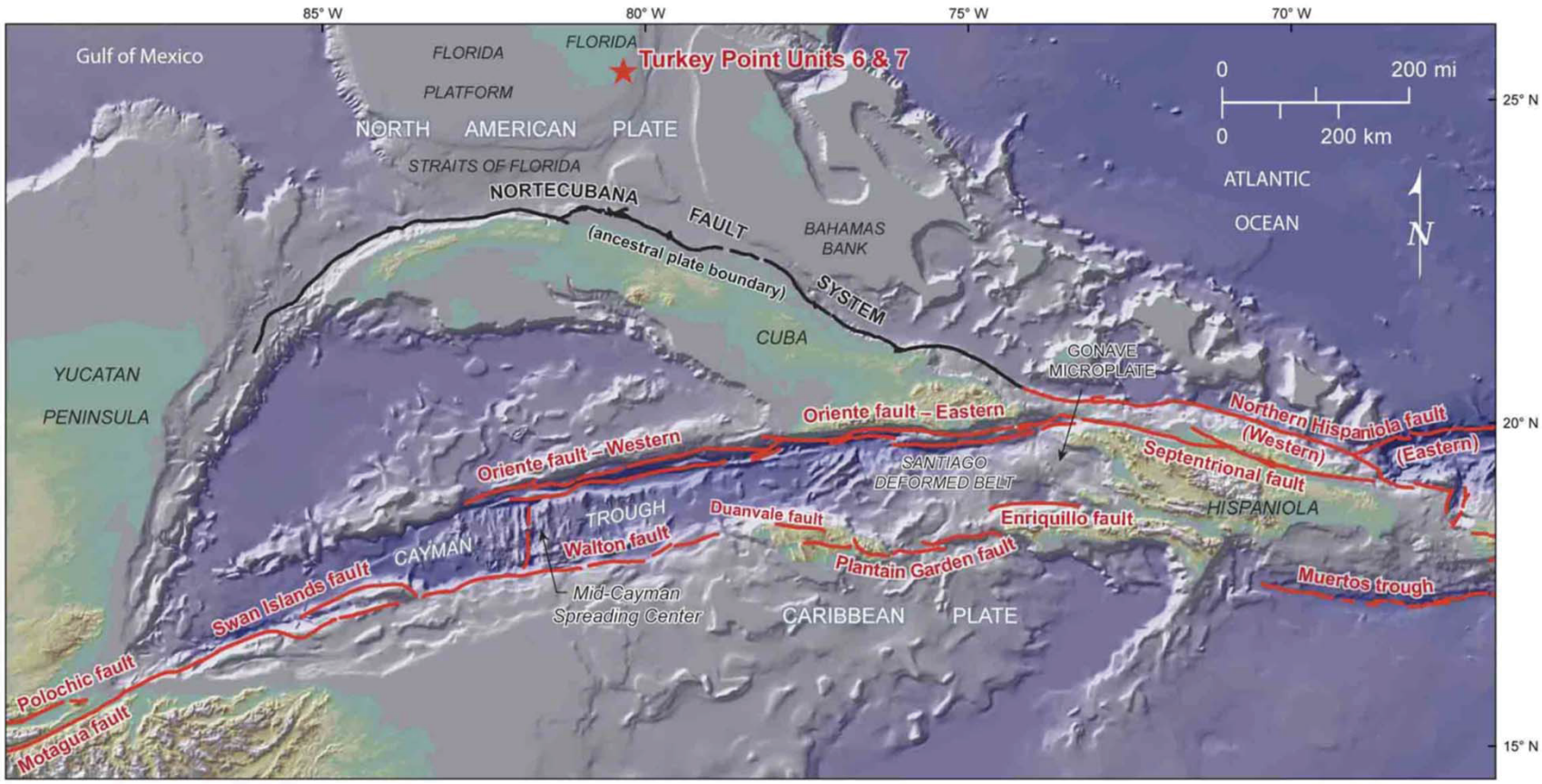
Turkey Point Nuclear Plant Units 6 & 7

Tectonic Map of the Northern Caribbean-North America Plate Boundary



FSAR Figure 2.5.1-202 Tectonic Map of the Northern Caribbean-North America Plate Boundary

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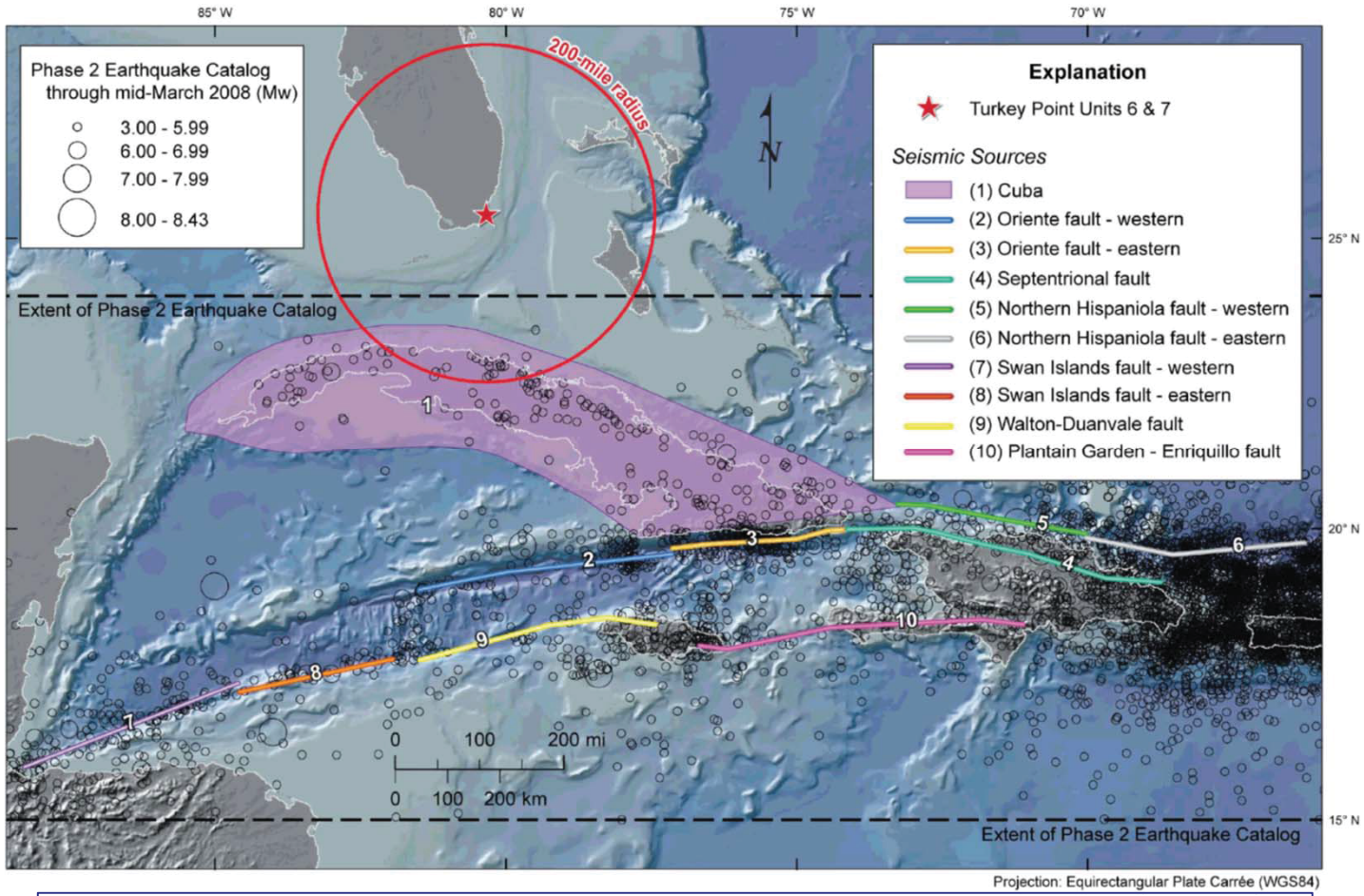
Turkey Point Nuclear Plant Units 6 & 7

Cuba and Northern Caribbean Seismic Source Model Sources



FSAR Figure 2.5.2-217 Cuba and Northern Caribbean Seismic Source Model Sources

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Surface Deformation

- **Geology Investigations**
  - Extensive literature reviews & interviews with local experts
  - Geologic and geomorphic interpretation of aerial photography and field reconnaissance focused on potential tectonic and non-tectonic surface deformation in the site vicinity
- **Conclusion**
  - No traceable tectonic lineaments
  - No evidence of capable or Quaternary tectonic surface deformation within the 25-mile radius site vicinity
  - The only geologic hazard identified in the site area is potential surface deformation related to carbonate dissolution.
    - -- As presented earlier, the potential for dissolution at the site is accounted for in foundation design

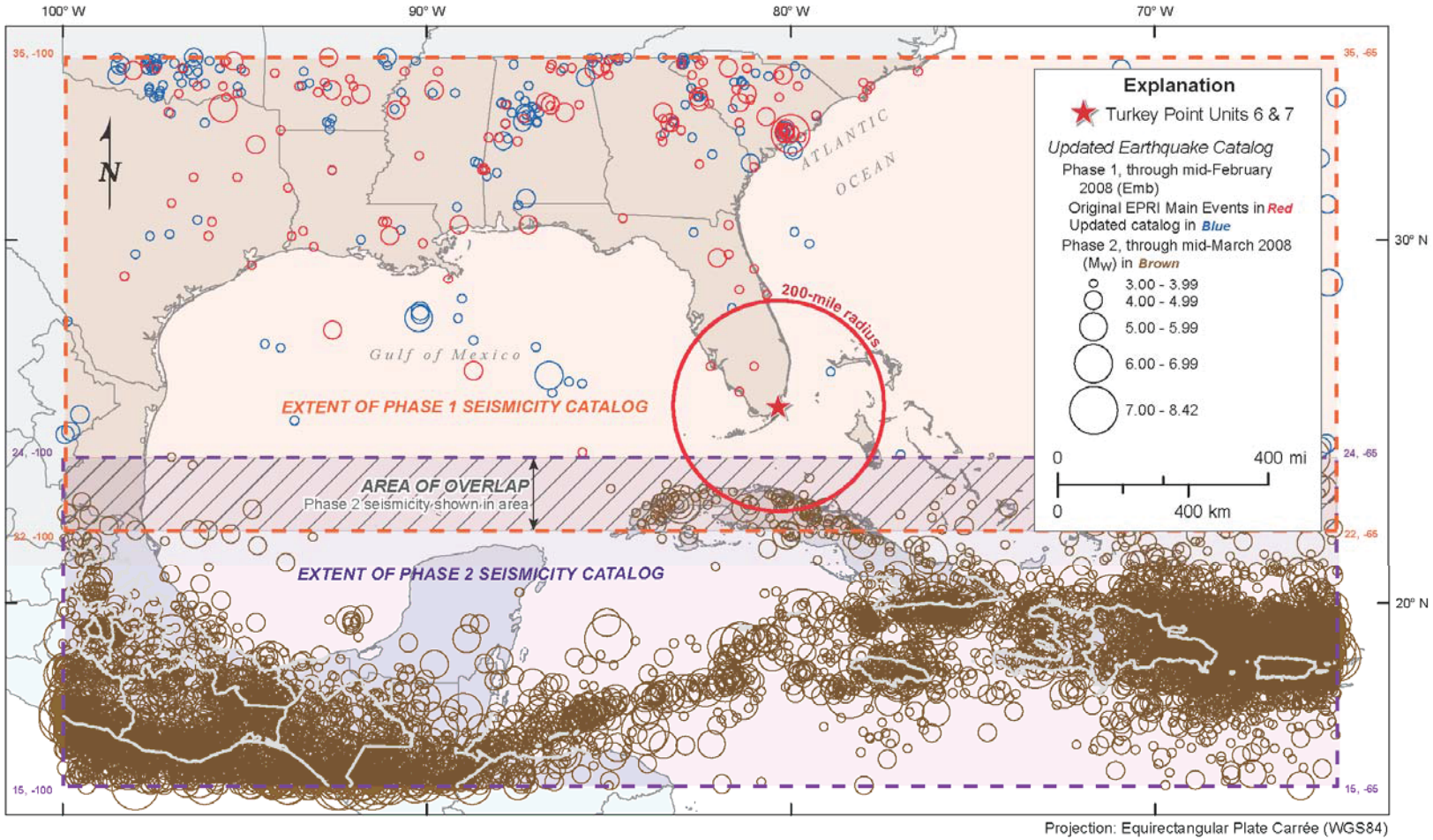
Seismicity

DEVELOPMENT OF THE PROJECT EARTHQUAKE CATALOG

- **Phase 1: Update of the EPRI-SOG (1988) catalog for CEUS**
  - EPRI-SOG (Seismicity Owners Group) catalog complete up through 1984: updated to mid-Feb. 2008
  - 34 earthquake catalogs
  - Objective: all earthquakes of uniform body wave magnitude "Rmb" ≥ 3.0 or maximum intensity $I_0 \geq$ IV
- **Phase 2: Development of a Cuba and Caribbean catalog**
  - Developed earthquake catalog complete to mid-March 2008
  - 23 earthquake catalogs
  - Objective: all earthquakes of uniform moment magnitude $M_W \geq 3.0$

Turkey Point Nuclear Plant Units 6 & 7

Seismicity



FSAR Figure 2.5.2-201 Seismicity in the Study Region, Phase 1 and Phase 2

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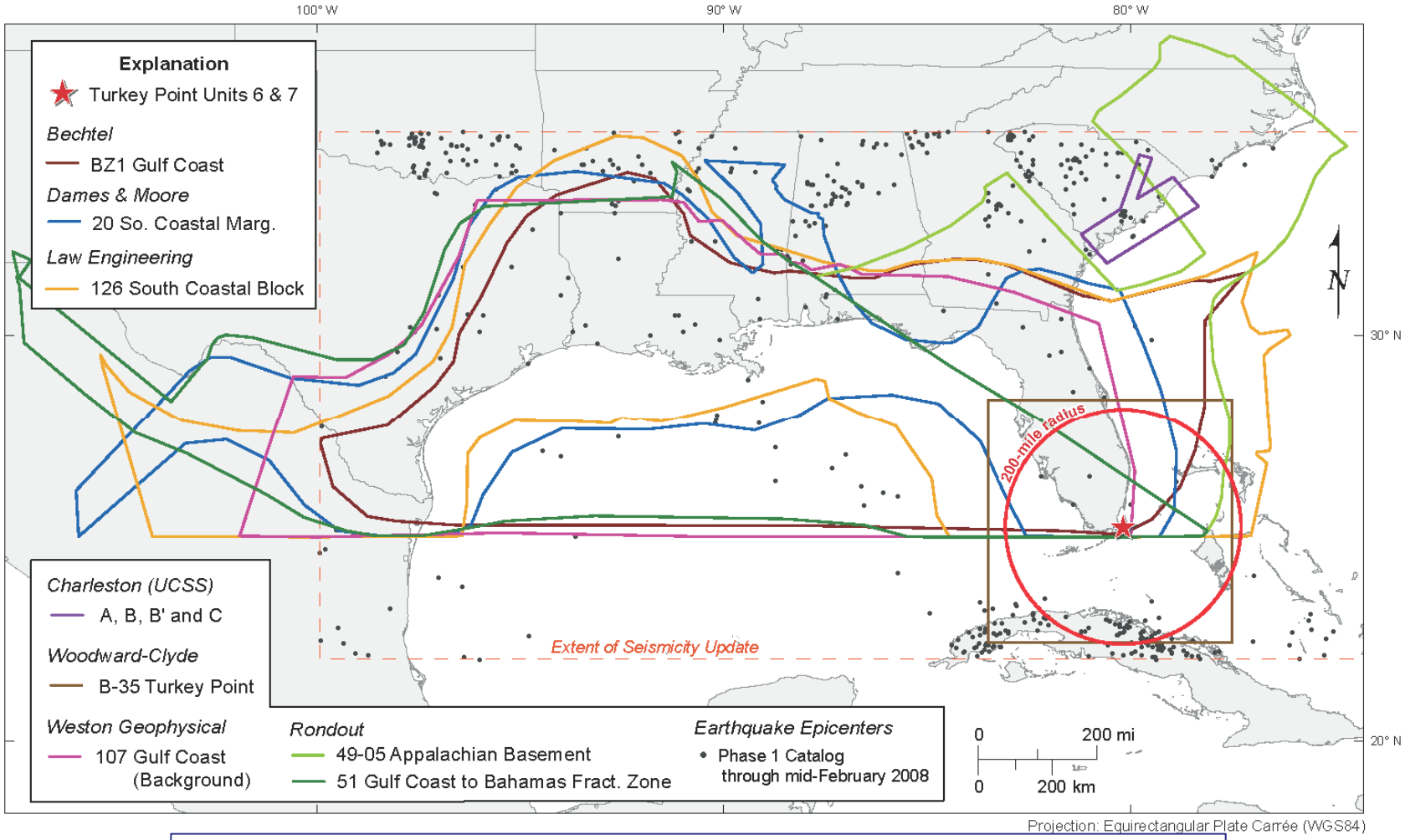
Seismic Source Characterization [SSC]: EPRI-SOG + UCSS



FSAR Figure 2.5.2-203 EPRI Seismic Source Zones and Updated Charleston Seismic Source (UCSS) Model Sources

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Seismic Source Characterization [SSC]: Update

- **Modifications to the six EPRI-SOG seismic source models:**
  - Evaluated activity rates for seismic sources covering the Gulf of Mexico and near Atlantic Ocean
  - Supplemented EPRI-SOG seismic sources for 200-mile radius site region
  - Updated Mmax of seismic sources given updated Phase 2 earthquake catalog
- **Adoption of the Updated Charleston Seismic Source (UCSS) initially developed for the Vogtle Early Site Permit Application**
- **Development of Caribbean seismic sources:**
  - Cuba (single area source)
  - North America-Caribbean plate boundary region (9 fault sources)

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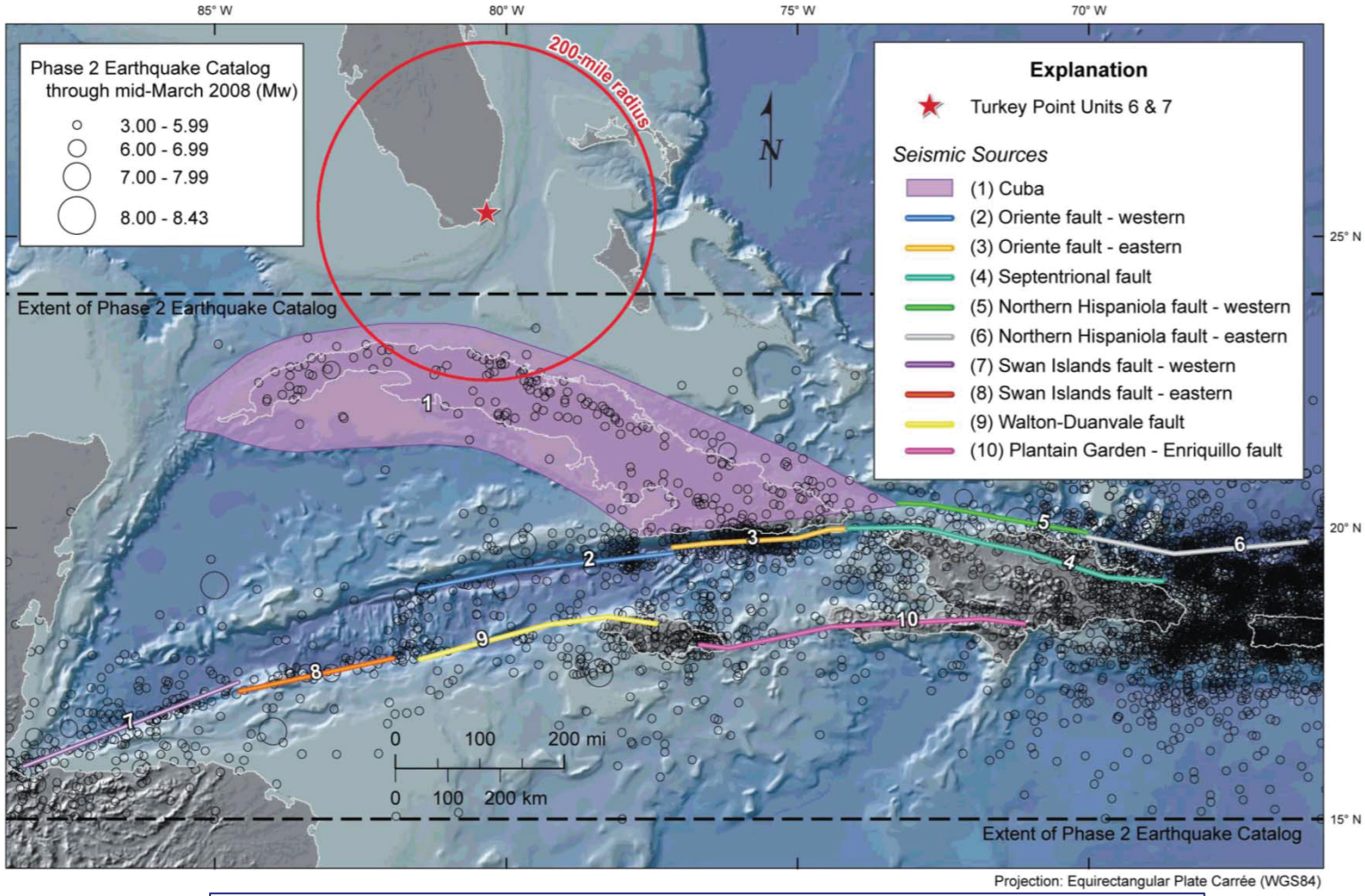
Turkey Point Nuclear Plant Units 6 & 7

Seismic Source Characterization [SSC]: Update



FSAR Figure 2.5.2-217 Cuba and Northern Caribbean Seismic Sources

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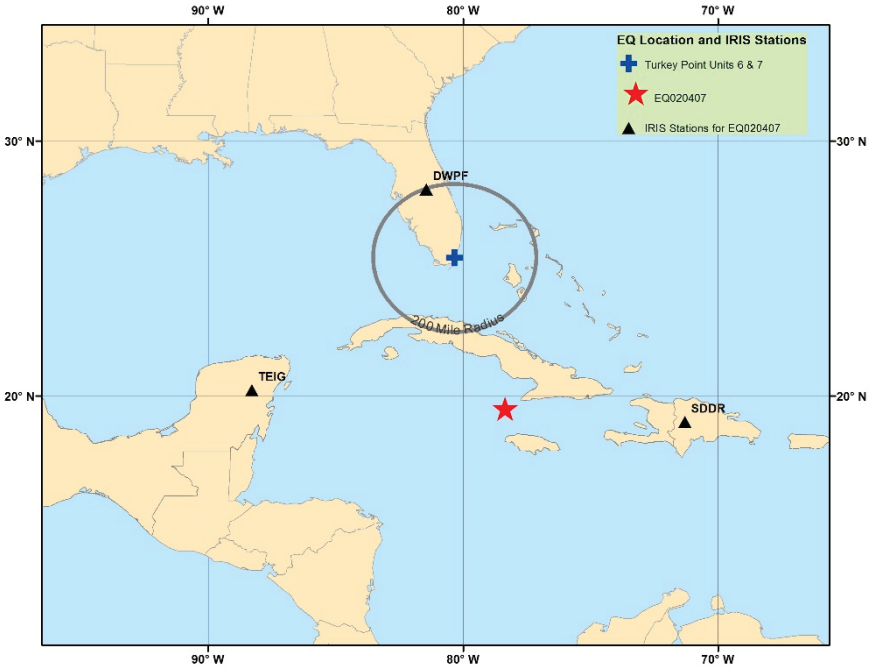
Ground Motion Model [GMM]

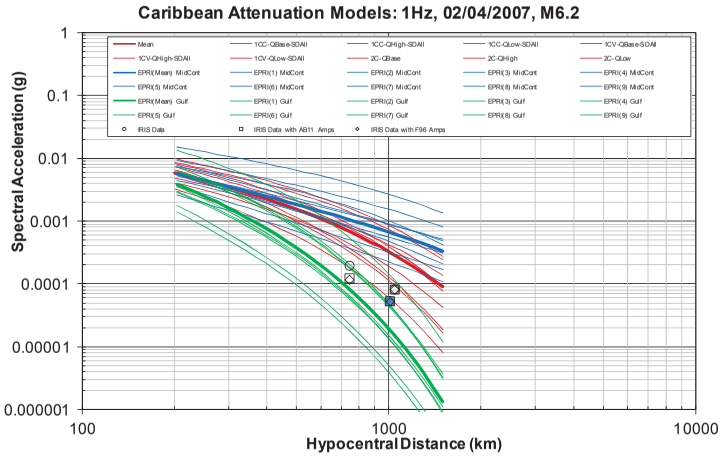
- **CEUS**
  - Replaced EPRI (1988) GMM with EPRI (2004, 2006) GMM [Mid-Continent]
- **Cuba and Caribbean**
  - As no appropriate GMM was available, one was developed for this COLA
  - Guided by published GMM for Puerto Rico, stochastic simulations performed for a range of source, path, and crustal amplification factors
  - Compared new Caribbean GMM with 5 IRIS GM recordings
    - -- New GMM marginally conservative [high] compared with observations
  - Compared new Caribbean GMM with EPRI (2004) Mid-Continent and Gulf Coast
    - -- Gulf Coast < new Caribbean GMM < Mid-Continent
  - Six ground motion attenuation experts were asked to review and comment on both the methodology and results
    - -- Found the Caribbean GMM acceptable

Turkey Point Nuclear Plant Units 6 & 7

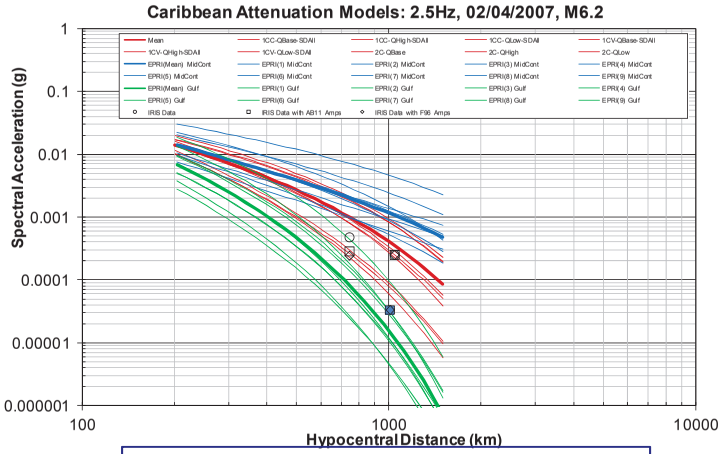
Ground Motion Model [GMM]



FSAR Figure 2.5.2-260a Map Showing the Earthquake Location for the 02/04/2007 Cuba Region Earthquake (Mw 6.2), the IRIS Station Locations Used in the Analysis, and Turkey Point Units 6 & 7 Site Location



FSAR Figure 2.5.2-260b: 1 Hz



FSAR Figure 2.5.2-260c: 2.5 Hz

Blue:	EPRI (2004) Mid-Cont.
Red:	Caribbean GMM
Black symbols:	IRIS data
Green:	EPRI (2004) Gulf Coast

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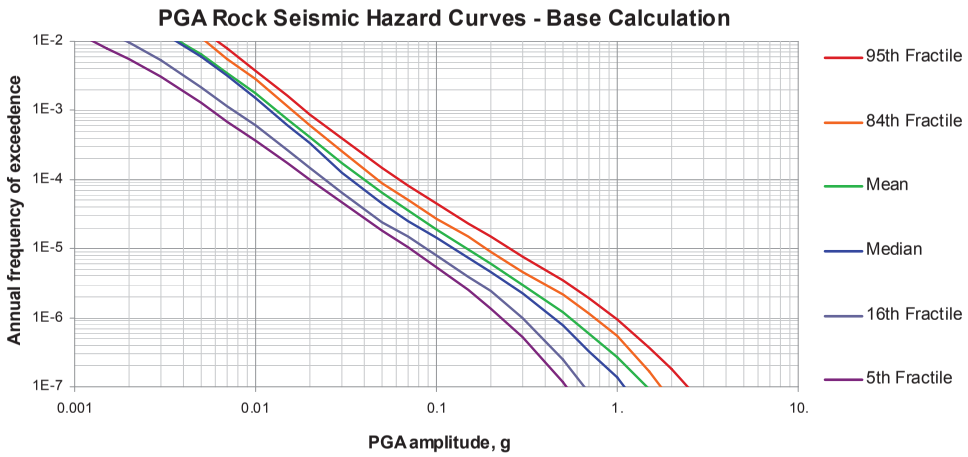
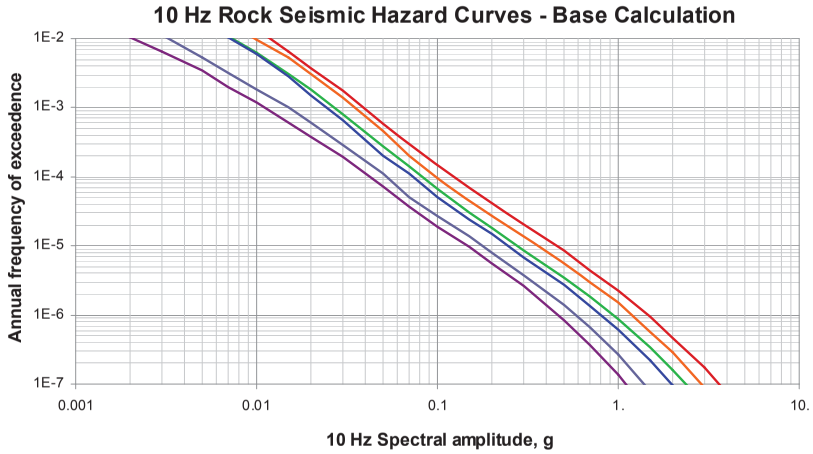
Probabilistic Seismic Hazard Analysis (PSHA)

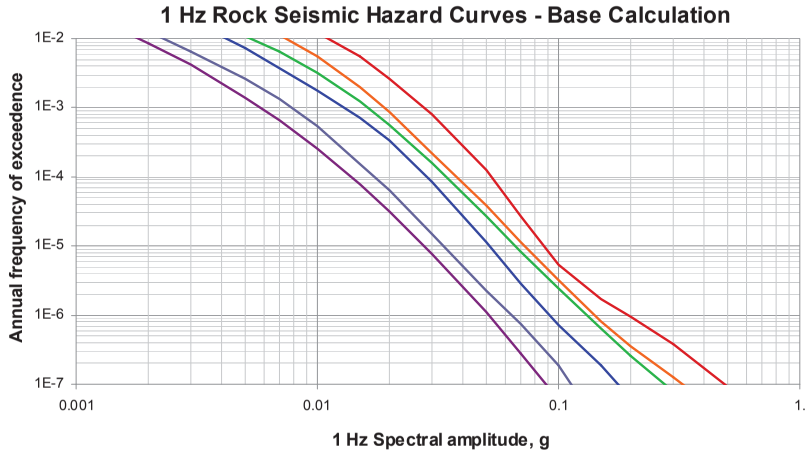
- **Horizontal Hard Rock Ground Motions**
  - EPRI (2004, 2006) & Caribbean GMM hazard curves: PGA, 25, 10, 5, 2.5, 1, & 0.5 Hz
  - "Hard rock": shear-wave velocity of 9,200 ft/sec [11,400 ft deep]
- **PSHA Deaggregation**
  - Magnitude and Distance
    - -- "Controlling earthquakes" for high-frequency [HF: 5 to 10Hz] and low-frequency [LF: 1 to 2.5Hz] portions of the ground motions for a given mean hazard level
    - -- Following Reg. Guide 1.208, separate HF and LF rock response spectra are used for input to site response per Approach 2A of NUREG/CR-6728
  - Seismic Sources
    - -- Hazard curves from discrete sources give an alternate view of the seismic sources contributing most to the total hazard
      - LF hazard at 10^{-4} almost solely from Cuba/Caribbean; 10^{-5} dominated equally by Cuba/Caribbean and Charleston, then moderately by local sources
      - HF hazard dominated by local CEUS sources

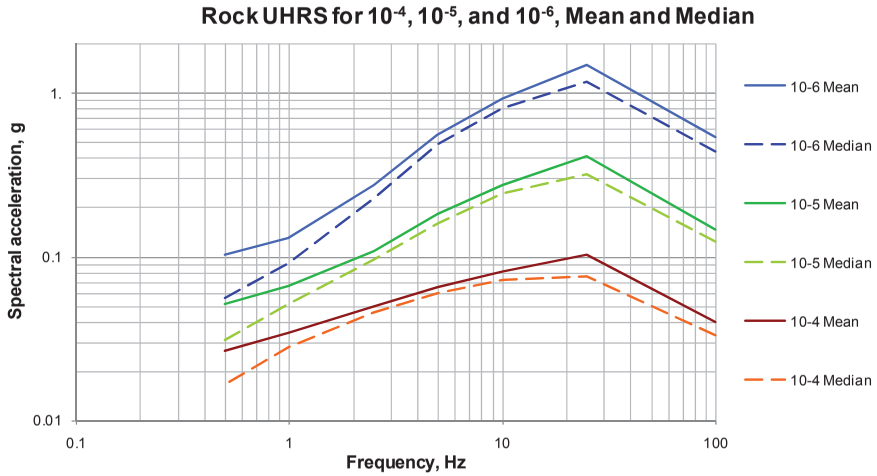
Turkey Point Nuclear Plant Units 6 & 7

Probabilistic Seismic Hazard Analysis









Figures 2.5.2-218, -220, & -223 Mean and Fractile Rock Seismic Hazard Curves

Figure 2.5.2-225 Mean and Median Rock UHRS for 1E-04, 1E-05, and 1E-06

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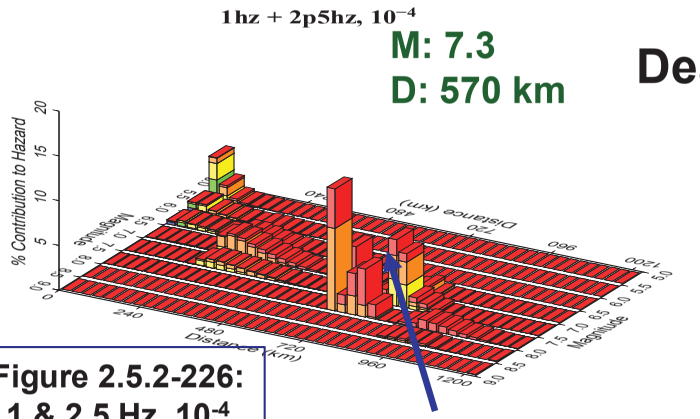
Turkey Point Nuclear Plant Units 6 & 7

Probabilistic Seismic Hazard Analysis

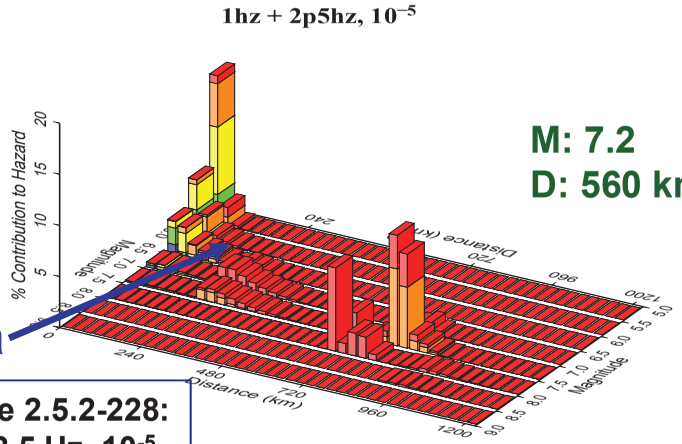
M and D Deaggregation



M: 7.3
D: 570 km

Caribbean and Charleston

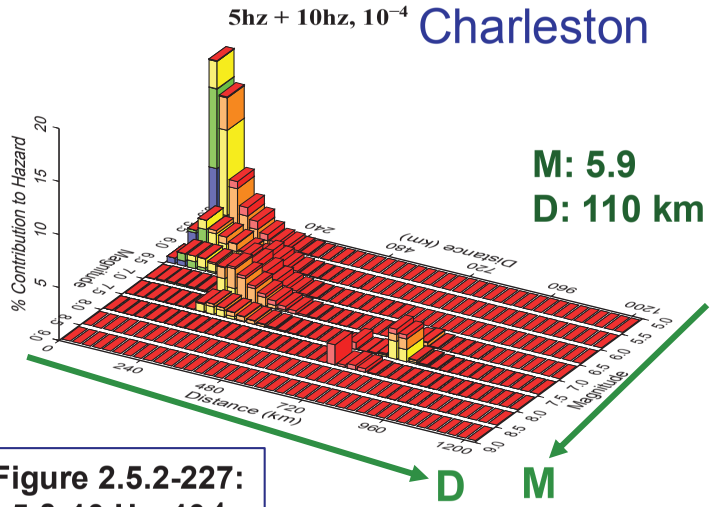
Figure 2.5.2-226: 1 & 2.5 Hz, 10^{-4}



M: 7.2
D: 560 km

Cuba

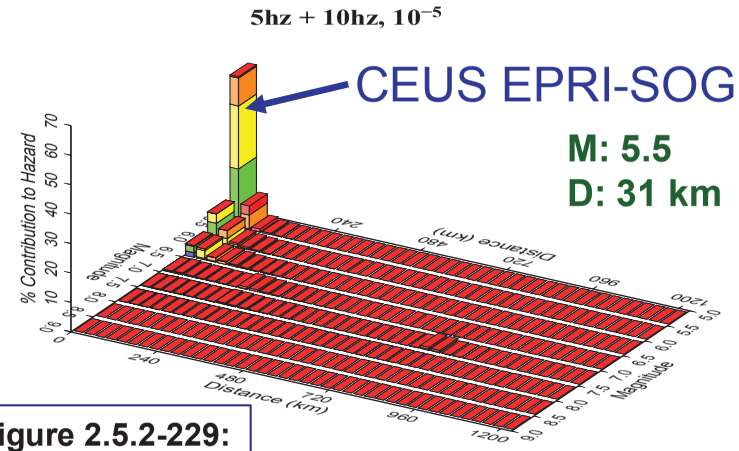
Figure 2.5.2-228: 1 & 2.5 Hz, 10^{-5}



M: 5.9
D: 110 km

D M

Figure 2.5.2-227: 5 & 10 Hz, 10^{-4}



CEUS EPRI-SOG

M: 5.5
D: 31 km

Figure 2.5.2-229: 5 & 10 Hz, 10^{-5}

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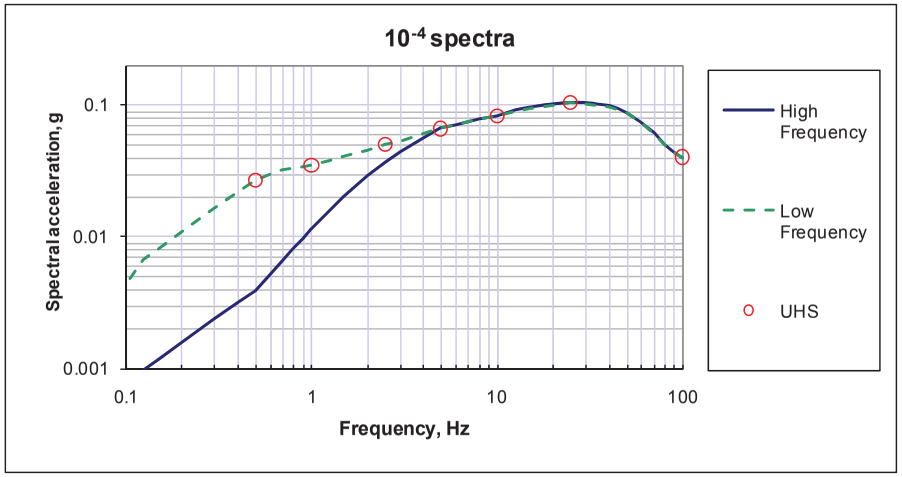
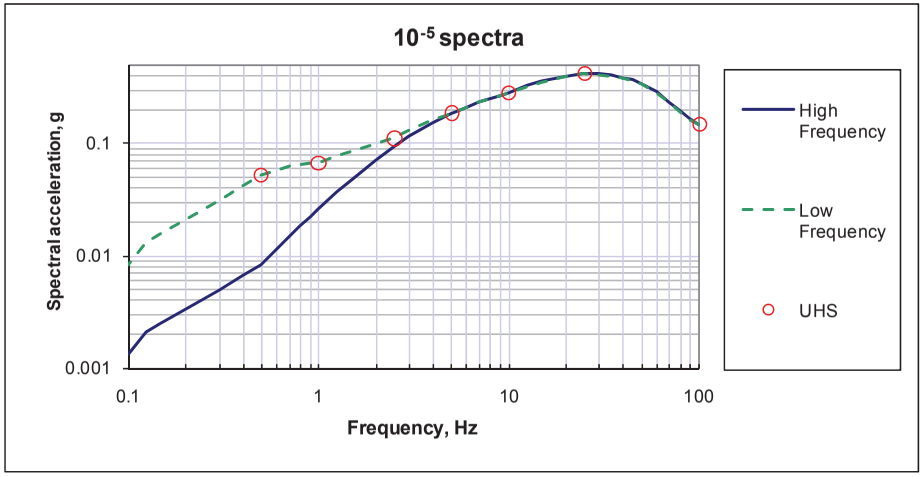
Turkey Point Nuclear Plant Units 6 & 7

Probabilistic Seismic Hazard Analysis

Hard Rock Input Ground Motions to Site Response Analysis



FSAR Figure 2.5.2-232 HF and LF Rock Spectra Anchored to Mean UHRS Values from Hazard Calculation for 10^{-4} Spectra



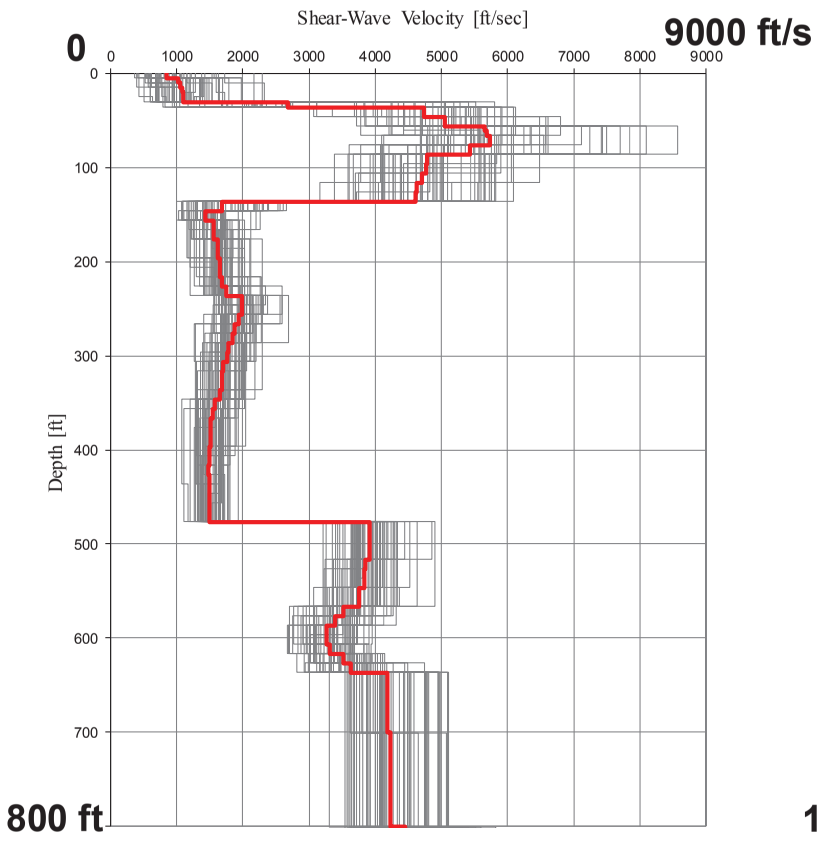
FSAR Figure 2.5.2-233 HF and LF Rock Spectra Anchored to Mean UHRS Values from Hazard Calculation for 10^{-5} Spectra

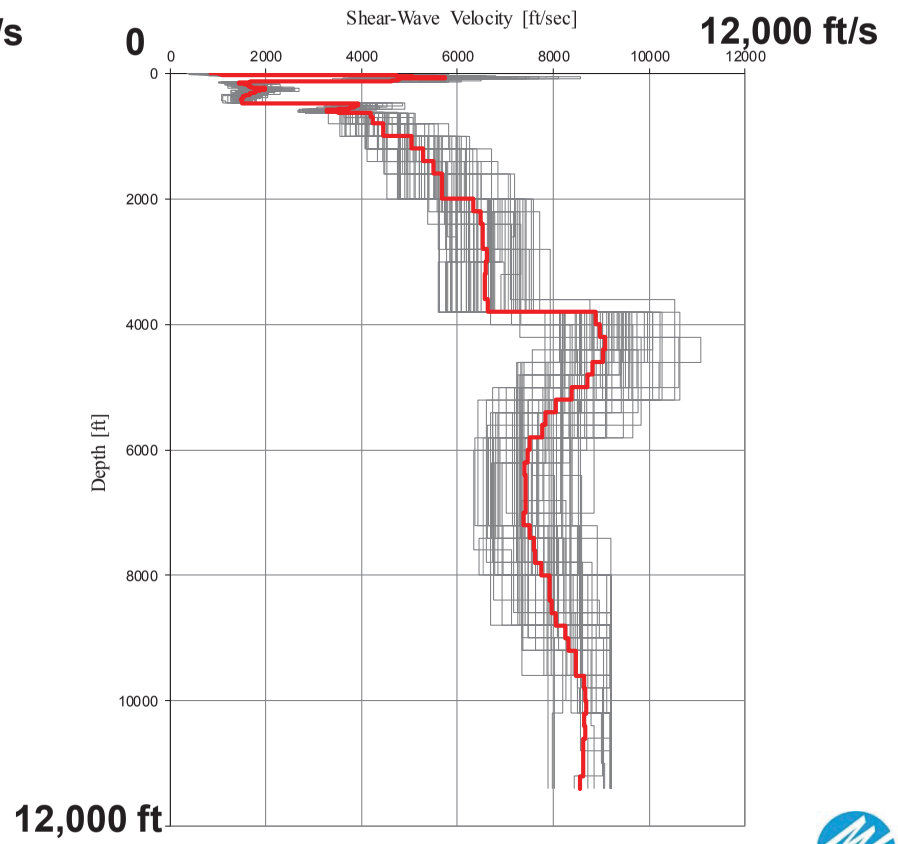
Reg. Guide 1.208: GMRS is determined from site-specific evaluations of ground motions associated with mean hazards of 10^{-4} and 10^{-5}.

Turkey Point Nuclear Plant Units 6 & 7

Randomized Shear-Wave Velocity Profiles

- 60 randomized profiles simulating in-situ soil conditions
- GMRS at El. -35 ft (depth of 60.5 ft) in Key Largo formation





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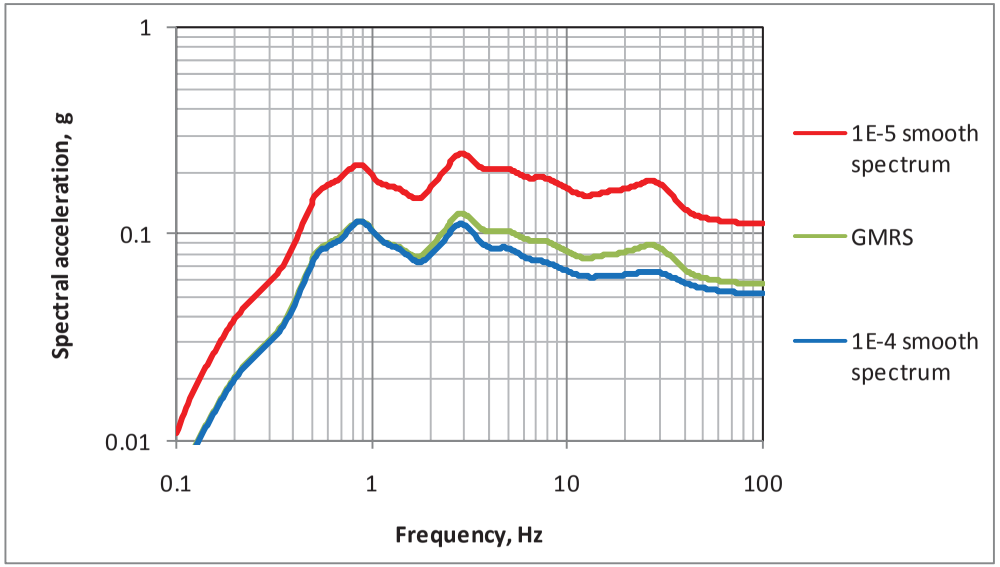
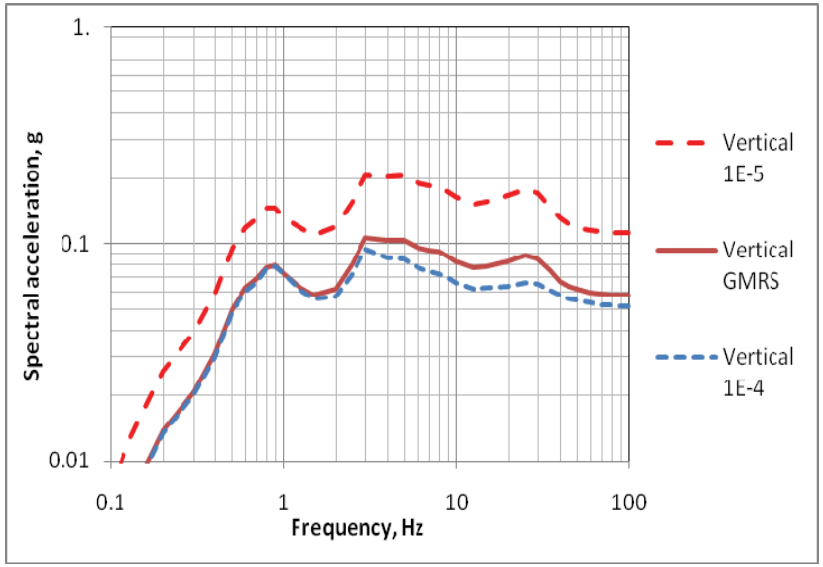
Turkey Point Nuclear Plant Units 6 & 7

Ground Motion Response Spectra





V/H: Reg. Guide 1.60

FSAR Figure 2.5.2-253 Smoothed Horizontal 1E-04 and 1E-05 Site Spectra and GMRS

FSAR Figure 2.5.2-254 Smoothed Vertical 1E-04 and 1E-05 Site Spectra and GMRS

Reg. Guide 1.208: Determination of the GMRS

$A_R = SA(10^{-5})/SA(10^{-4})$	Equation 2.5.2-14
$DF = 0.6 \times A_R^{0.8}$	Equation 2.5.2-15
$GMRS = max[SA(10^{-4}) \times max(1.0, DF), 0.45 \times SA(10^{-5})]$	Equation 2.5.2-16

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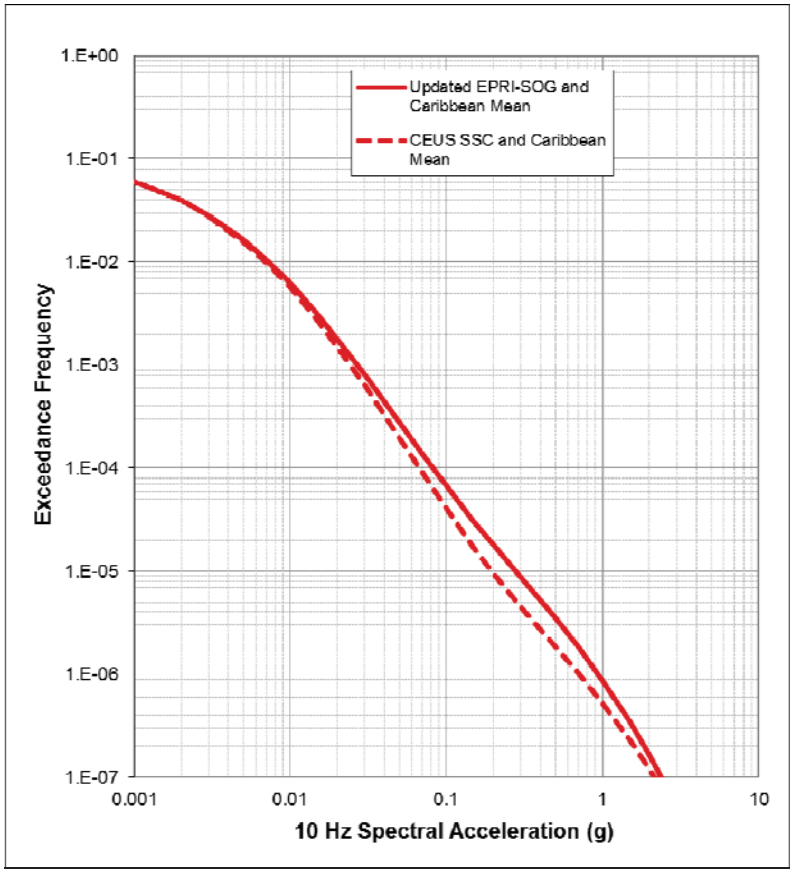
Comparison of PSHA Using Updated EPRI-SOG (1980's) SSC with EPRI et al. (2012) CEUS SSC

- **Following FSAR PSHA and GMRS development, a newer CEUS SSC model was published by EPRI et al. (2012)**
- **Cuba and Caribbean hazard added to PSHA using new CEUS SSC model to make comparison with FSAR total hazard**
- **The comparison shows:**
  - **2.5 Hz and higher:** Hazard from new CEUS SSC model lower
  - **1 Hz and lower:** Hazard from new CEUS SSC model is slightly higher

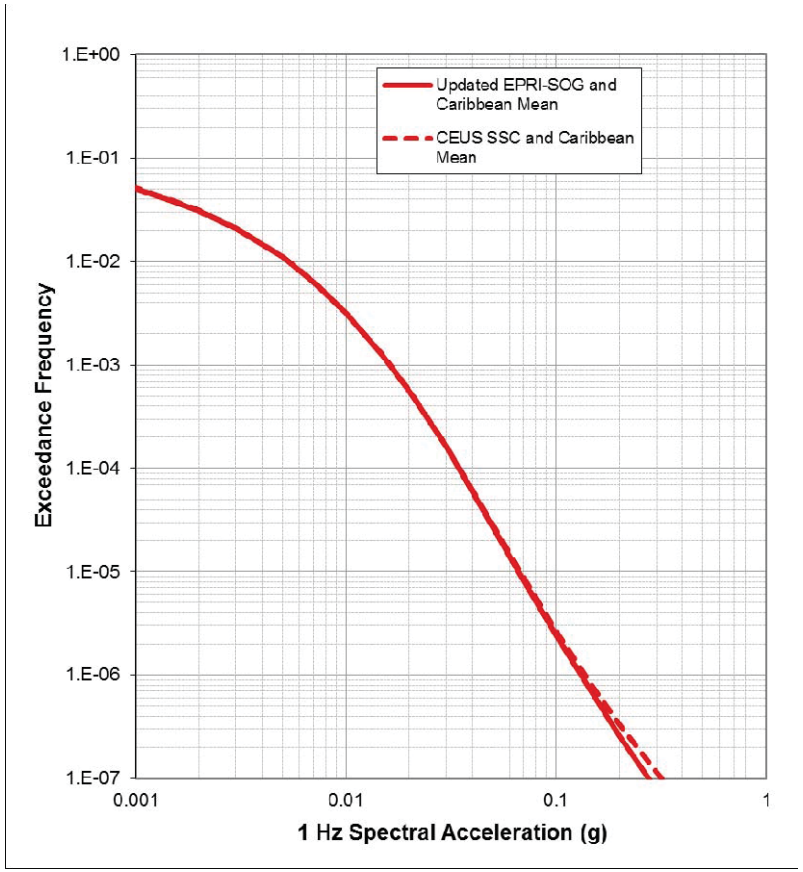
Turkey Point Nuclear Plant Units 6 & 7

CEUS SSC Sensitivity Analysis

Comparison of Hard Rock Hazard Results



FSAR Figure 2.5.2-283 Contributions of Various Source Types to Hard Rock Hazard for 10 Hz (modified)



FSAR Figure 2.5.2-284 Contributions of Various Source Types to Hard Rock Hazard for 1 Hz (modified)

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Turkey Point Nuclear Plant Units 6 & 7
Day 2

- Section 2.5 Geology, Seismology, and Geotechnical Engineering
- **Chap. 3 Design Of Structures, Components, Equipment and Systems**
- Section 13.3 Emergency Planning
- Chap. 19 Probabilistic Risk Assessment
- Chap. 20 Requirements Resulting from Fukushima Near Term Task Force Recommendations
- Chap. 21 Design Changes Proposed in Accordance with ISG-11

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FPL

Turkey Point Nuclear Plant Units 6 & 7

Chap. 3 - Design Of Structures, Components, Equipment and Systems

Paul Jacobs
Engineering Supervisor
New Nuclear Projects

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Chapter 3 Summary

- AP1000 DCD Incorporated by Reference
- Standard Material Incorporated (including Supplements and Departures)
- External Missile Evaluations
- Foundation Input Response Spectra (FIRS)
- Soil Structure Interaction Analysis

Hurricane Missiles - Code Requirements & Provisions

- General Design Criterion (GDC) 1, "Quality Standards and Records" requires, in part, that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed
- GDC 2, "Design Basis for Protection against Natural Phenomena" requires structures, systems, and components that are important to safety be designed to withstand the effects of natural phenomena, such as hurricanes, without loss of the ability to perform their safety functions
- GDC 4, "Environmental and Dynamic Effects Design Basis" requires, in part, that structures, systems and components that are important to safety be adequately protected against the effects of missiles resulting from events and conditions outside the plant

Hurricane Missiles - Code Requirements & Provisions

- **RG 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)"**
- **RG 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Rev. 1 decreased design basis tornado wind speeds, and tornado is no longer bounding for all areas of the U.S. for horizontal missiles**
- **RG 1.221, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants" (2011)**
  - Hurricane missile spectrum:
    - -- A massive high-kinetic-energy missile that deforms on impact (automobile)
    - -- A rigid missile that tests penetration resistance (pipe)
    - -- A small rigid missile of a size sufficient to pass through any opening in protective barriers (solid steel sphere)
  - Missiles are capable of striking in all directions
  - The barrier design should be evaluated using normal impact to the surface
  - All external missiles for hurricane are enveloped by the tornado missiles in the vertical direction, but not in the horizontal direction

Hurricane Missiles - Code Requirements & Provisions

AP1000 Design Tornado Missiles

Missile	Description	Weight #	Vh mph	Vv mph
1	Auto	4000	105	74
2	Armor Piercing Artillery Shell	275	105	74
3	Solid Steel Sphere	0.147	105	105

Turkey Point Unit 6 & 7 Hurricane Missiles

Missile	Description	Weight #	Vh mph	Vv mph
1	Auto	4000	180	58
2	Schedule 40 pipe	287	144.5	58
3	Solid Steel Sphere	0.147	128.5	58

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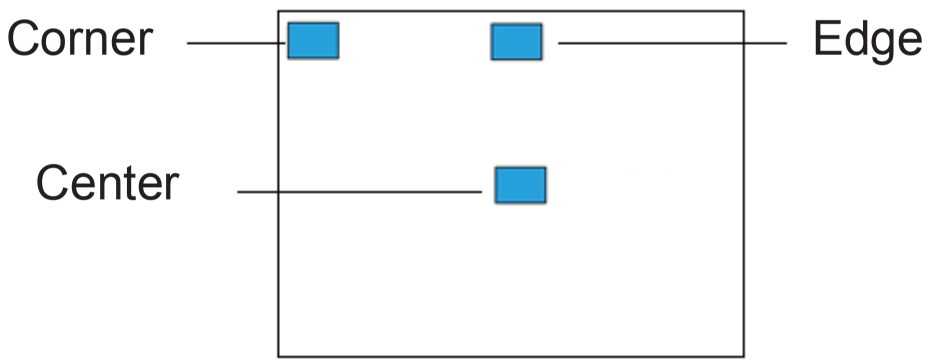
Hurricane Missiles - Code Requirements & Provisions

- **ACI 349-01 Appendix C – Special Provisions for Impulsive and Impactive Effects**
  - C.1.4: Impactive loading may be defined in terms of time-dependent force or pressure
    - -- The AP1000 plant uses a time-dependent force function for the automobile missile
  - Energy balance techniques as prescribed in C.6.2 are used for pipe and sphere missiles
  - In accordance with ACI code, allowable ductility factor (μ) of 10 for flexure and 1.3 for shear are used

Automobile Missile Impact Evaluation

- **Center impact**
  - Both one-way and two-way shear are evaluated
  - Wind load and automobile missile load are considered
  - Dynamic Increase Factors (DIF) are used when applicable
- **Edge and corner impact**
  - Edge and corner effects are studied with dynamic analysis using the finite element code ABAQUS and the AP1000 plant NI05 model



Automobile Missile Impact Evaluation

- A dynamic time history analysis is performed using a single degree of freedom system. Flexure and shear strengths are evaluated to ACI 349-01
- Nonlinear finite element analyses are performed to investigate shear behavior
- Impacts were evaluated at center, edge and corner of critical walls
- Critical walls of the Auxiliary Building are selected based on thickness, reinforcement, location, span distance from the floor, and wall supports associated with the critical wall slab being evaluated
- Finite element analyses were performed to further investigate shear behavior. It is shown that out-of-plane shear behavior remains essentially linear elastic.

Hurricane Missiles - Conclusion

- The three hurricane missiles (automobile, pipe & sphere) were evaluated for horizontal impact on concrete walls
- The automobile missile was evaluated for impact at center, edge and corner of the critical walls

The certified design of the AP1000 concrete walls is acceptable for site-specific hurricane missile impacts at the Turkey Point site.

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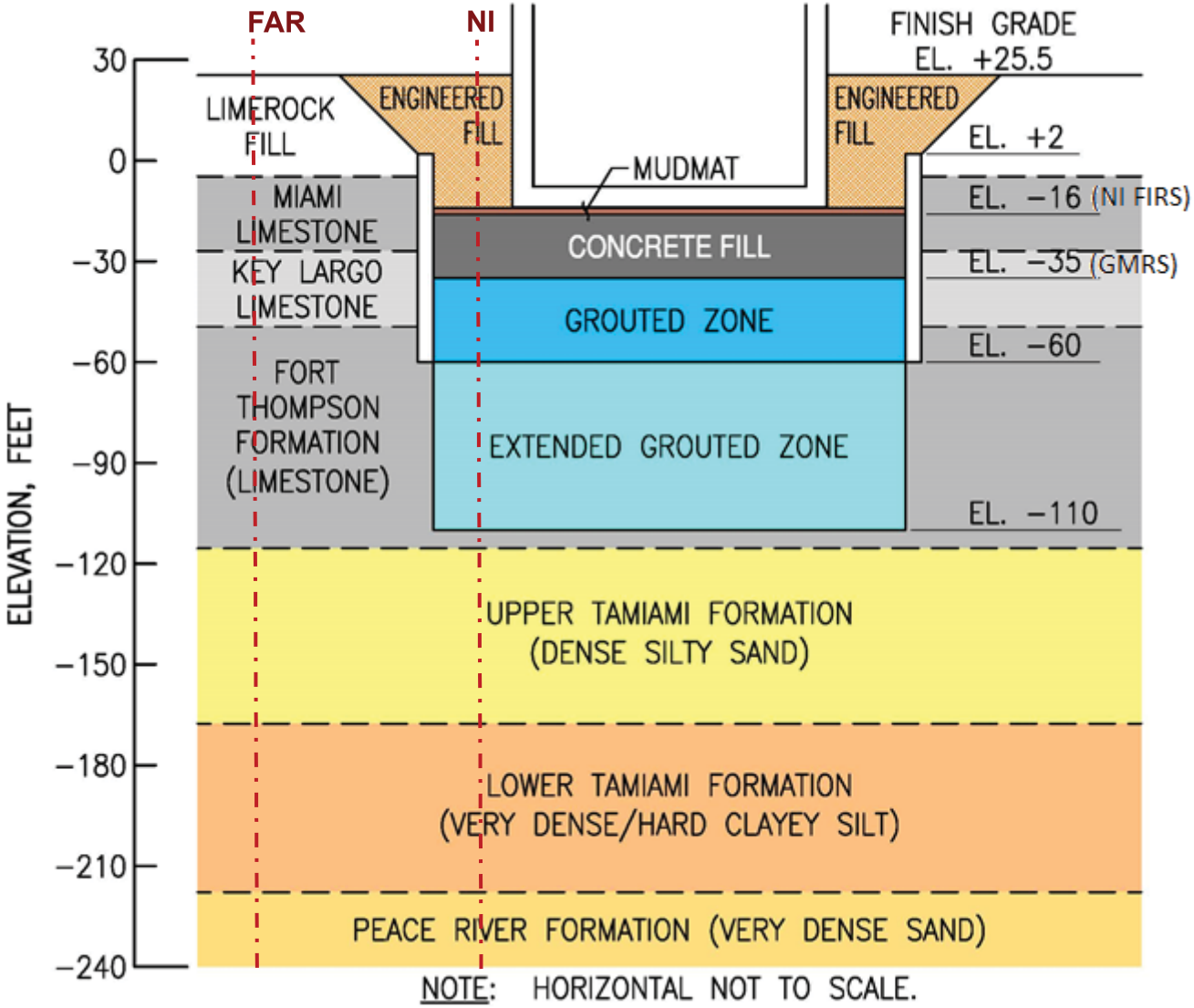
Turkey Point Nuclear Plant Units 6 & 7

Subsection 3.7.1.1 – Design Response Spectra

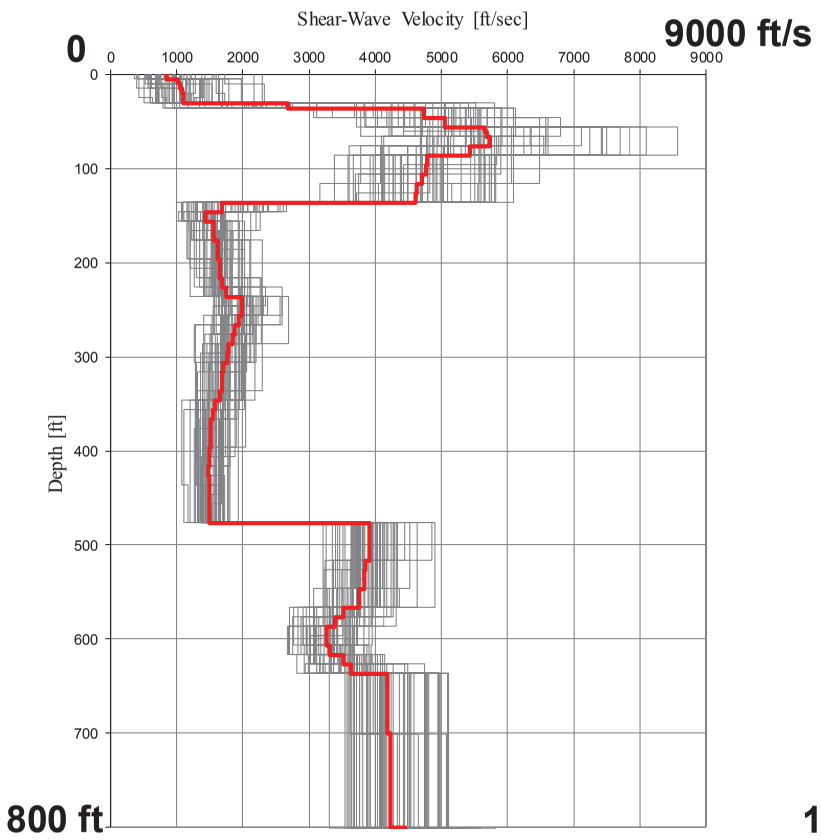
Considered Profiles (FAR and NI)

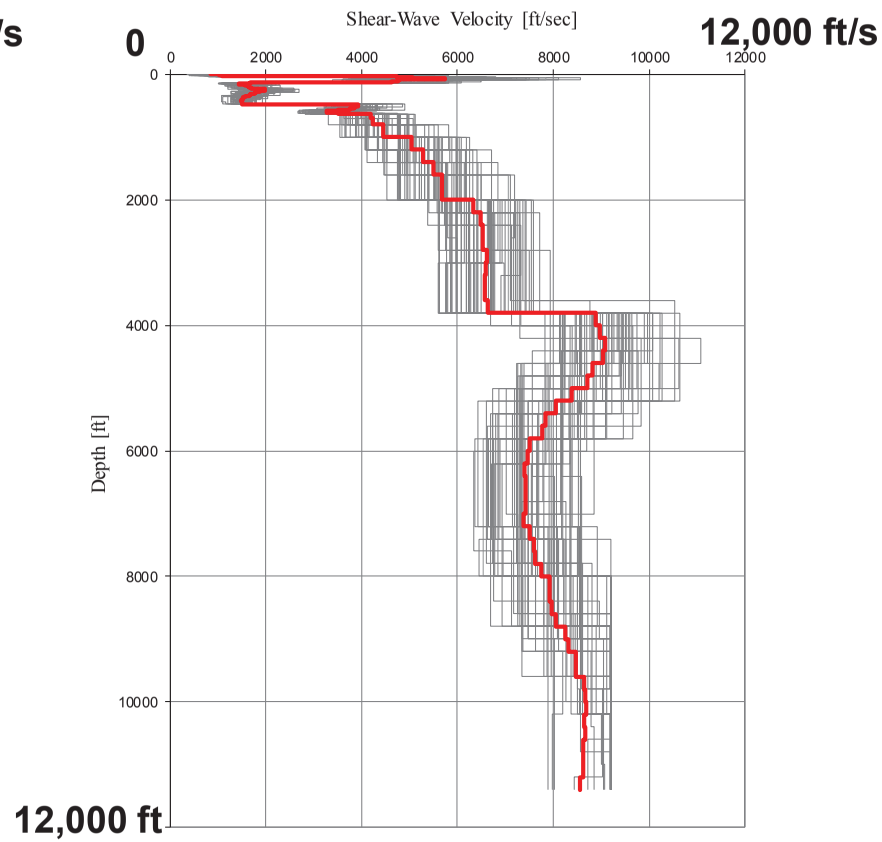


Turkey Point Nuclear Plant Units 6 & 7

Randomized Shear-Wave Velocity Profiles

NI Profile: 60 randomized profiles simulating soil conditions at the Nuclear Island





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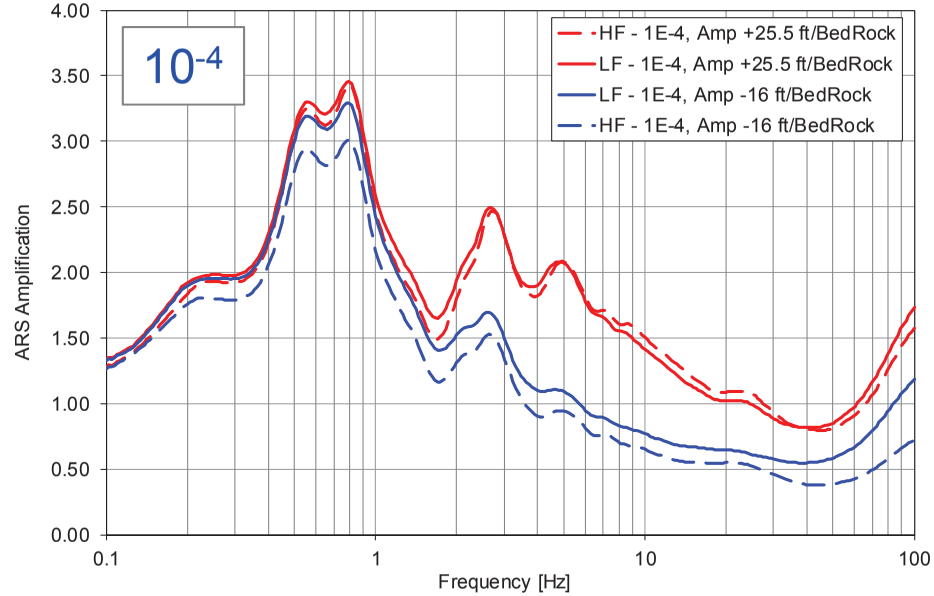
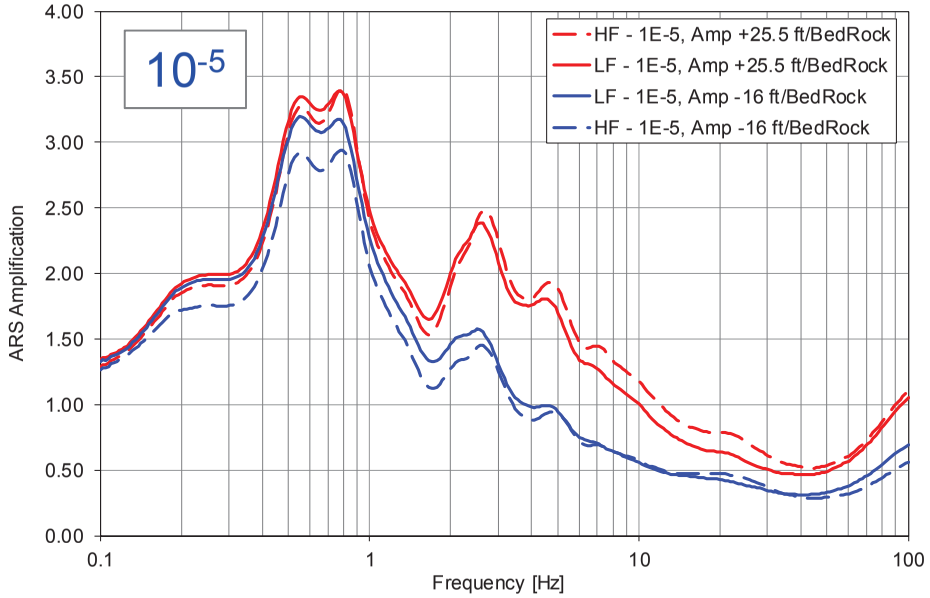
Turkey Point Nuclear Plant Units 6 & 7

Site Response Analysis Results (NI site conditions)





ARS amplification functions at:

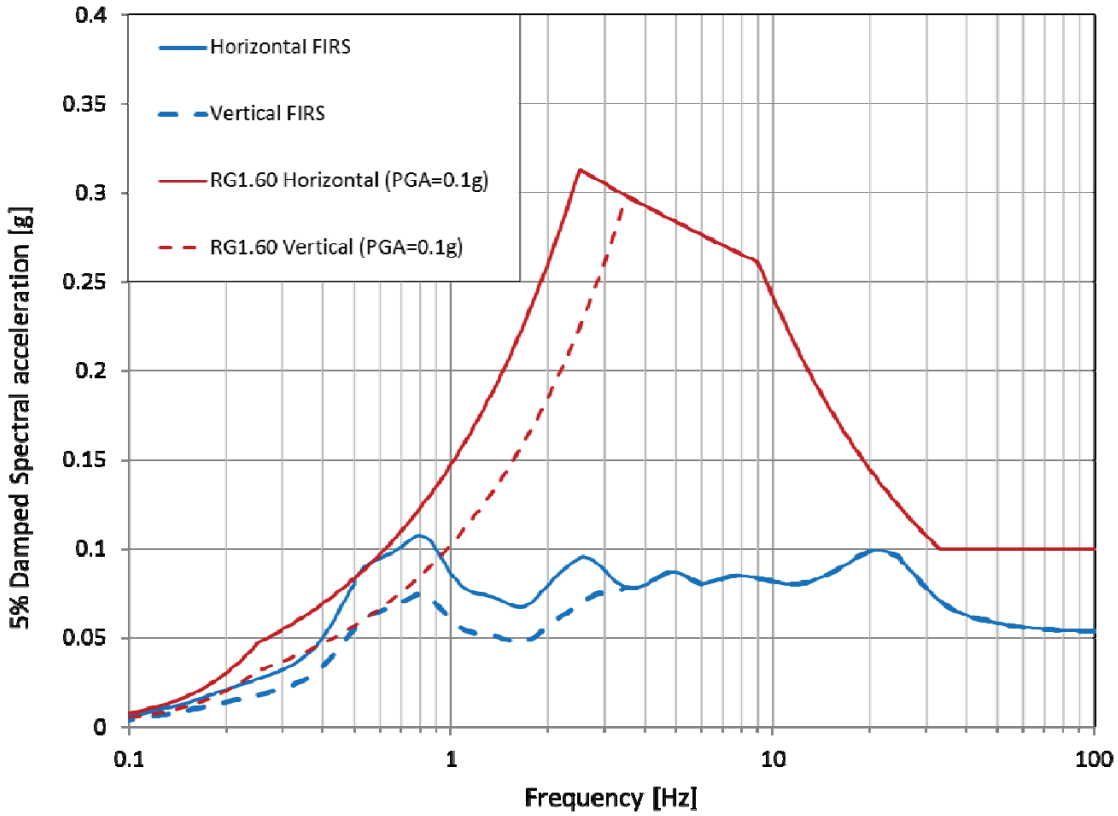
- Finish grade at El. +25.5 ft
- NI foundation at El. -16 ft

Turkey Point Nuclear Plant Units 6 & 7

FIRS and SSE

SSE is the envelope of:

- FIRS at NI foundation (Envelope of NI and FAR site conditions)
- RG 1.60 scaled to a PGA of 0.1g



Adapted from FSAR Figure 3JJ-238

Selected SSE far exceeds site-specific motion

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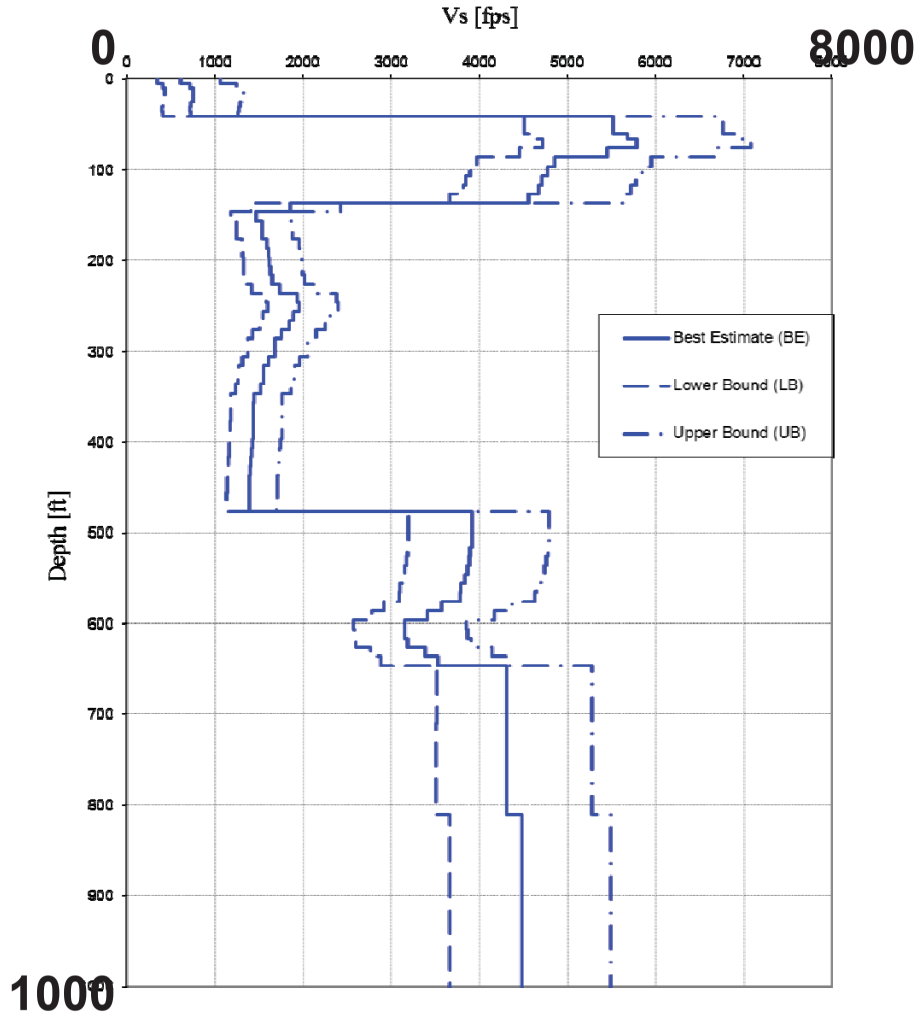
Turkey Point Nuclear Plant Units 6 & 7

SSI Profiles for NI Site Condition



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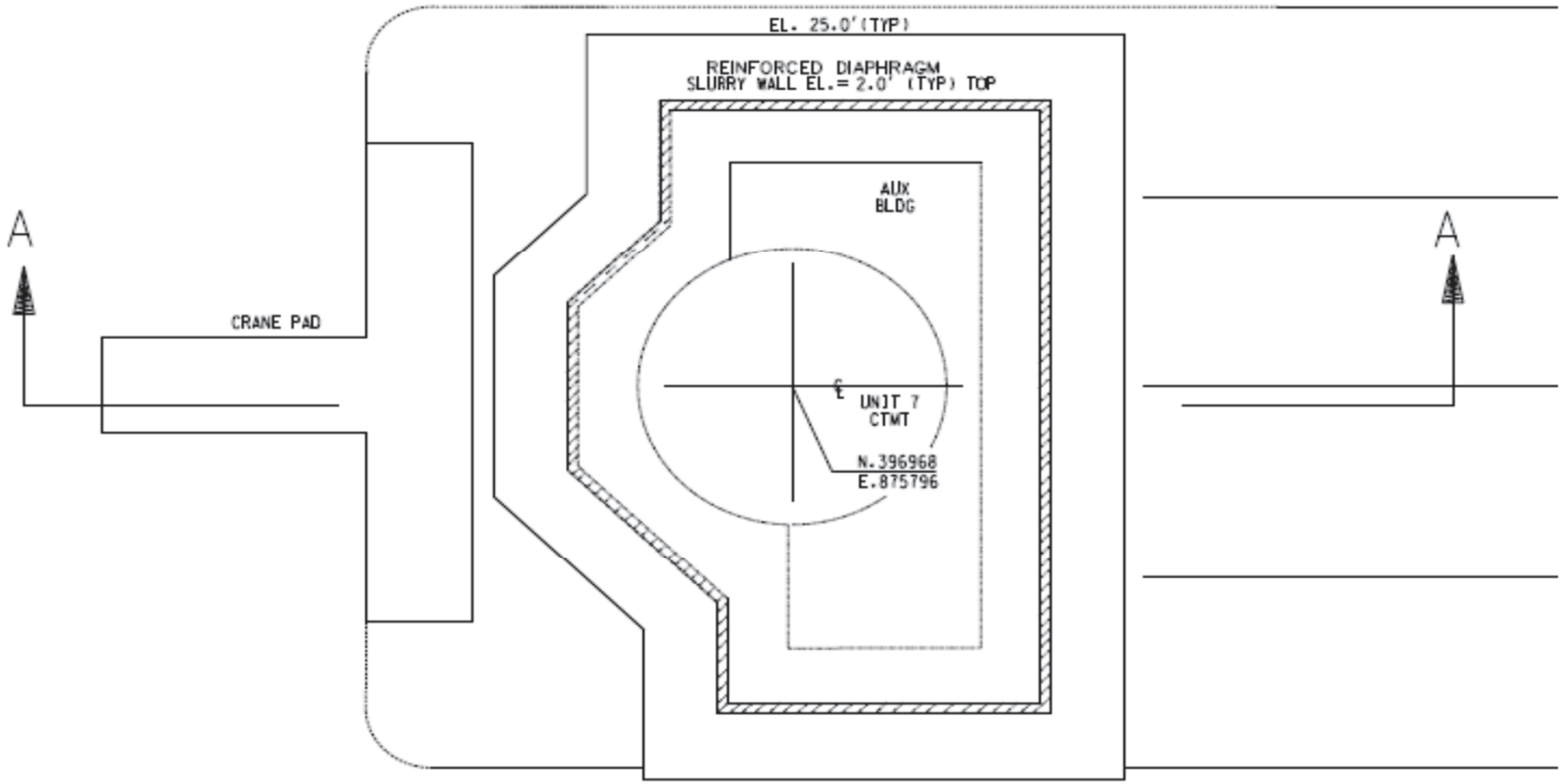
Turkey Point Seismic SSI Analyses Summary

- **Westinghouse has been performing soil structure interaction (SSI) analyses of the Florida Power & Light Company (FPL) Turkey Point Units 6 & 7 (PTN 6&7) Nuclear Island (NI) since 2009**
- **The SSI analyses have evaluated the effects of:**
  - FEM mesh size and its adequacy
  - The lean concrete fill
  - Variations of soil properties
  - Adjacent structures

Turkey Point Nuclear Plant Units 6 & 7

Turkey Point Nuclear Plant Unit 7 Excavation Limits Plan



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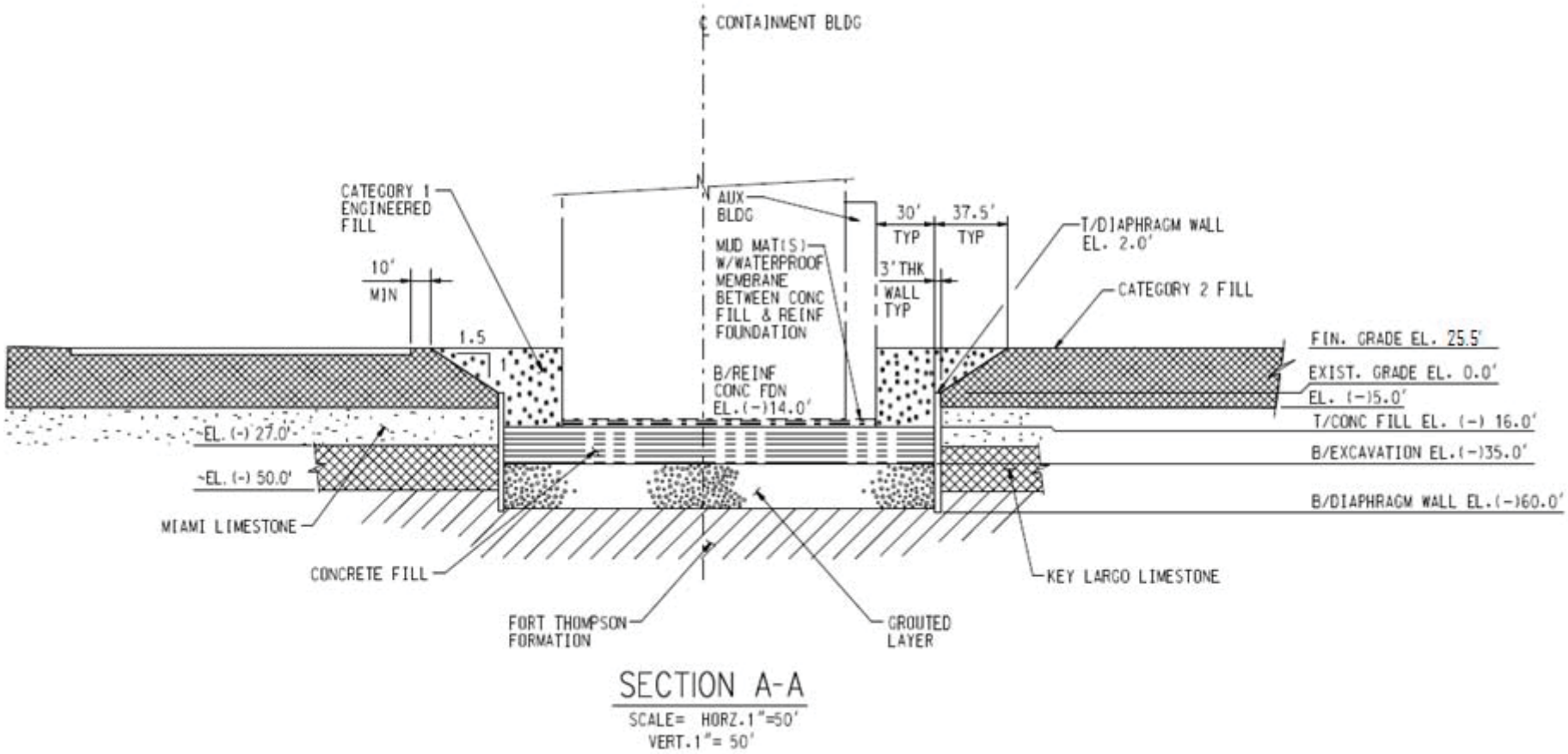
Turkey Point Nuclear Plant Units 6 & 7

Turkey Point Nuclear Plant Unit 7 Excavation Cross-Section



SECTION A-A

SCALE= HORZ.1"=50'
VERT.1"= 50'

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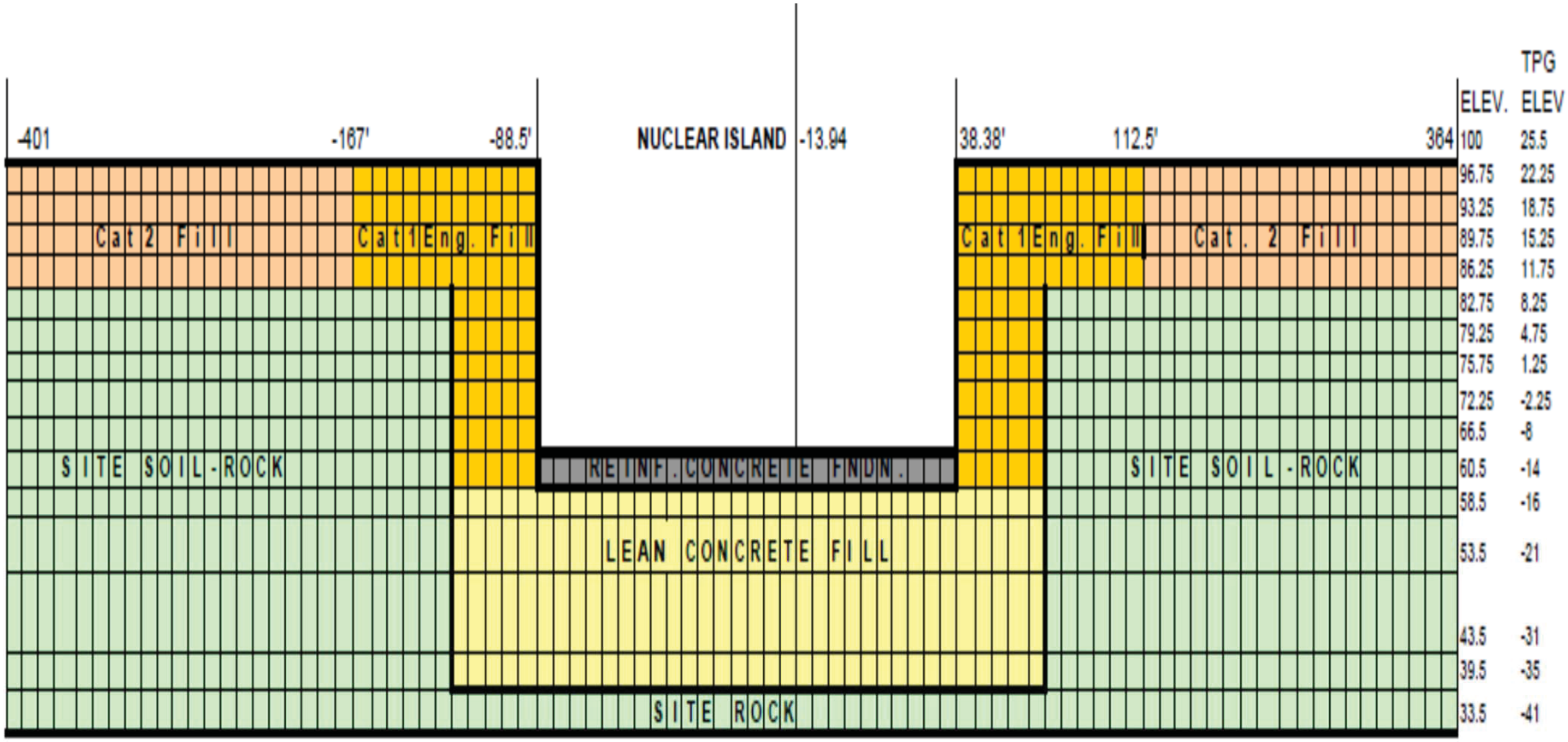
Turkey Point Nuclear Plant Units 6 & 7

Turkey Point Nuclear Plant 2D Fine SASSI Model (not to scale)



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Seismic SSI Analyses Summary Conclusions

- **The PTN 6&7 site-specific design-basis SSI analyses have incorporated multiple levels of conservatism to address potential seismic input, material parameter and analytical uncertainties including:**
  - RG 1.60 and PTN 6&7 site-specific FIRS
  - BE and LB to UB ranges of soil, rock, concrete, and grouted rock strain compatible shear wave, compression wave, damping and unit weight properties
  - 2D – 3D model mesh size and passing frequency bump factors
  - Enveloped BE, LB and UB SSI ISRS
  - Broadening (±15 percent) of the ISRS envelope

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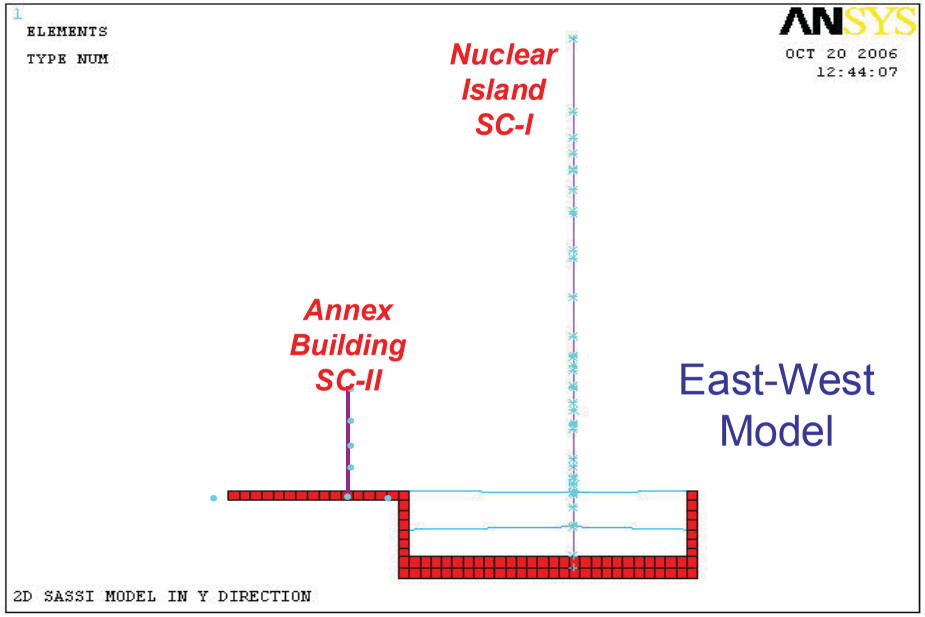
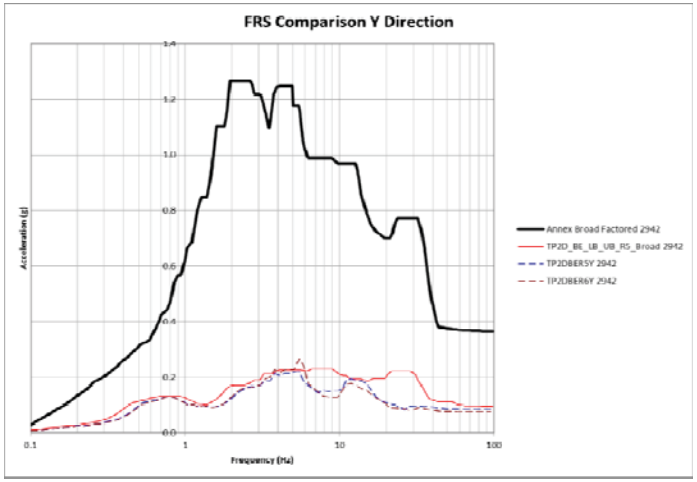
Design-Basis BE, LB and UB Seismic SSI Analyses Summary

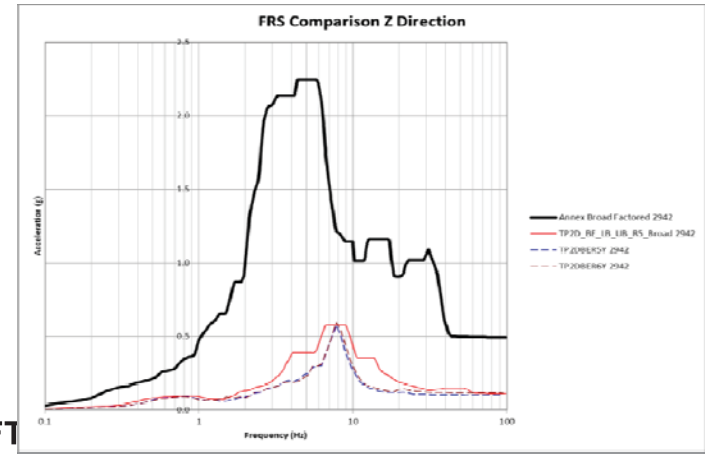
- The nuclear island (NI) and adjacent structures SSI analyses utilized an envelope of RG 1.60 and PTN 6&7 site-specific FIRS anchored to minimum PGA = 0.1g for the NI, and incorporated the site-specific performance-based surface response spectra (PBSRS) for adjacent structures
- The updated SSI analyses incorporated hazard consistent, strain compatible BE, LB and UB soil, rock, concrete and grouted rock profiles in both NI and SCII adjacent structures evaluations
- Relative displacements of SCII structures indicated no seismic interaction between NI and Turbine Building 1st Bay and Annex Building
- The resulting NI and adjacent structures in-structure response spectra (ISRS) for all cases, i.e., BE, LB and UB were enveloped, broadened ±15 percent, which were compared to, and enveloped by the AP1000 CSDRS envelope spectra with appreciable margin

Comparison of ISRS: CSDRS vs PTN 6&7 BE Sensitivity and Detailed Analysis

Annex Building Foundation (AP1000 El. 100 feet)







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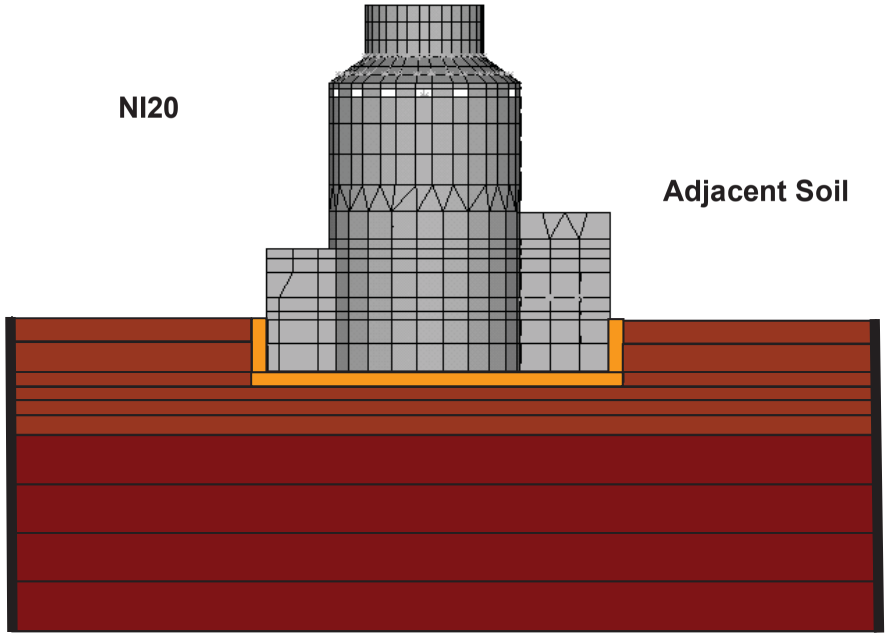
SCII (Appendix F) BE Seismic Sensitivity SSI Analyses Summary

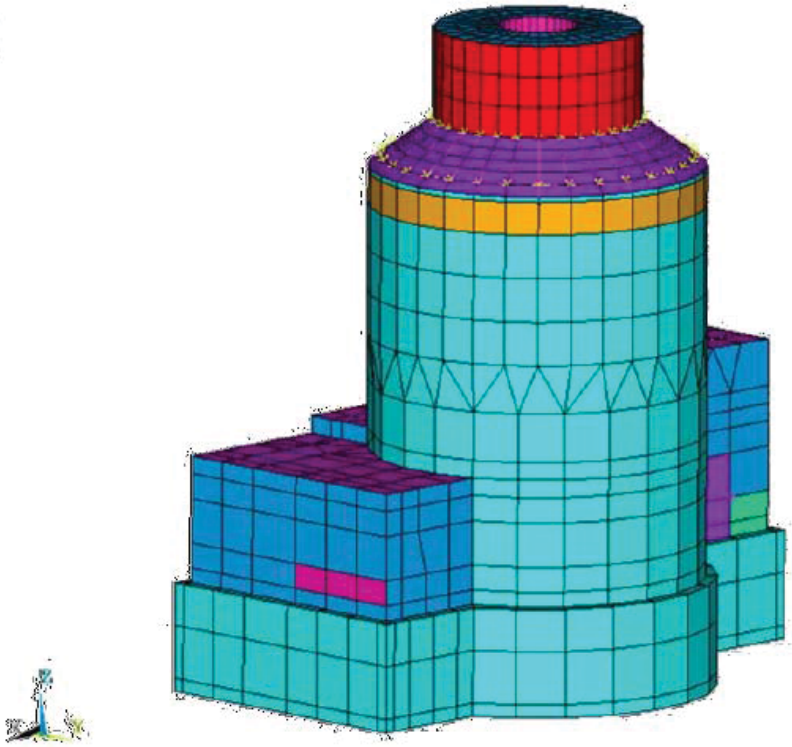
- **The 2D NS and EW models were used to obtain updated BE sensitivity analyses relative displacements at the following locations:**
  - Turbine Building 1st Bay foundation to Nuclear Island
  - Top of Turbine Building 1st Bay to Nuclear Island
  - Annex Building foundation to Nuclear Island
  - Top of Annex Building to Nuclear Island
- **SCII adjacent structures SSI sensitivity analysis relative displacements were compared to the site-specific design-basis relative displacements**
- **To prevent contact, the relative displacements between the NI and the foundations and top of the adjacent structures must be less than 2 inches and 4 inches, respectively**

Turkey Point Nuclear Plant Units 6 & 7

Seismic Design



SASSI Model Looking East



SASSI MODEL Isometric View

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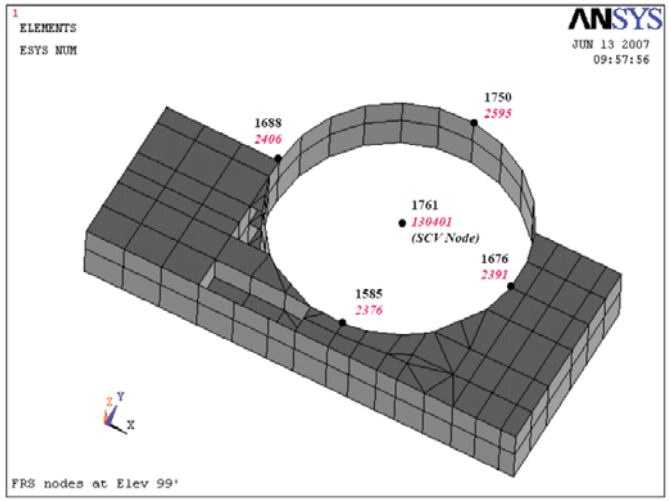
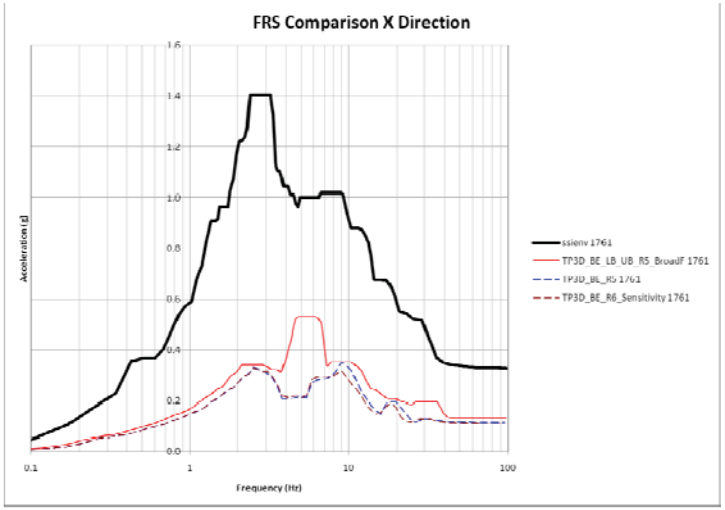
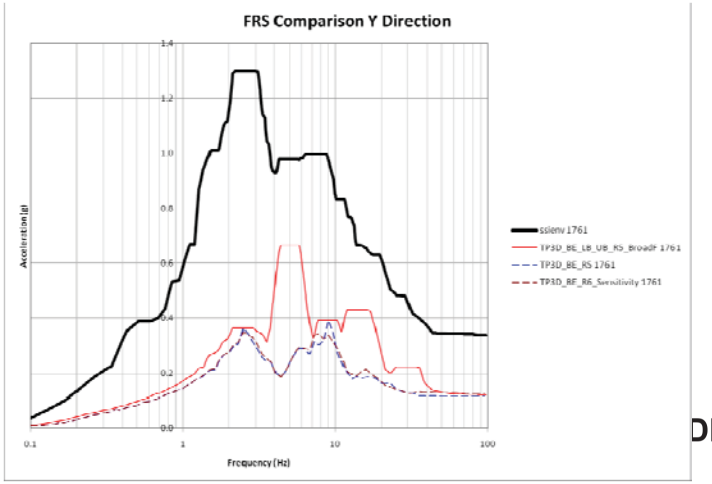
Turkey Point Nuclear Plant Units 6 & 7

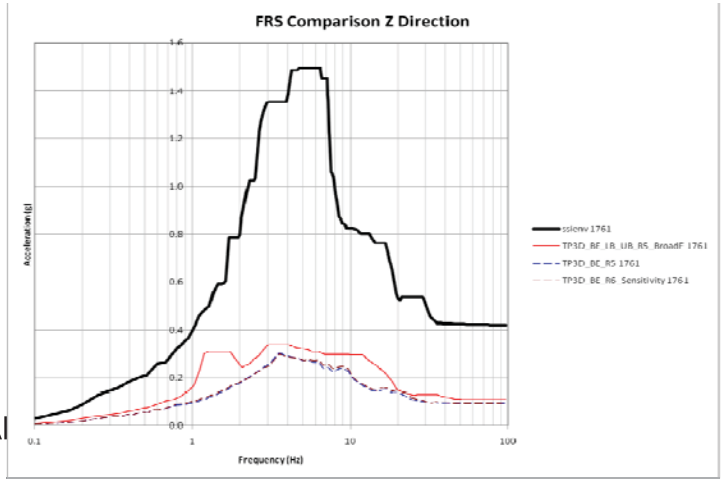
Comparison of ISRS: CSDRS vs PTN 6&7 BE Sensitivity and Detailed Analysis

Containment Internal Structures at Elevation 99'-0" of Reactor Vessel Support









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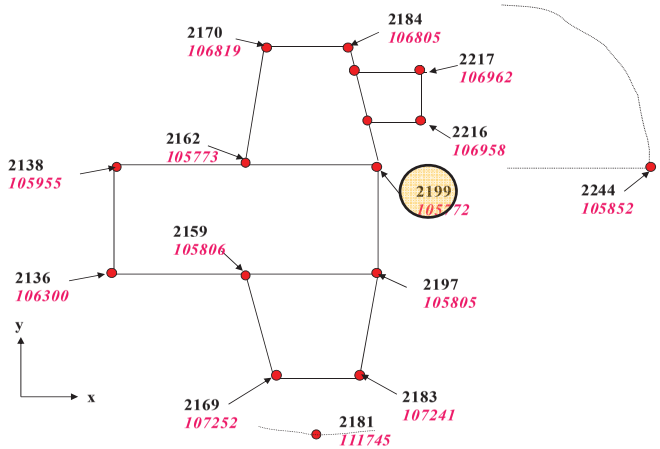
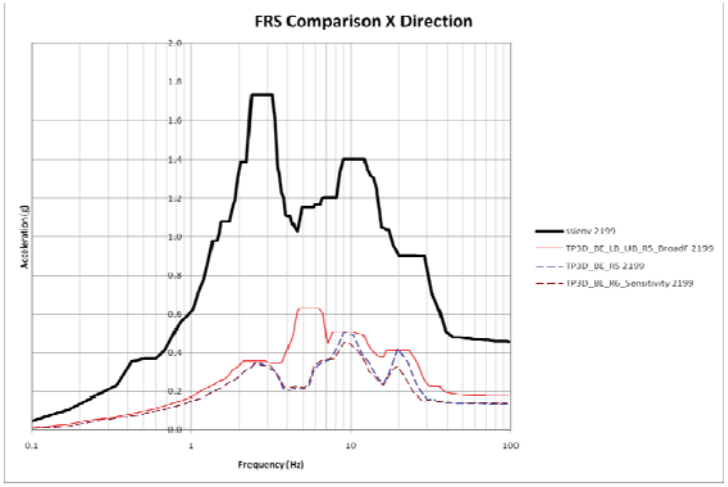
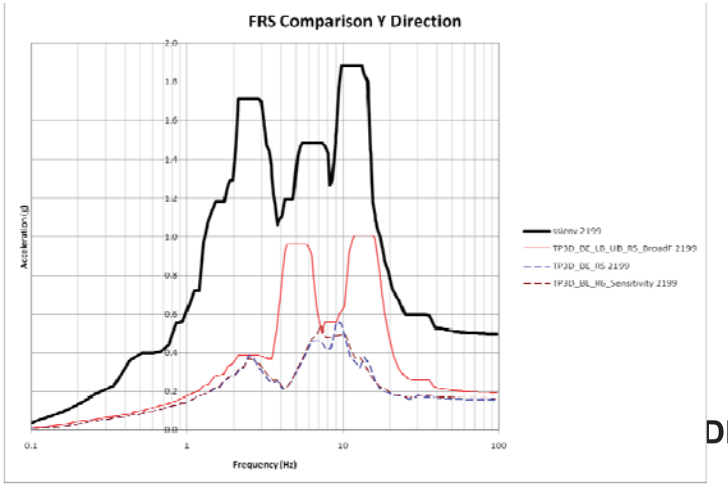
Turkey Point Nuclear Plant Units 6 & 7

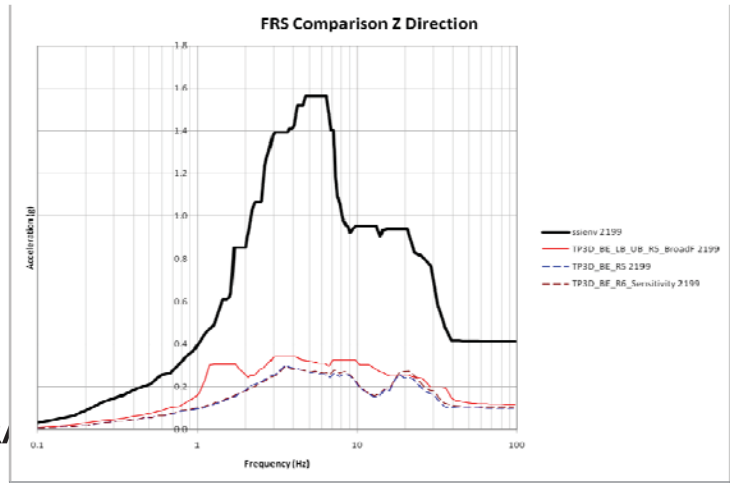
Comparison of ISRS: CSDRS vs PTN 6&7 BE Sensitivity and Detailed Analysis

Containment Operating Floor









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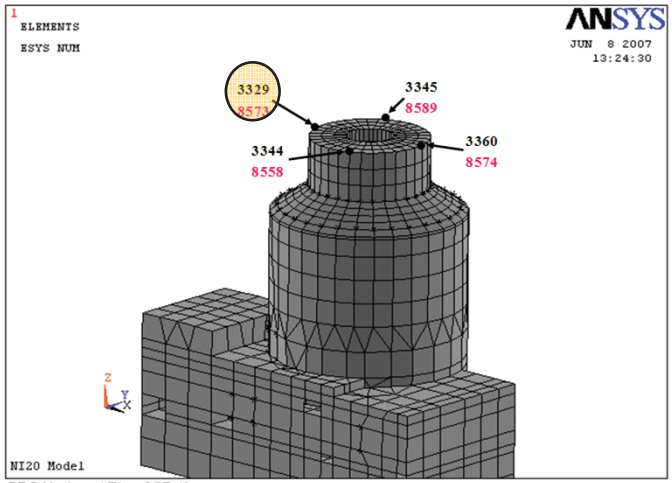
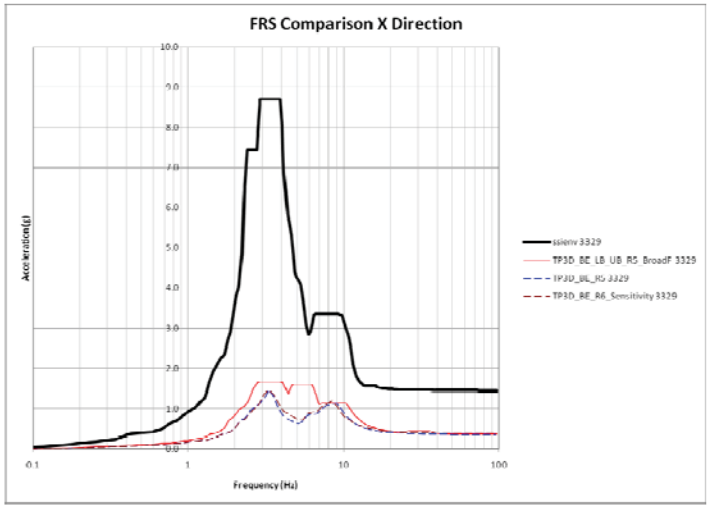
Turkey Point Nuclear Plant Units 6 & 7

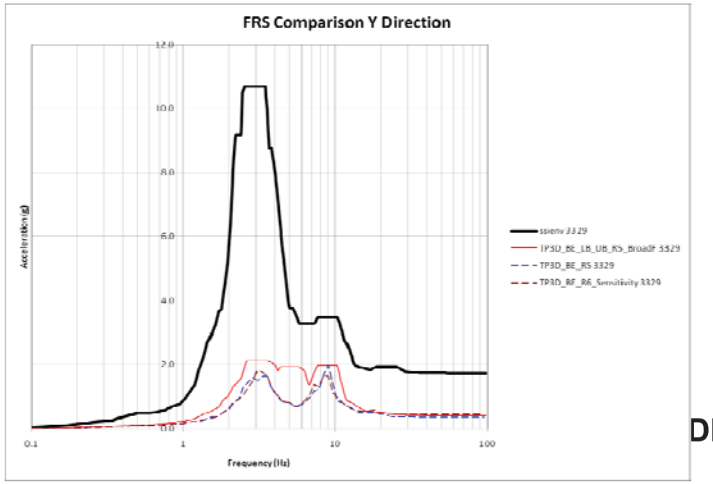
Comparison of ISRS: CSDRS vs PTN 6&7 BE Sensitivity and Detailed Analysis

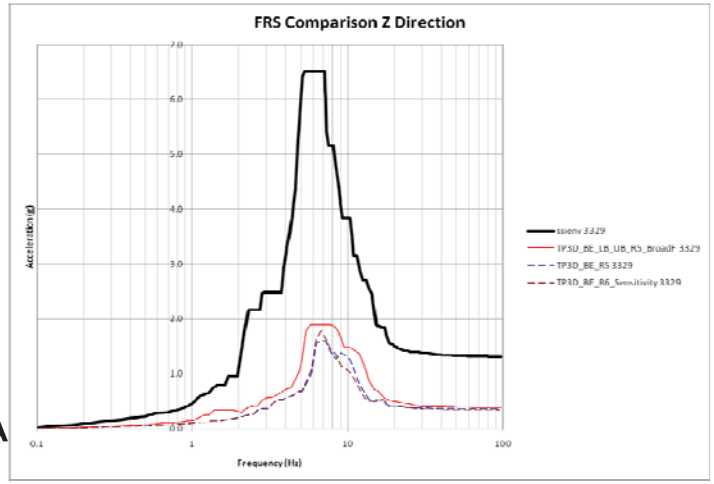
Shield Building Roof Elevation 327'



FRS Nodes at Elev. 327.4'







DRA

Final Seismic SSI Analyses Conclusions

- **Finally, the PTN 6&7 site-specific SSI analyses have incorporated multiple levels of conservatism and sensitivity analyses to address potential seismic input, material parameter and analytical uncertainties including:**
  - RG 1.60 and PTN 6&7 site-specific FIRS
  - 2D – 3D model mesh size and passing frequency bump factors
  - Validation of ISRS and transfer functions due to variations in Poisson's Ratio
  - Broadening (±15 percent) of the ISRS envelope
- **The PTN 6&7 site-specific ISRS are enveloped by the AP1000 design spectra envelope with margin at the key NI and SCII adjacent structure locations**

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Turkey Point Nuclear Plant Units 6 & 7
Day 2

- Section 2.5 Geology, Seismology, and Geotechnical Engineering
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- **Section 13.3 Emergency Planning**
- Chap. 19 Probabilistic Risk Assessment
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Turkey Point Nuclear Plant Units 6 & 7

Section 13.3 Emergency Planning

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Emergency Plan Summary

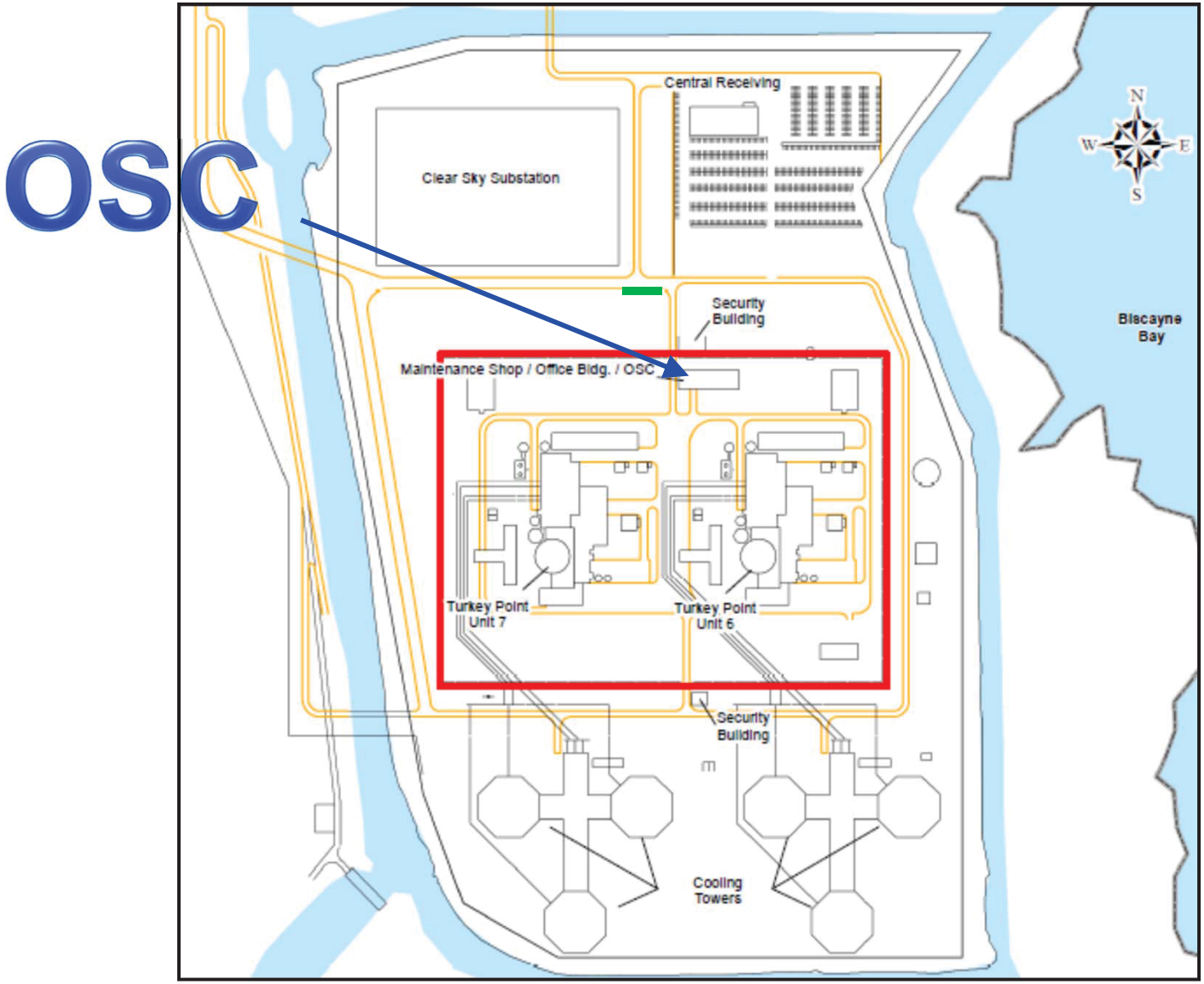
- **Single Emergency Plan for all four (4) Turkey Point Site Units**
  - Follows NUREG-0654 format
    - -- Addresses the sixteen planning standards & associated evaluation criteria
    - -- Part 1 provides introductory information
    - -- Part 2 provides generic information applicable to all the units
    - -- 3 Annexes describe unit specific information
      - – Annex 1 applies to existing Units 3 & 4
      - – Annex 2 applies to new Unit 6 single unit operation
      - – Annex 3 applies to Unit 6 & 7 operation
  - Developed in accordance with:
    - -- NUREG-0654/FEMA-REP-1 Rev 1
    - -- 10 CFR 50.47
    - -- 10 CFR 50 Appendix E

Turkey Point Nuclear Plant Units 6 & 7

Emergency Plan Facilities

Turkey Point Nuclear Plant Units 6 & 7

Emergency Plan Facilities

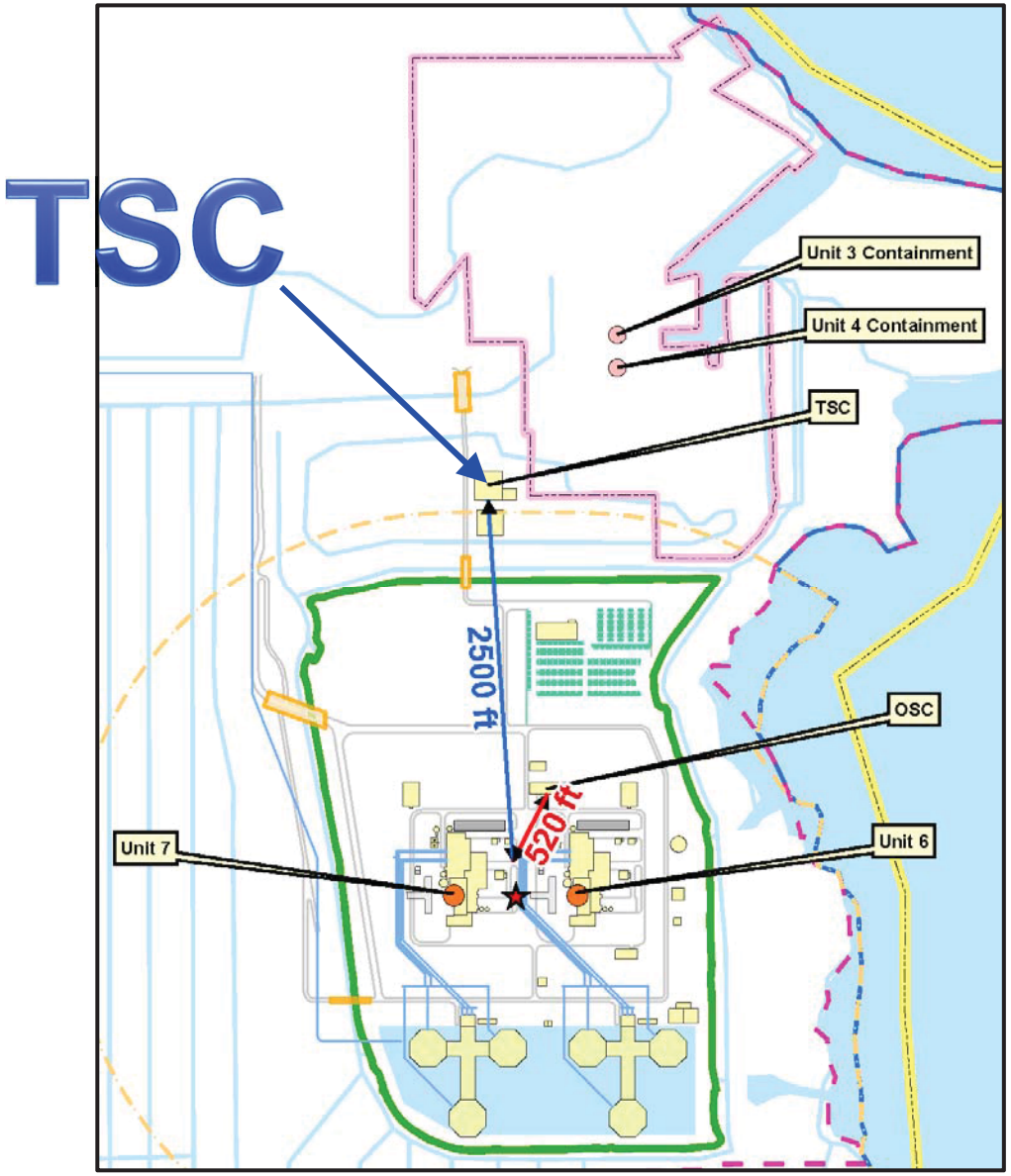


Operations Support Center (OSC)

- **The Units 6 & 7 Protected Area has a dedicated OSC located in the Maintenance Support Building**
- **Identified by DCD Departure PTN DEP 18.8-1**
- **The use of a common OSC for a Protected Area is consistent with existing FPL Plants**
  - St. Lucie Units 1 & 2
    - -- Separate Control Rooms for each unit
    - -- Common TSC for the Site located inside Unit 1 Auxiliary Building
    - -- Common OSC located in the Maintenance Support Building
  - Existing Turkey Point Units 3 & 4
    - -- Single Control Room for both Units
    - -- Common TSC for both units located inside the PA
    - -- Common OSC for both units located in the Maintenance Support Building

Turkey Point Nuclear Plant Units 6 & 7

Emergency Plan Facilities



Technical Support Center (TSC)

- **Common for all 4 Turkey Point Site Units**
  - Located in the New Turkey Point Nuclear Training Building.
    - -- Identified by DCD Departure PTN DEP 18.8-2
    - -- This location provides the ability to respond and activate the facility in a timely fashion independent of the unit(s) that may be affected by the emergency
    - -- It also will permit the use of the TSC in a security event that may curtail the entry of ERO personnel into a Protected Area of the affected unit(s)
  - The TSC meets the guidance of NUREG-0696, *Functional Criteria for Emergency Response Facilities* and RG 1.206, *Combined License Applications for Nuclear Power Plants*
    - -- regarding structure, habitability, size, communications, instrumentation, data system equipment, power supplies, technical data, records availability, and management

Technical Support Center (TSC)

- **Common for all 4 Turkey Point Site Units**
  - The TSC does not meet the guidance of NUREG-0696, *Functional Criteria for Emergency Response Facilities,* regarding location of the TSC
    - -- The location of the TSC is outside of the Protected Areas between the Control Room for Units 3 & 4 and the Control Rooms for Units 6 & 7
    - -- The separation of the TSC from any of the 3 control rooms is approximately 2500 ft. with travel time of 10-15 minutes and includes processing time through the Protected Area Security Control Points
    - -- Although the TSC does not provide capability for face-to-face communications or being within 2 minutes of the affected Control Room(s), it is provided with communication links that can transmit and receive direct voice and data communications from the affected Control Room, TSC, OSC, and the EOF
  - Use of current technologies such as updated computer equipment, teleconferencing, real time system monitoring of plant data, and telephone and radio systems for primary and emergency communications will bridge the physical separation
  - Similar to the TSC arrangement approved for V.C. Summer Units 2 & 3 COL

Turkey Point Nuclear Plant Units 6 & 7
Day 2

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Turkey Point Nuclear Plant Units 6 & 7

Chap. 19 Probabilistic Risk Assessment

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Chapter 19 Probabilistic Risk Assessment

- **AP1000 DCD Incorporated by Reference**
- **Standard Material Incorporated (including Supplements)**
- **Site-Specific Information**
  - Annual frequency of severe winds and tornados events exceeds 1.0E-07 events per year
  - Annual frequency of aviation accidents exceeds 1.0E-07 events per year

Section 19.58 – Winds, Floods, and Other External Events

- **Two Screening Criteria used to determine whether a detailed PRA is required:**
  - External event category screened out on the basis of its annual frequency (less than 1.0E-7/yr)
  - External event category screened out based on the annual core damage frequency (CDF) associated with that external event category—If CDF does not exceed 1.0E-8/yr, the external event category can be screened out
- **Annual frequency of aviation accidents presented in Section 2.2 exceeds 1.0E-7 per year**
  - Screening CDF is calculated for aviation accidents
  - The base case result (2.26E-13 events/year) is below the screening criterion of 1.0E-8/year and further detailed PRA is not required
- **Annual frequency of tornado and hurricane events presented in Section 2.3 exceeds 1.0E-7 per year (PTN DEP 19.58-1)**
  - Screening CDF is calculated for high winds
  - The base case analysis (1.0E-8 per year) demonstrates second criterion is met and further detailed PRA is not necessary

Turkey Point Nuclear Plant Units 6 & 7
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Turkey Point Nuclear Plant Units 6 & 7

Chap. 20 Requirements Resulting from Fukushima Near Term Task Force Recommendations

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Fukushima NTTF Recommendations

- **NRC Fukushima Near-term Task Force (NTTF) Recommendations resulted in NRC RAI Letter No. 58, dated May 1, 2012, being issued for the Turkey Point Unit 6 & 7 COL application**
  - NTTF Recommendation 9.3, EP Staffing and Communications
  - NTTF Recommendation 4.2, Mitigating Strategies
  - NTTF Recommendation 7.1, SFP Instrumentation

Fukushima NTTF Recommendations

- **Recommendation 9.3 (EP)**
  - NRC Fukushima Near-term Task Force (NTTF) Recommendation 9.3 on EP staffing and communications resulted in NRC RAI Letter No. 58, RAI 1.05-4, dated May 1, 2012, being issued for the Turkey Point Unit 6 & 7 COL application
    - -- Turkey Point Units 6 & 7 responded to this RAI based on NTTF Recommendation 9.3 requirements
    - -- Turkey Point Units 6 & 7 has proposed a license condition to address the recommended staffing and communications assessments using NRC endorsed NEI 12-01, Rev 0, *Guidelines for Assessing Beyond Design Basis Accident Response Staffing and Communications Capabilities*

Fukushima NTTF Recommendations

- **Recommendation 4.2 (Mitigating Strategies)**
  - Fukushima NTTF Recommendation 4.2 on mitigating strategies resulted in NRC RAI Letter No. 58, RAI 1.05-2, dated May 1, 2012, being issued for the Turkey Point Unit 6 & 7 COL application
    - -- Turkey Point Units 6 & 7 responded to this RAI based on NTTF Recommendation 4.2 requirements
    - -- Turkey Point Units 6 & 7 has committed to a proposed license condition to address the recommended actions to address Mitigation of Beyond-Design-Basis Events (MBDBE) proposed rule (10 CFR 50.155) using the guidance described in NRC endorsed NEI 12-06, Rev 0, *Diverse and Flexible Coping Strategies (FLEX) Implementation* Guide, Appendix F, *Guidance for AP1000 Design*, and Westinghouse Report, APP-GW-GLR-171, *AP1000 Flex Integrated Plan*

Fukushima NTTF Recommendations

- **Recommendation 7.1 (Spent Fuel Pool Instrumentation)**
  - Fukushima NTTF Recommendation 7.1 on spent fuel pool (SFP) instrumentation resulted in NRC RAI Letter No. 58, RAI 1.05-3, dated May 1, 2012, being issued for the Turkey Point Unit 6 & 7 COL application
    - -- Turkey Point Units 6 & 7 responded to this RAI based on NTTF Recommendation 7.1 requirements
    - -- Turkey Point Units 6 & 7 has a proposed license condition to address the training portion of the actions required for this recommendation
    - -- NEI 12-02, Appendix A4, *AP1000 Spent Fuel Pool Instrumentation Guidance*, addresses how the other portions of the NTTF Recommendation 7.1 are satisfied by the AP1000 plant design
    - -- DCD Chapter 9 text was supplemented with additional information on SFP level instrumentation in Turkey Point Units 6 & 7 FSAR Chapter 9
    - -- Turkey Point Units 6 & 7 Departure (PTN DEP 3.11-1) was taken to correct an inconsistency in DCD Table 3.11-1, Sheet 14 of 51 relative to SFP level instrument "Envir. Zone" number

Turkey Point Nuclear Plant Units 6 & 7
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Turkey Point Nuclear Plant Units 6 & 7

Chap. 21 Design Changes Proposed In Accordance With ISG-11

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Design Changes Proposed In Accordance With ISG-11

AP1000® Emergent Issues

- PXS Condensate Return
- Post Accident Main Control Room Operator Dose
- Hydrogen Venting Inside Containment
- Flux Doubling Compliance with IEEE 603
- Main Control Room Heat Up

Design Changes Proposed In Accordance With ISG-11

PXS Condensate Return

- **Problem Statement:**
  - The analysis performed during design certification assumed a constant condensate return rate of 90%
- **Issue Resolution:**
  - Plant changes have been incorporated to increase condensate return to the IRWST
    - -- Add downspouts to polar crane girder and internal stiffener to drain condensate directly to In-containment Refueling Water Storage Tank (IRWST)
      - – Minimizes losses associated with re-attaching flow to containment wall and with flow over support plates
    - -- Optimize IRWST gutter design and location
      - – Extended to collect above upper equipment hatch and personnel airlock
    - -- Changed routing of cables to hydrogen sensors
      - – Reduces quantity of support plates (obstacles) attached to the containment dome
  - Licensing Basis would not have been met without design changes

Design Changes Proposed In Accordance With ISG-11

PXS Condensate Return (cont.)

- **Conclusions:**
  - Design Basis Analysis demonstrates:
    - -- The PRHR closed loop cooling can maintain the plant in a safe, stable condition for 72 hours
  - Conservative, non-bounding analysis demonstrates:
    - -- PRHR closed loop cooling can cool the RCS to 420°F in less than 36 hours
    - -- PRHR closed loop cooling can maintain safe shutdown (< 420°F for at least 14 days)
    - -- Adiabatic analysis of the RCS is appropriate.

Design Changes Proposed In Accordance With ISG-11

Post-Accident Main Control Room Dose

- **Problem Statement:**
  - The certified design did not include direct dose contributions from the Main Control Room (MCR) Emergency Habitability System (VES) filter unit; direct filter dose increases the operator dose when considered
  - The Main Steam line break analysis did not model the most limiting release scenario: secondary side coolant release timing assumptions were non-bounding
  - Discrepancies were identified in the underlying shielding calculations for post-accident operator dose: AP1000 shielding design non-conservatively differed from the analysis model
- **Issue Resolution:**
  - A combination of design and analysis changes were needed to demonstrate operator doses satisfy General Design Criterion (GDC) 19
  - Reported doses decrease from DCD Revision 19

Design Changes Proposed In Accordance With ISG-11

Hydrogen Venting Inside Containment

- **Problem Statement:**
  - AP1000 design changes to containment layout were implemented without revision to supporting analyses for hydrogen diffusion flame
  - In one particular severe accident scenario (frequency = 6E-9/yr), a hydrogen diffusion flame may create a locally high temperature near containment pressure boundary, hatch, and penetrations
    - -- Analysis required to verify containment survivability
    - -- ITAAC revision is required to reflect containment layout design changes
- **Issue Resolution:**
  - Updated analysis confirms containment survivability during a hydrogen burn event

Design Changes Proposed In Accordance With ISG-11

Flux Doubling Compliance with IEEE-603

- **Problem Statement:**
  - The design did not comply with a portion of IEEE 603 Sub-clause 6.6 criteria:

    Whenever the applicable permissive conditions are not met, a safety system shall automatically prevent the activation of an operating bypass or initiate the appropriate safety function(s).
- **Issue Resolution:**
  - A new permissive, P-8, based on minimum required reactor coolant temperature for criticality (MTC), was added
  - Design now complies with IEEE-603

Design Changes Proposed In Accordance With ISG-11

Main Control Room Heat Up

- **Problem Statement:**
  - Throughout the design evolution of the MCR, the size and quantity of equipment have increased, raising the total MCR heat load. These increases result in a MCR temperature response exceeding the current licensing basis limit and equipment qualification conditions
  - A new more limiting transient where non-safety power is provided to non-safety equipment but the Nuclear Island Non-Radioactive Ventilation System (VBS) is NOT available was identified
- **Issue Resolution:**
  - Two stage automatic load shed
    - -- This automatic operation is proposed to maintain the required MCR environmental conditions
      - Only select non-safety loads are de-energized, with no impact to the minimum inventory of displays / controls provided by the primary dedicated safety panel
      - No impact to the plant controls & indication of plant parameters at operator workstations
      - Load shed circuitry is safety related

Design Changes Proposed In Accordance With ISG-11

Main Control Room Heat Up (cont.)

- **Issue Resolution (cont.):**
  - Additional Surveillance Requirements
    - -- Limit initial conditions for adjacent rooms in the updated MCR Heat Up analysis
    - -- Limit moisture content for air in the VES storage tanks
  - Human Factors Considerations
    - -- Analysis supports unlimited operator stay time at a wet bulb globe temperature (WBGT) Index of 90°F
      - – Acceptance criterion is from NUREG-0700
      - – Same limit is met for post-72 hour ancillary fan operation
  - Evaluation concludes that proposed changes confirm MCR temperature requirements are met and no limits are imposed on personnel stay time

QUESTIONS?

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