Status Meeting on Turkey Point Units 6 & 7 FSAR Section 2.5

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July 24, 2012

Agenda

- **Summary of Significant Technical Changes**
- **FPL's Technical Approach & Resolution of Key Issues**
- **Meeting Summary & Path Forward**

The information provided in the following presentation is of a preliminary nature and may be subject to change.

Agenda

- **Summary of Significant Technical Changes**
- FPL's Technical Approach & Resolution of Key Issues
- Meeting Summary & Path Forward

During the review of the RAI responses for FSAR Section 2.5, other opportunities to clarify and provide additional information were identified

Summary of Significant Technical Changes

- Florida marine terraces (RAI 2.5.1-4)
- Magnitude Conversions for the Phase 2 Earthquake Catalog (RAI 2.5.2-5)
- USGS seismic hazard model (RAI 2.5.2-13)
- Tsunami (RAIs 2.5.1-6, -7, and -8)
- Karst (RAI 2.5.1-2)
- SPT and CPT data (RAI 2.5.4-2)
- High strain soil properties (RAI 2.5.4-5)
- Damping in rock (RAI 2.5.4-16)

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During the review of the RAI responses for FSAR Section 2.5, other opportunities to clarify and provide additional information were identified

Summary of Significant Technical Changes

- Settlement (RAI 2.5.4-19)
- Dynamic lateral earth pressure (RAI2.5.4-22)
- Stress increments (RAI 2.5.4-20)

During the review of the RAI responses for FSAR Section 2.5, other opportunities to clarify and provide additional information were identified

Additional RAIs under Consideration

- **Site response analyses (RAI 2.5.2-9)**
- **Karst (RAIs 2.5.1-1 and 17)**
- **Dissolution features in Biscayne Bay (RAI 2.5.3-1)**
- **MSE Wall (RAI 2.5.4-13)**
- **Site excavations (RAI 2.5.4-14)**
- **Limestone backfill dynamic response curves (RAI 2.5.4-15)**
- **Liquefaction (RAI 2.5.4-17)**
- **Stress increments (RAI 2.5.4-20)**
- **Lean concrete fill (RAI 2.5.4-12)**

Agenda

- Summary of Significant Technical Changes
- **FPL's Technical Approach & Resolution of Key Issues**
- Meeting Summary & Path Forward

Additional analyses are being performed to support resolution of the issues identified by NRC.

FPL's Technical Approach & Resolution of Key Issues

- SSHAC Level 2 Study Status & Develop GMPE for Caribbean Sources
- Young faulting within the Turkey Point site region
- Seismic source evaluations and sensitivity analyses for PSHA
- Potential dissolution features at Turkey Point Site
- Assessment of potential cavities and/or voids beneath safety related structures
- Variability and uncertainties in key geotechnical engineering properties
- Key inputs and assumptions in the safety analysis for the geotechnical area

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Both an upgrade of our GMPE SSHAC process and bounding sensitivity analyses are being performed

SSHAC Level 2 Study for Caribbean GMPE

- **Focus to assess center, body, and range of informed technical community.**
- **17 potential resource experts initially identified.**
- **6 resource experts retained.**
- **Distributed Caribbean GMPE model description and questionnaire.**
- **Expert response status update.**

FPL

Both an upgrade of our GMPE SSHAC process and bounding sensitivity analyses are being performed

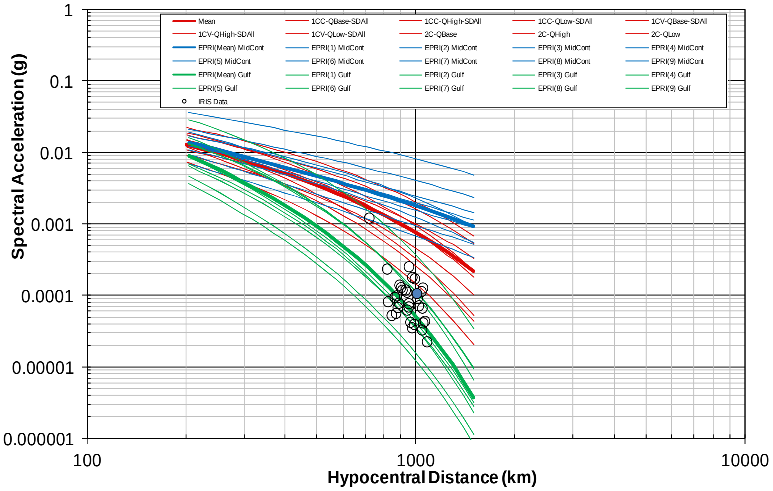
Develop GMPE for Caribbean Sources

- **Stochastic ground motion simulation.**
- **Regional attenuation and source parameters (Motazedian and Atkinson, 2005).**
- **Seismic Source Models.**
  - Single Corner with Constant Stress Parameter
  - Single Corner with Variable Stress Parameter
  - Double Corner
- **GMPE for CEUS Hard Rock site conditions.**
- **7 spectral frequencies: PGA, 25, 10, 5, 2.5, 1, and 0.5 Hz.**
- **Aleatory sigma = 0.645 (Motazedian and Atkinson, 2005).**

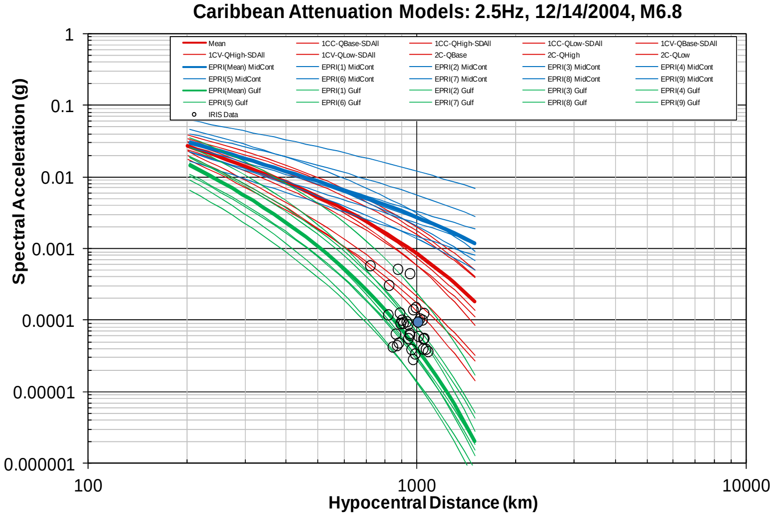
Caribbean GMPE – Comparison with IRIS Empirical Data

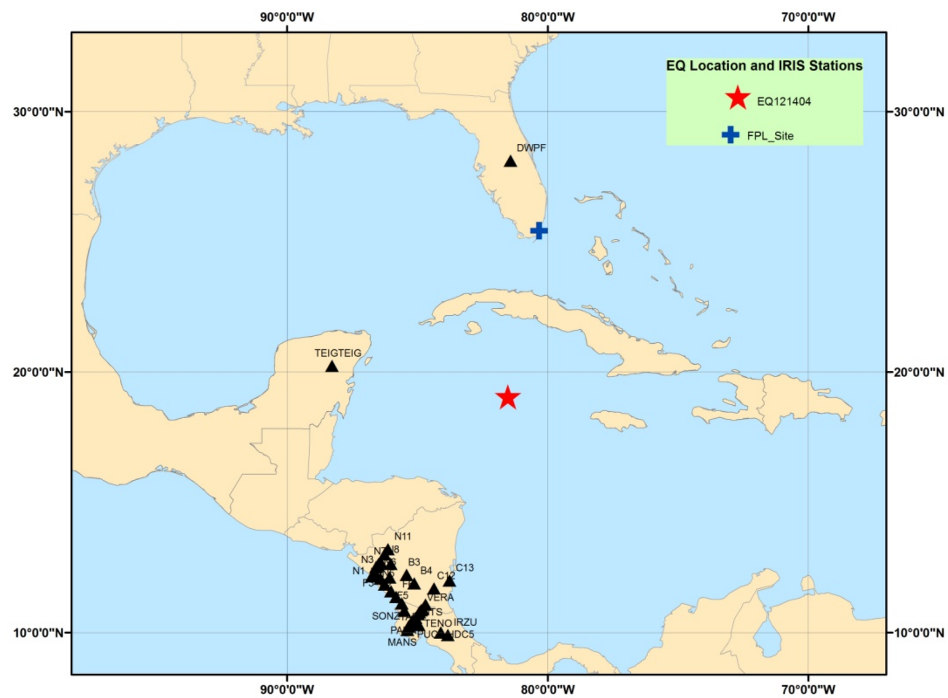
12/14/2004 Earthquake (M6.8)

Caribbean Attenuation Models: 1Hz, 12/14/2004, M6.8



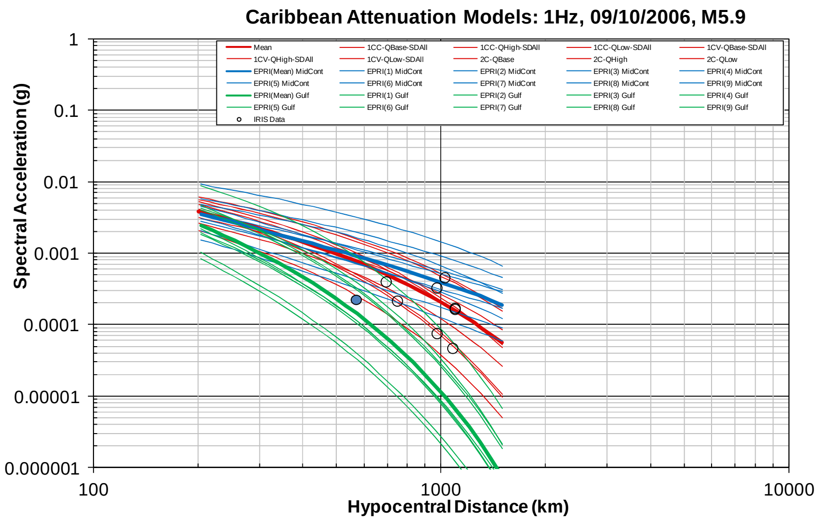
Caribbean Attenuation Models: 2.5Hz, 12/14/2004, M6.8

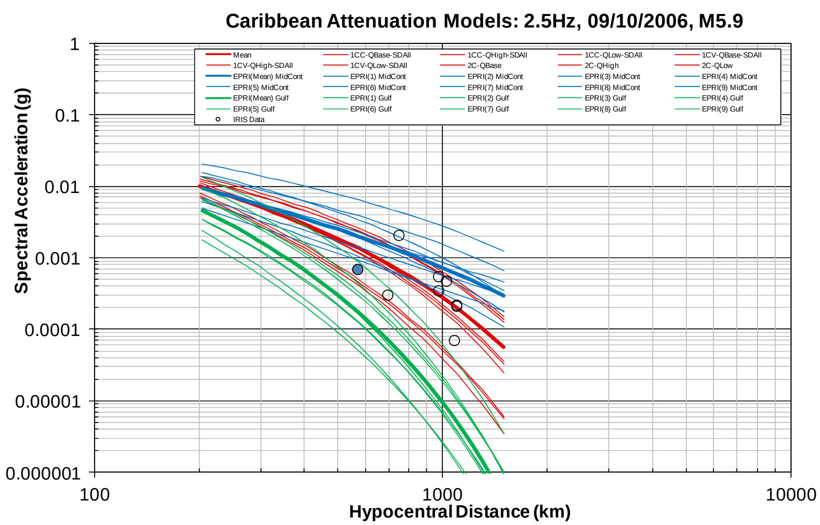




Caribbean GMPE – Comparison with IRIS Empirical Data

09/10/2006 Earthquake (M5.9)





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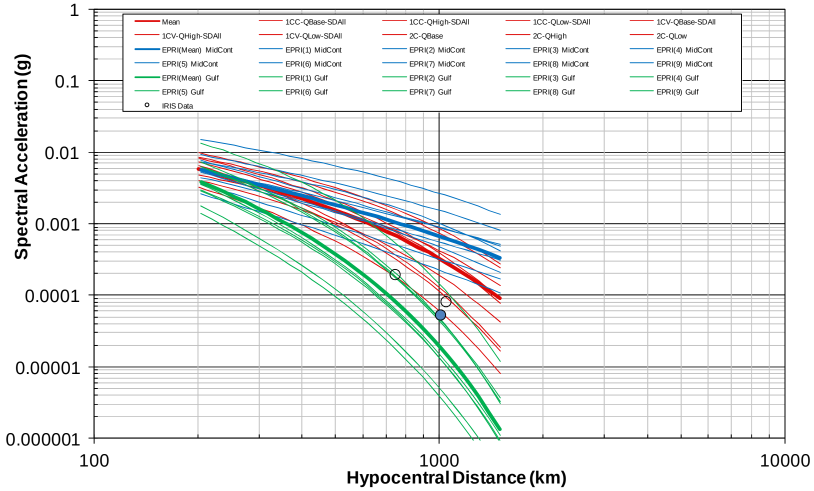
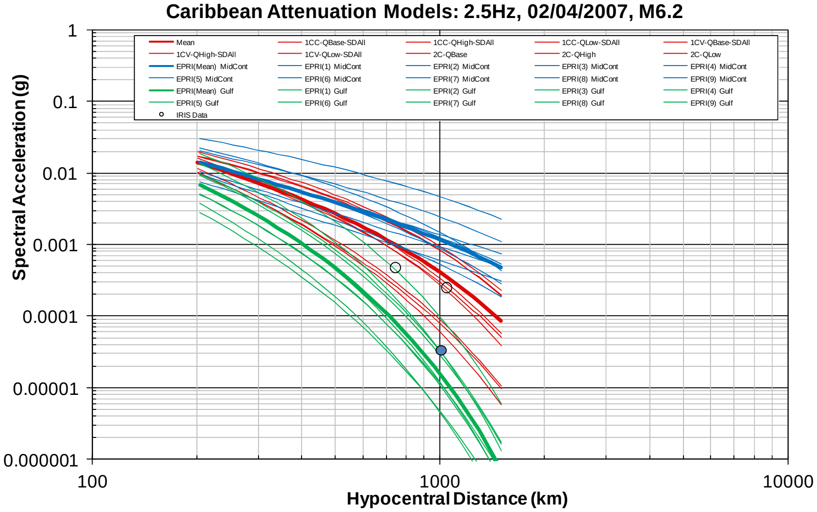
Caribbean GMPE – Comparison with IRIS Empirical Data

02/04/2007 Earthquake (M6.2)

Caribbean Attenuation Models: 1Hz, 02/04/2007, M6.2



Caribbean Attenuation Models: 2.5Hz, 02/04/2007, M6.2



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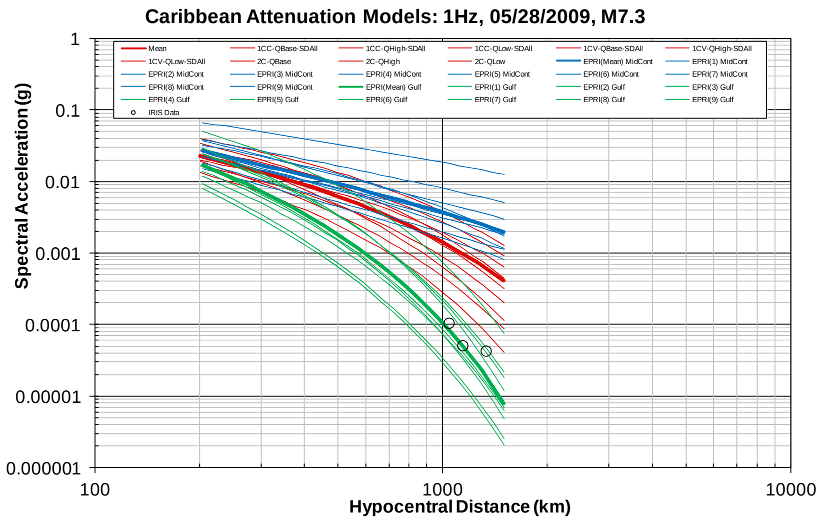
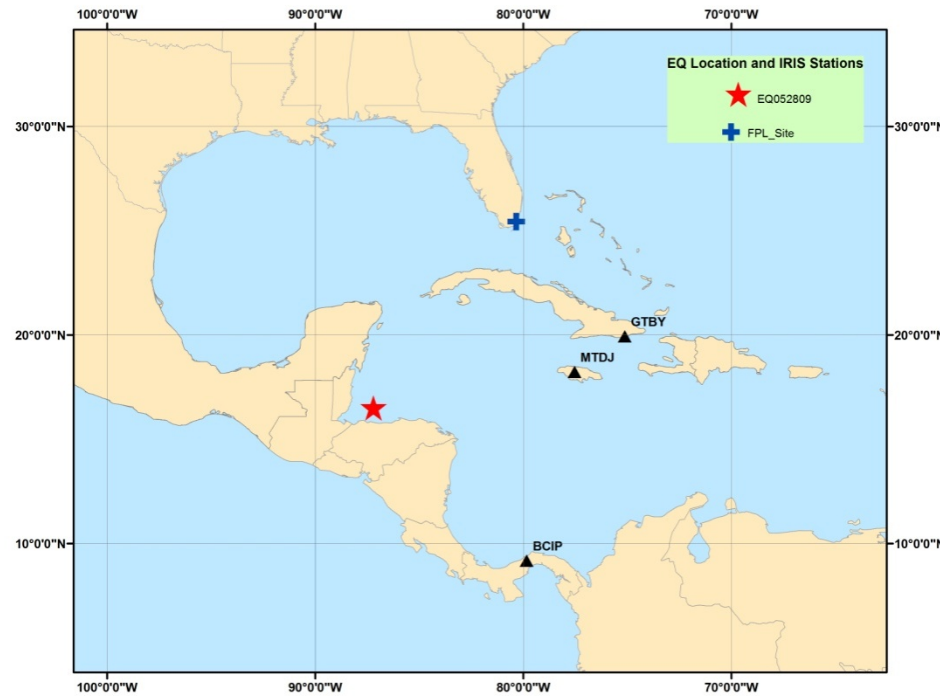
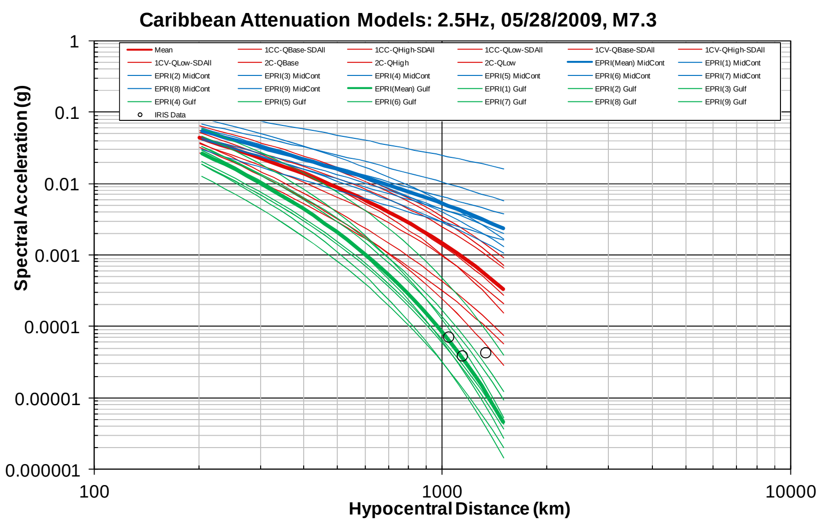
Caribbean GMPE – Comparison with IRIS Empirical Data

05/28/2009 Earthquake (M7.3)







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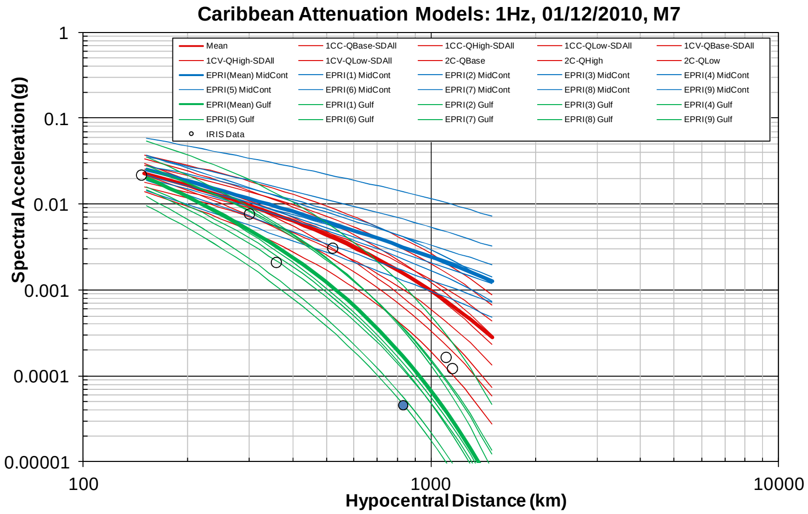
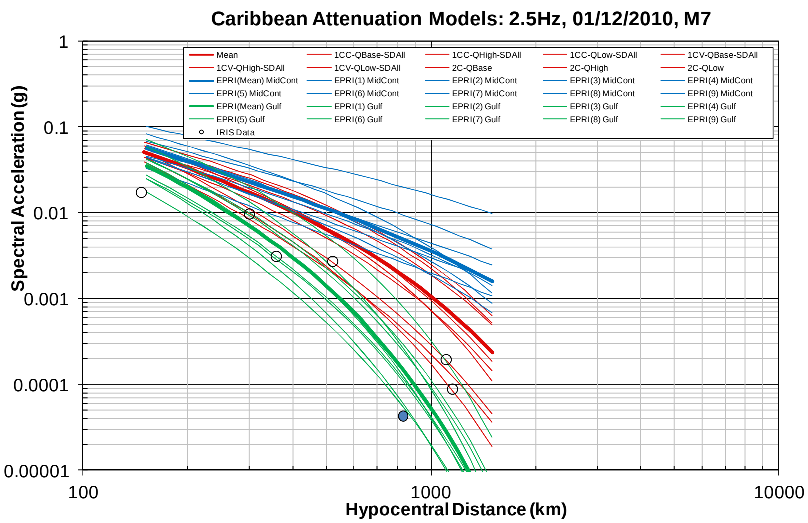
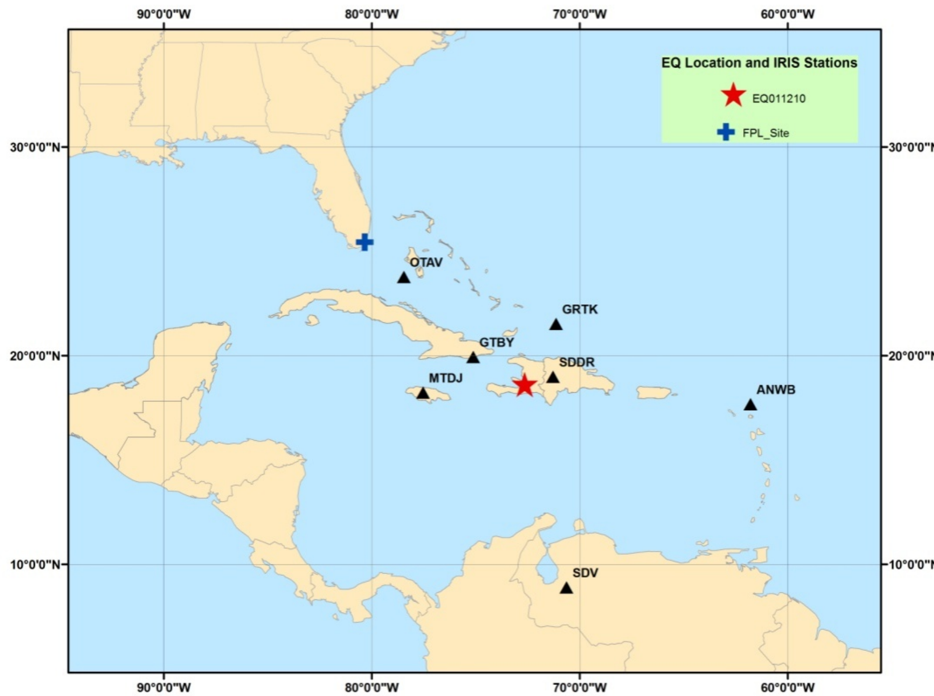
Caribbean GMPE – Comparison with IRIS Empirical Data

01/12/2010 Earthquake (M7.0)

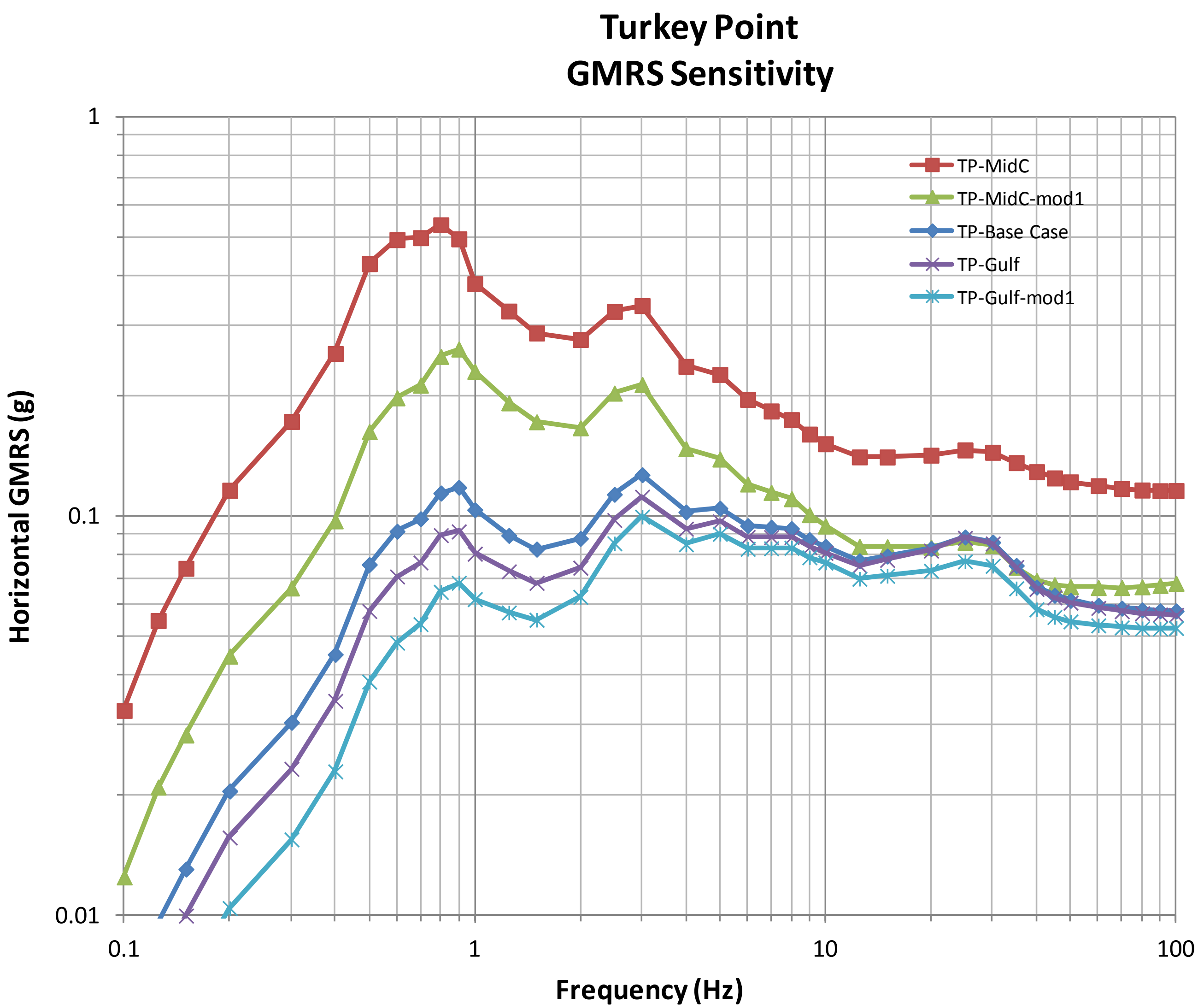






Caribbean GMPE – Effect of Alternative Attenuation Equations

GMRS Sensitivity for Caribbean GMPEs

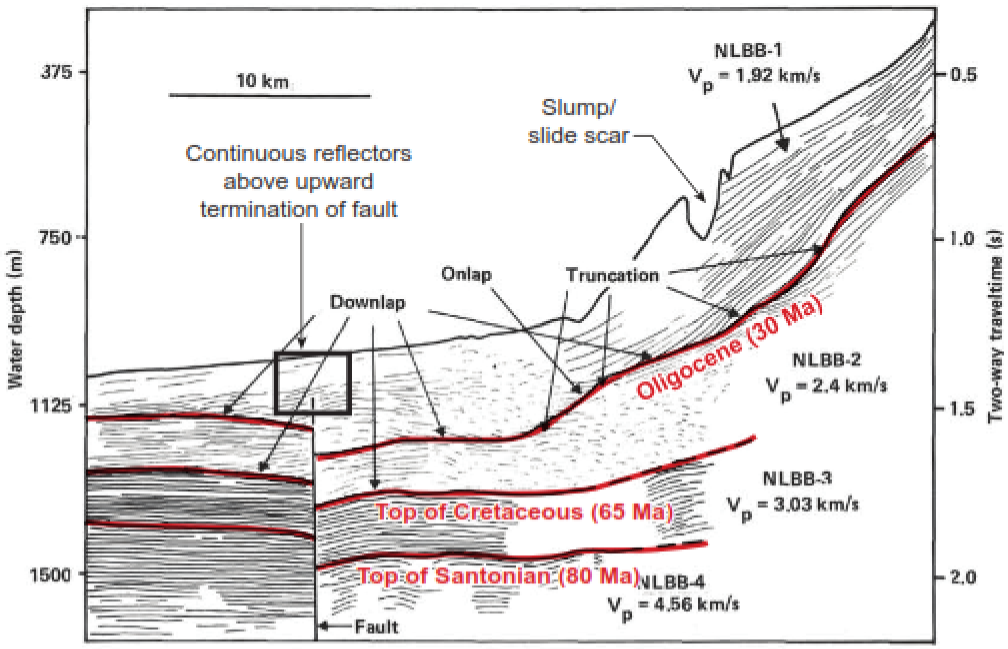


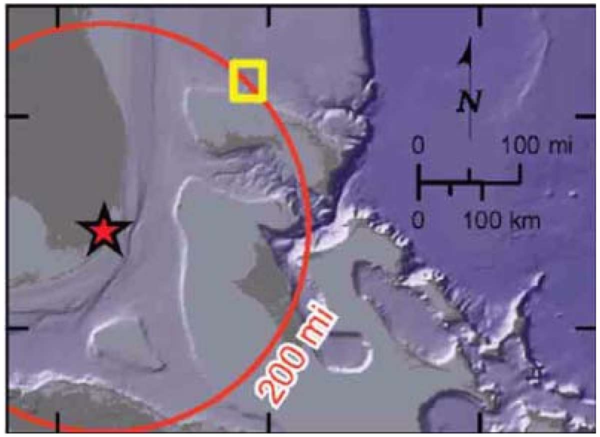
Additional information will be provided in re-written RAI responses that are responsive to NRC concerns

Young Faulting within the Turkey Point Site Region

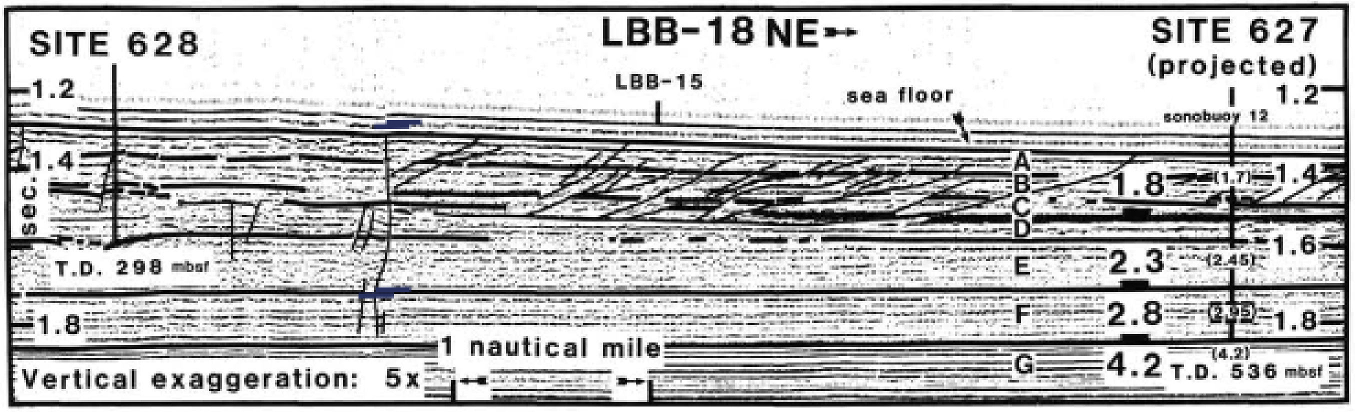
- **Provide additional information on geologic features**
  - Walkers Cay fault
  - Cuba faults
  - Marine terraces in northern Cuba
  - Cunningham et al.'s (1998) postulated fault in southern Florida
  - Straits of Florida faults

Walkers Cay Fault



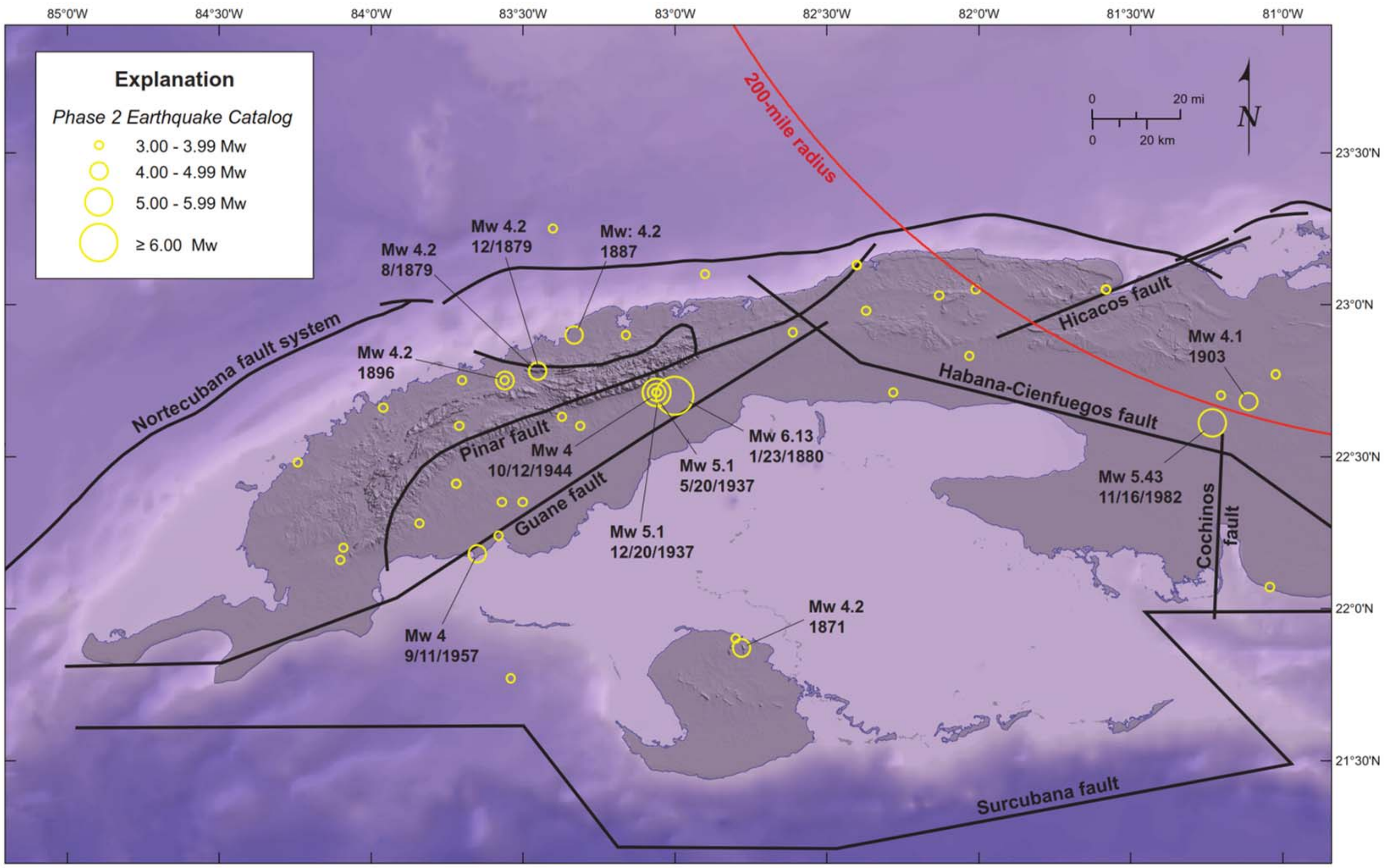


Van Buren and Mullins (1983); Revised FSAR Fig. 2.5.1-275

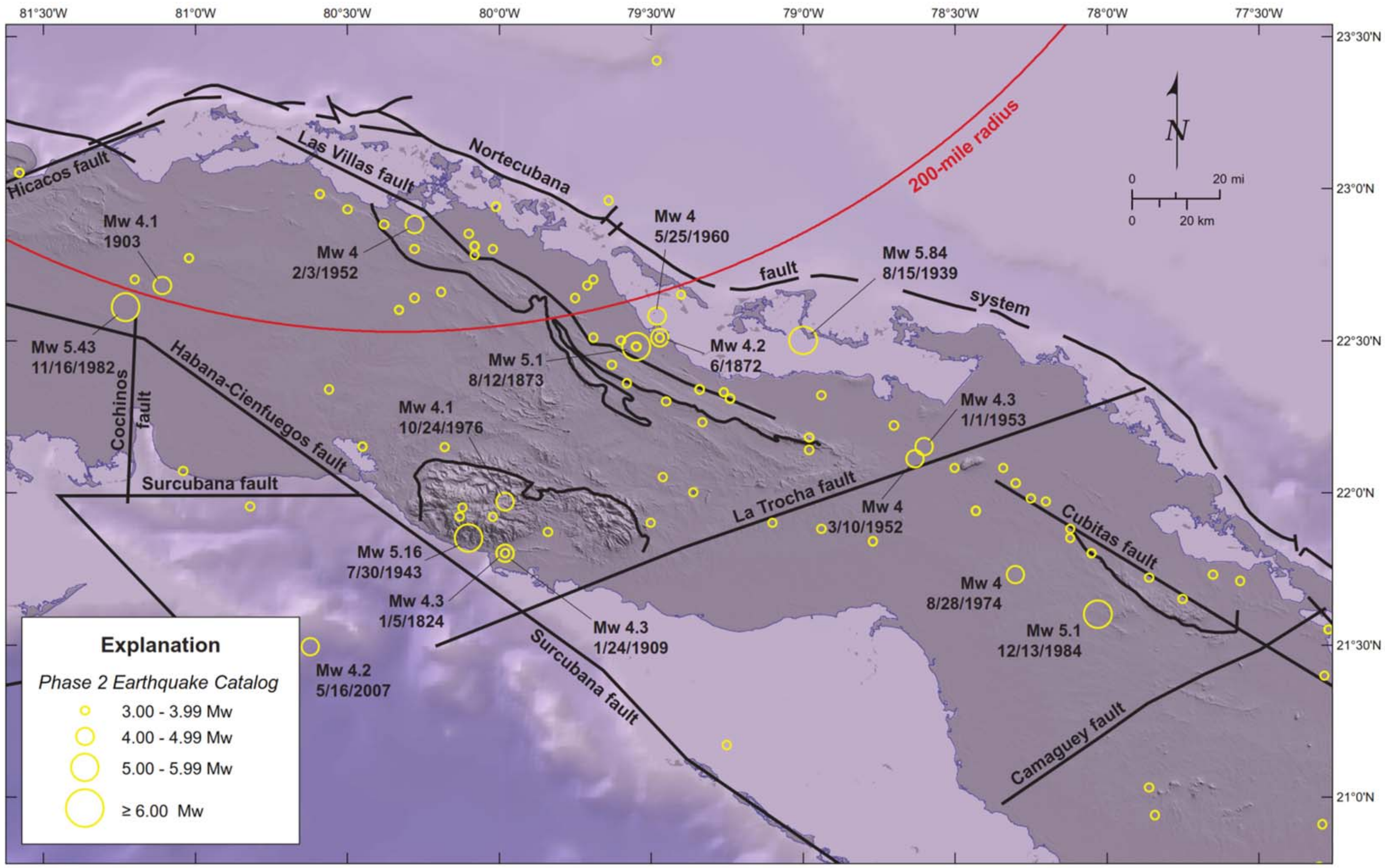


Austin et al. (1988); Revised RAI 2.5.1-14, Fig. 5

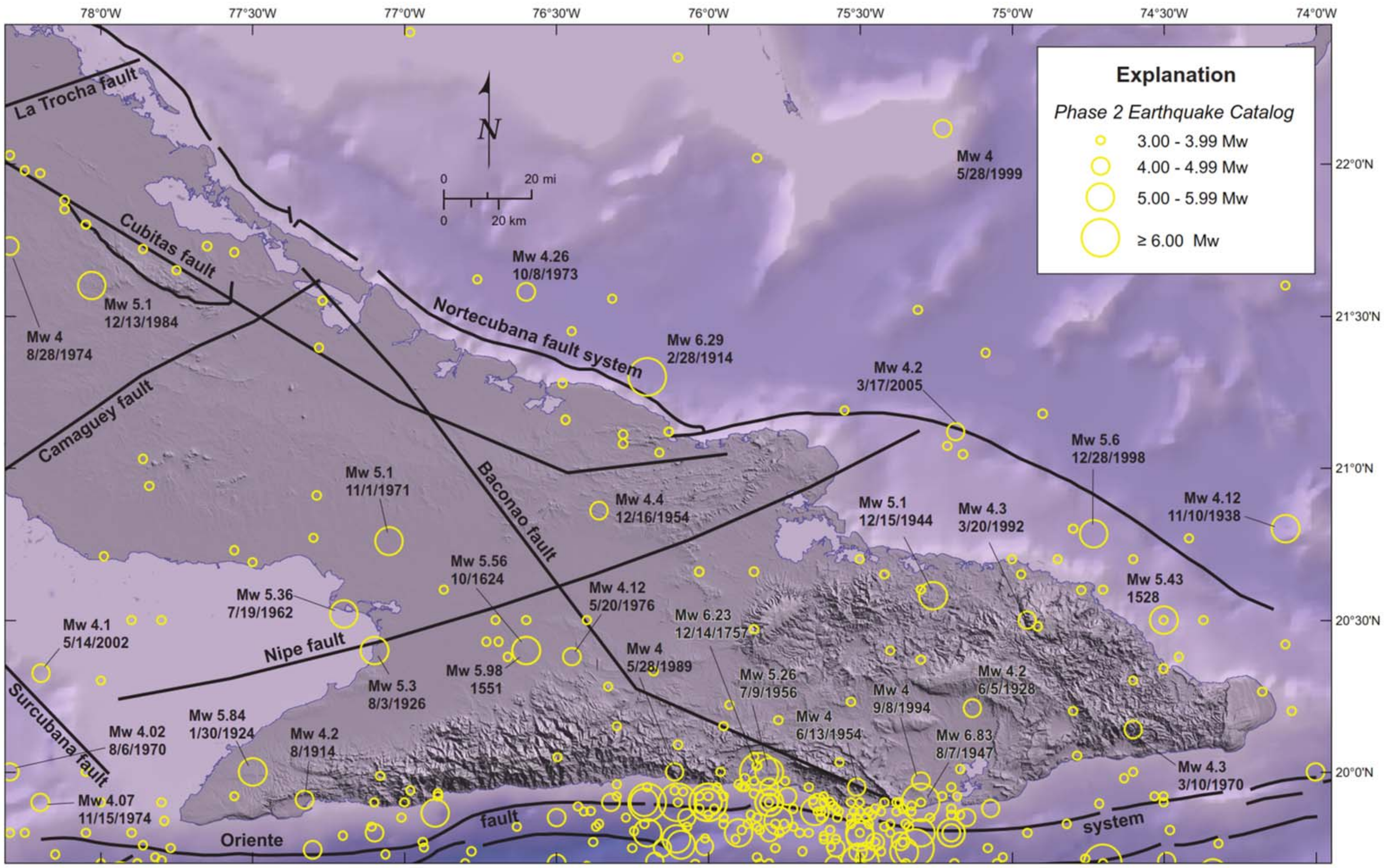
Western Cuba Faults



Central Cuba Faults



Eastern Cuba Faults



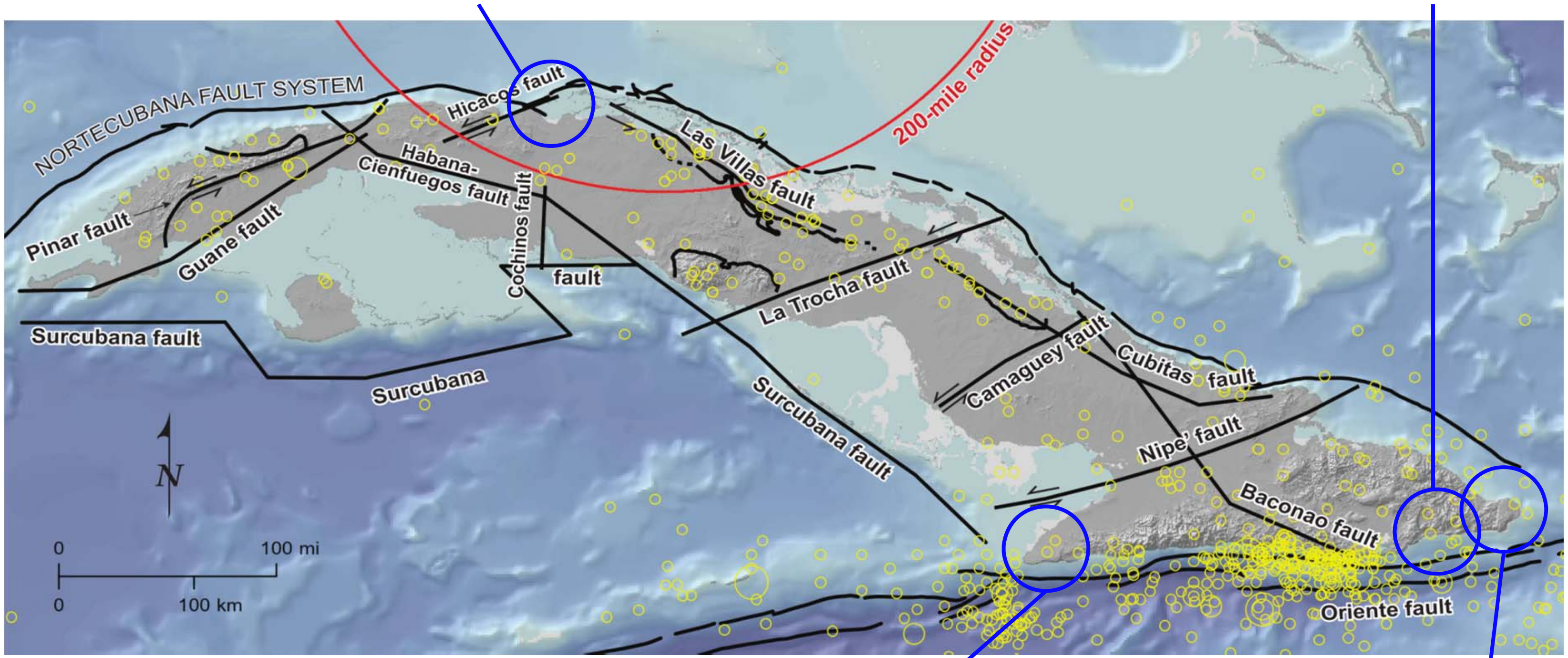
Marine Terraces in Northern Cuba

- Ducloz (1963): Describes Quaternary deposits and surfaces in the Matanzas region. Suggests that elevated marine terraces along Cuba's north coast likely formed as the result of both fluctuations in sea level and epeirogenic uplift.
- Shanzer et al. (1975): Identify three Pleistocene- and one Holocene-age marine terraces in the Matanzas-Havana region. Suggest possible tectonic deformation associated with unidentified structure.
- Toscano et al. (1999): Local study that uses radiometric dating to identify the Substage 5e marine terrace near Matanzas. Conclude "no obvious tectonic uplift is indicated for this time frame [i.e., approximately 122 ka] along the northern margin of Cuba."
- Pedoja et al. (2011): Global compilation that calculates uplift rates for marine terraces in northern Cuba of approximately 0.0-0.04 mm/yr or 0.00-0.06 mm/yr over last approximately 122 ka, consistent with those observed at other tectonically "stable" coastlines worldwide.

Elevations of the Substage 5e Marine Terrace in Cuba

Matanzas Bay:
2-3 m (Toscano et al. 1999)
7.5 m max. (Pedoja et al. 2011)

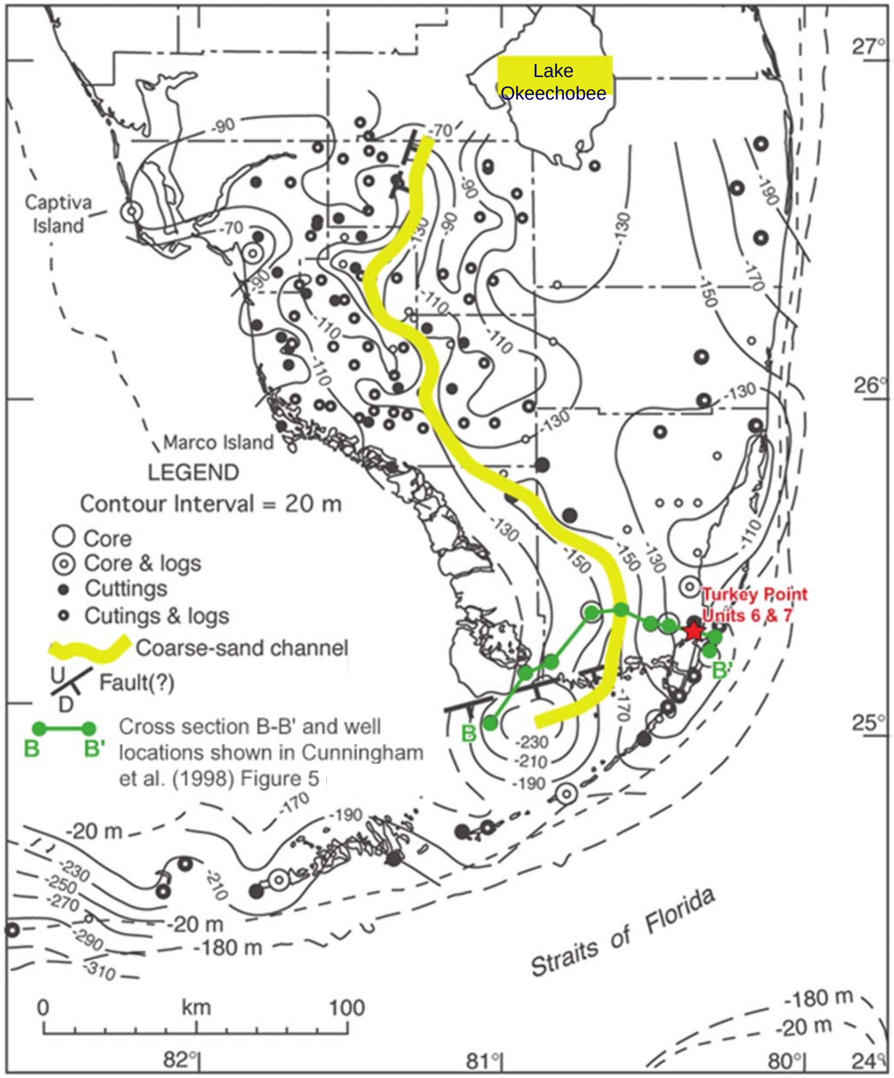
Tortuguilla-Imias:
7.5 m max. (Pedoja et al. 2011)



Cabo Cruz:
15 m max. (Pedoja et al. 1999)

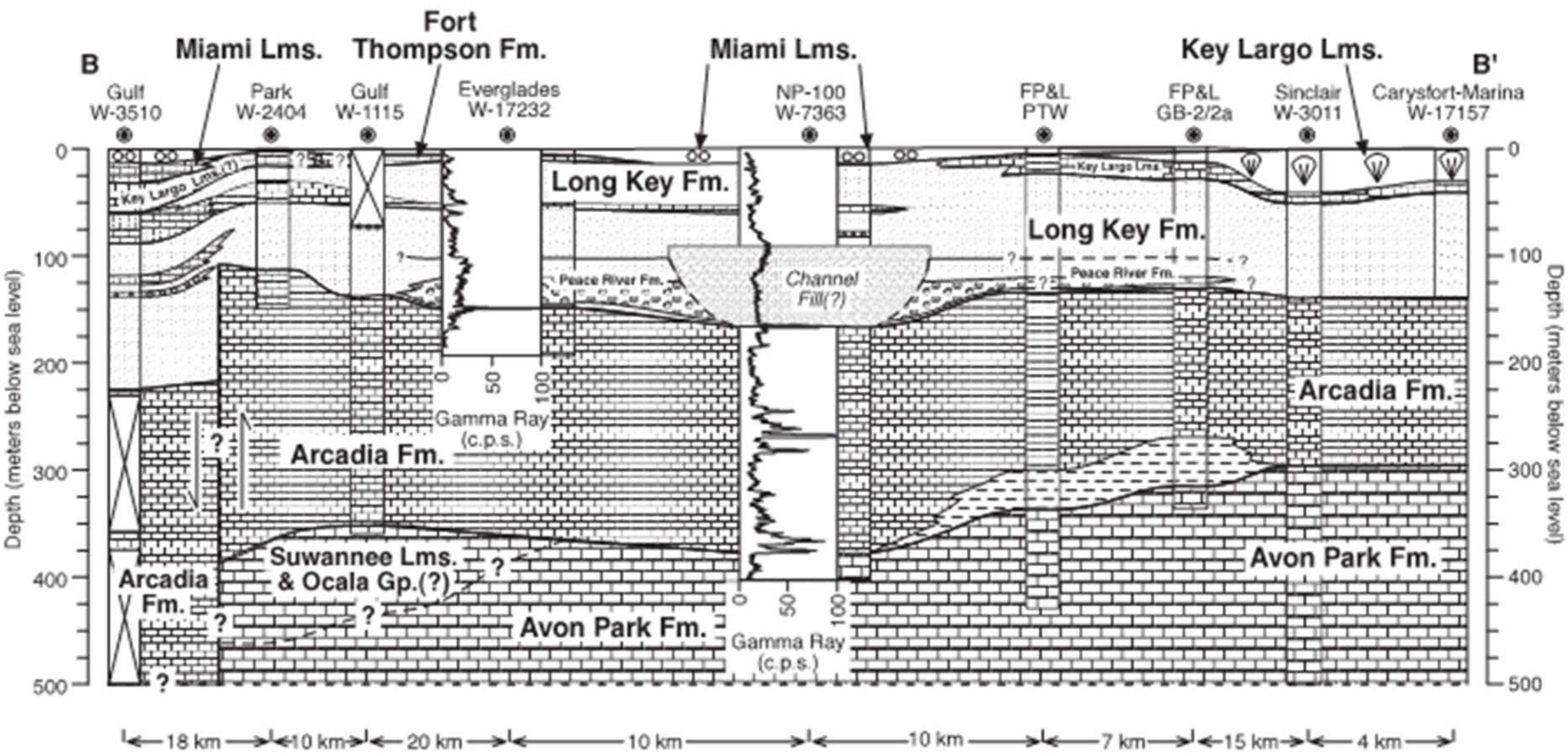
Punta de Maisi:
32.5 m max. (Pedoja et al. 1999)

Cunningham et al.'s (1998) Postulated Fault in Southern FL



Cunningham et al. (1998); Revised RAI 2.5.1-12, Fig. 2

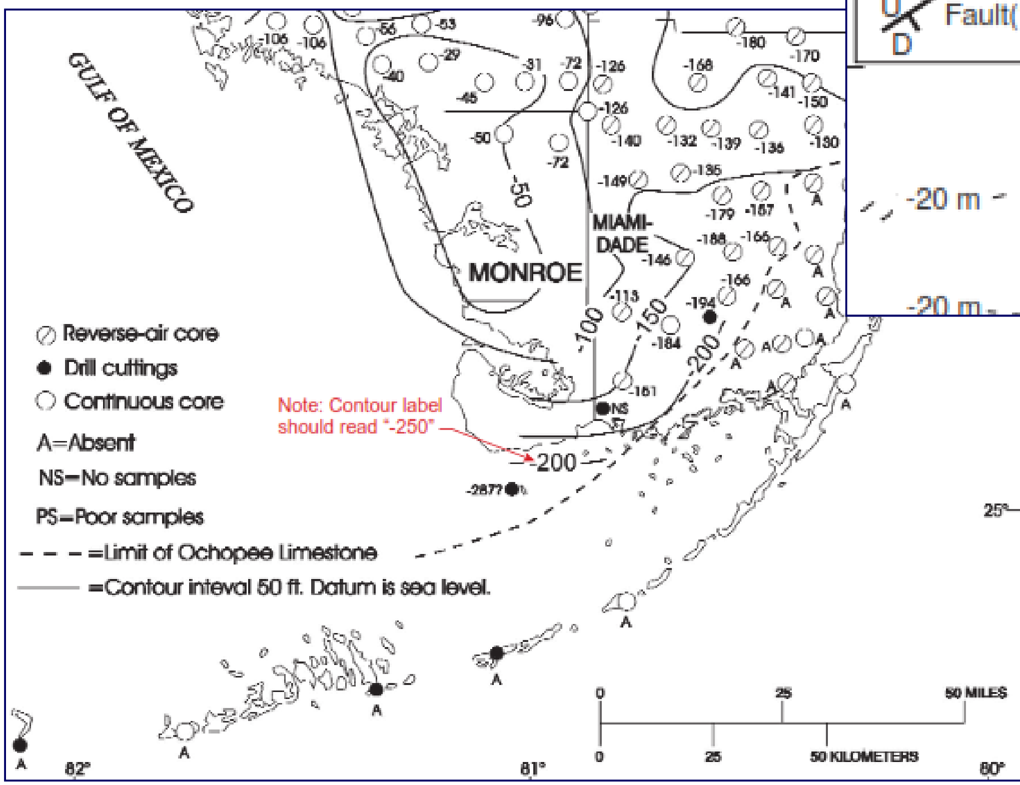
Cunningham et al.'s (1998) Postulated Fault in Southern FL

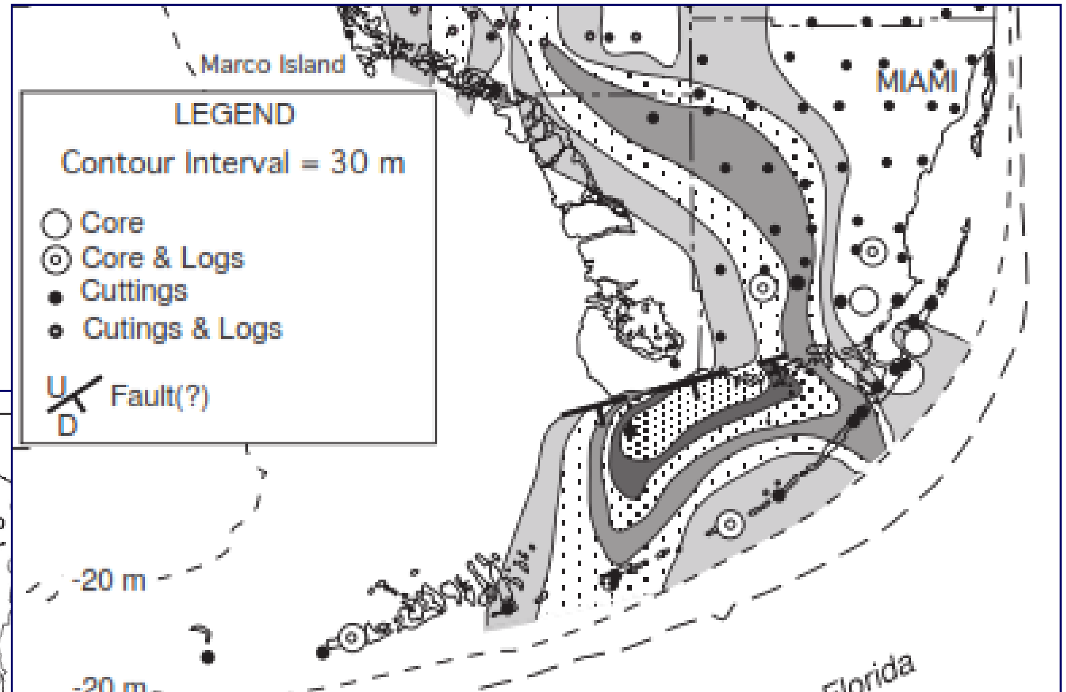


Cunningham et al., 1998; Revised RAI 2.5.1-12, Fig. 1

Cunningham et al.'s (1998) Postulated Fault in Southern FL

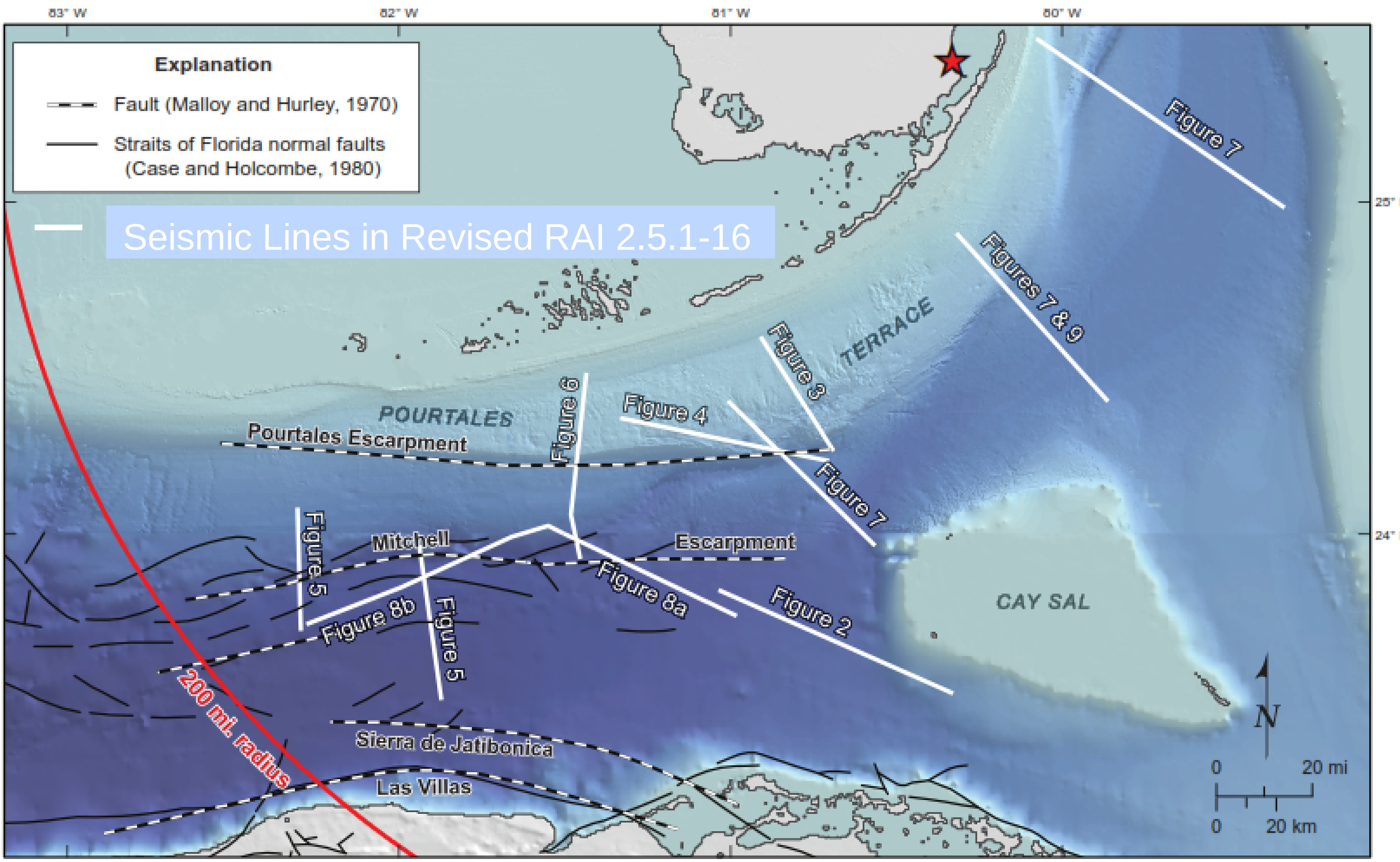
Base of Ochopee Limestone (Pliocene)
Cunningham et al. (2001); Revised RAI 2.5.1-12, Fig. 9





Miocene and Pliocene clastics isopach
Cunningham et al. (1998); Revised RAI Fig. 3

Straits of FL Faults



Results of sensitivity calculations will be described in revised responses to RAIs 2.5.1-14, 2.5.1-21, and 2.5.2-4

Seismic Source Evaluations and Sensitivity Analyses for PSHA

- **Perform sensitivity calculation to assess Walkers Cay fault**
  - Assume capable tectonic source
  - Assess impact to site hazard
- **Perform sensitivity calculations to assess alternate modeling approaches for Cuba:**
  - Increase rate for single areal source zone
  - Subdivide Cuba into six areal sources
  - Model 15 Cuba fault sources
  - Combine fault and areal sources
- **Provide additional information on the Garcia et al. (2003) and Garcia et al. (2008) source characterizations for Cuba**

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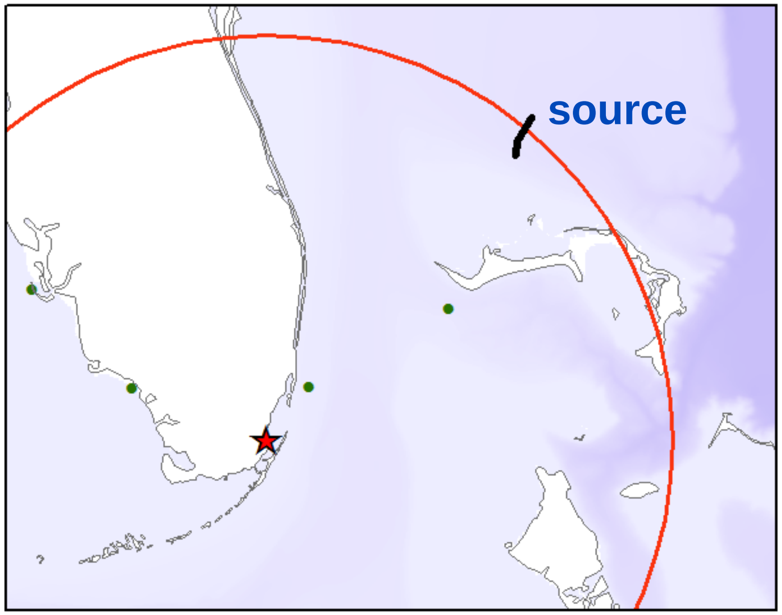
Characterization of Walkers Cay Fault Source

Walkers Cay fault sensitivity source



Walkers Cay fault source parameters

Fault Source	Pa	Magnitude (Mw) [and weight]	Slip Rate (mm/yr) [and weight]
Walkers Cay	1.0	6.6 [0.2] 6.8 [0.6] 7.0 [0.2]	0.001 [0.3] 0.01 [0.6] 0.05 [0.1]

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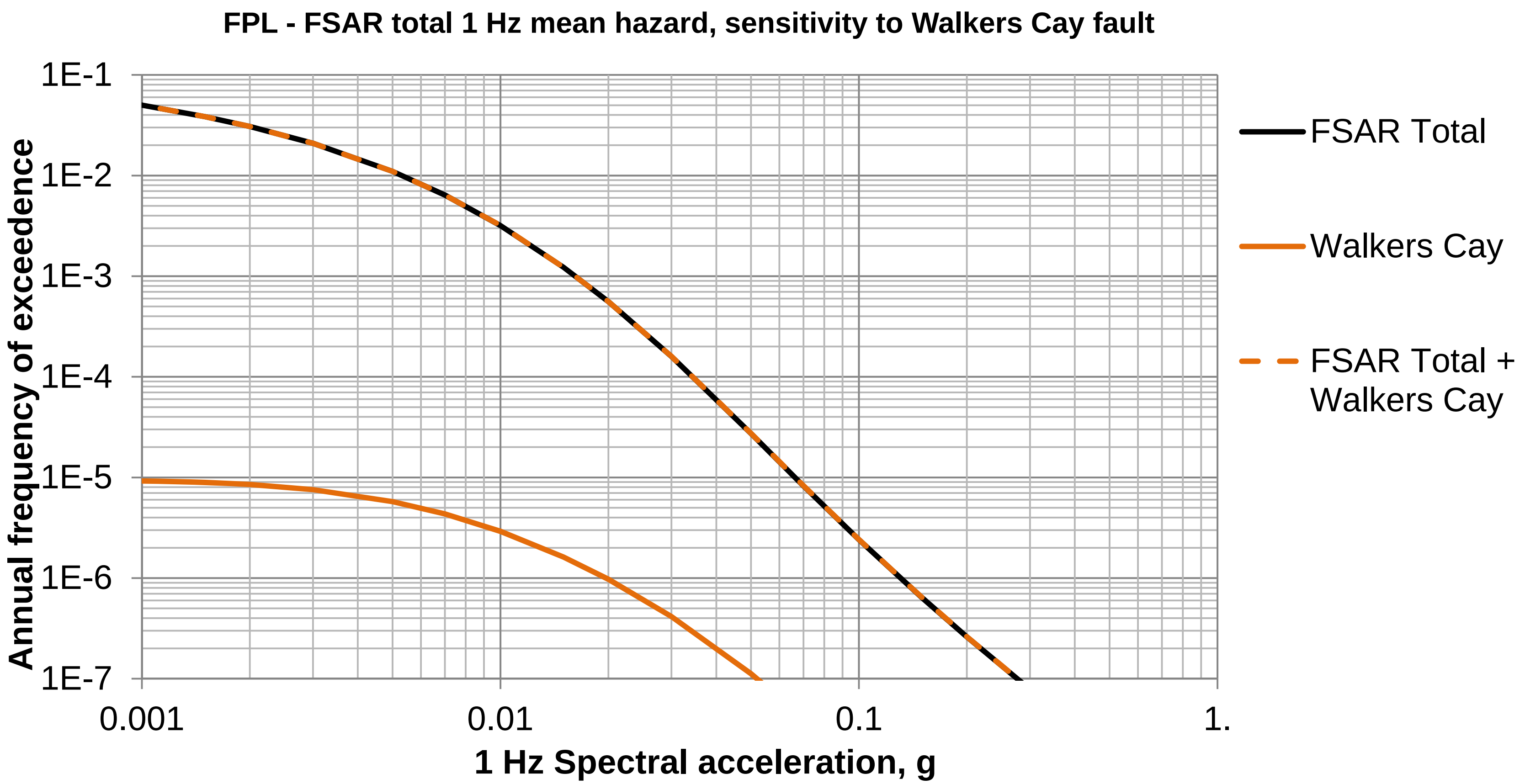
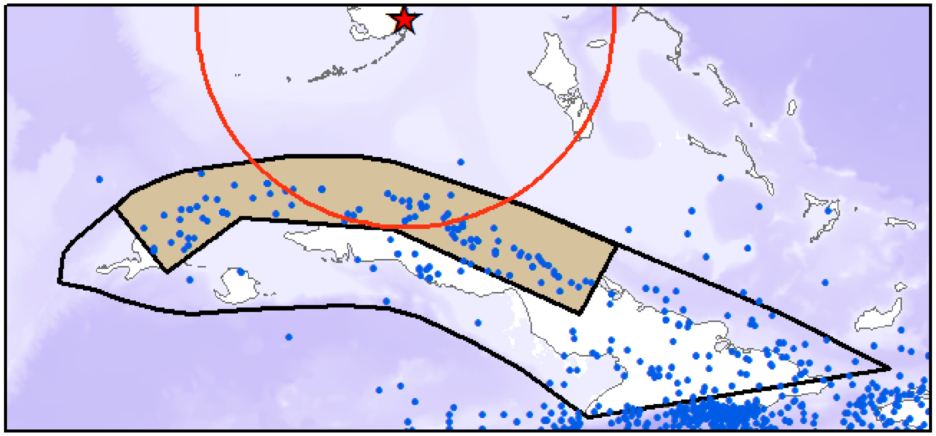
Sensitivity Results for Walkers Cay Fault



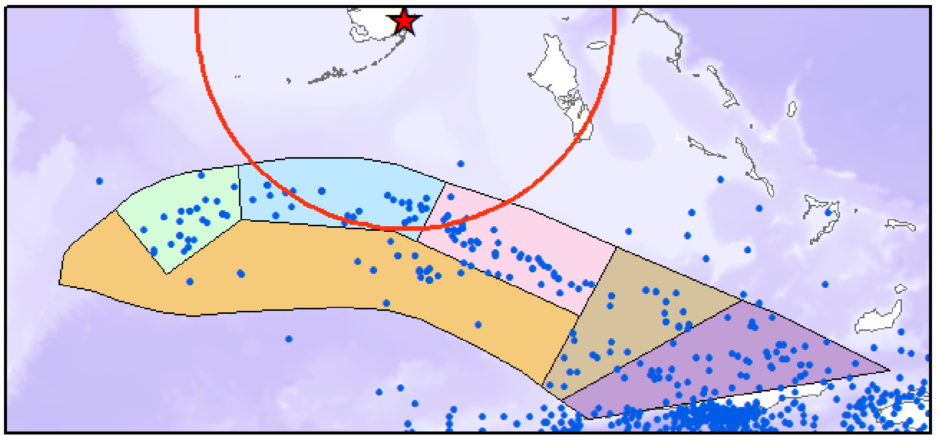
Alternate Cuba Areal Source Characterizations for Sensitivity Analyses

Cuba northern subzone



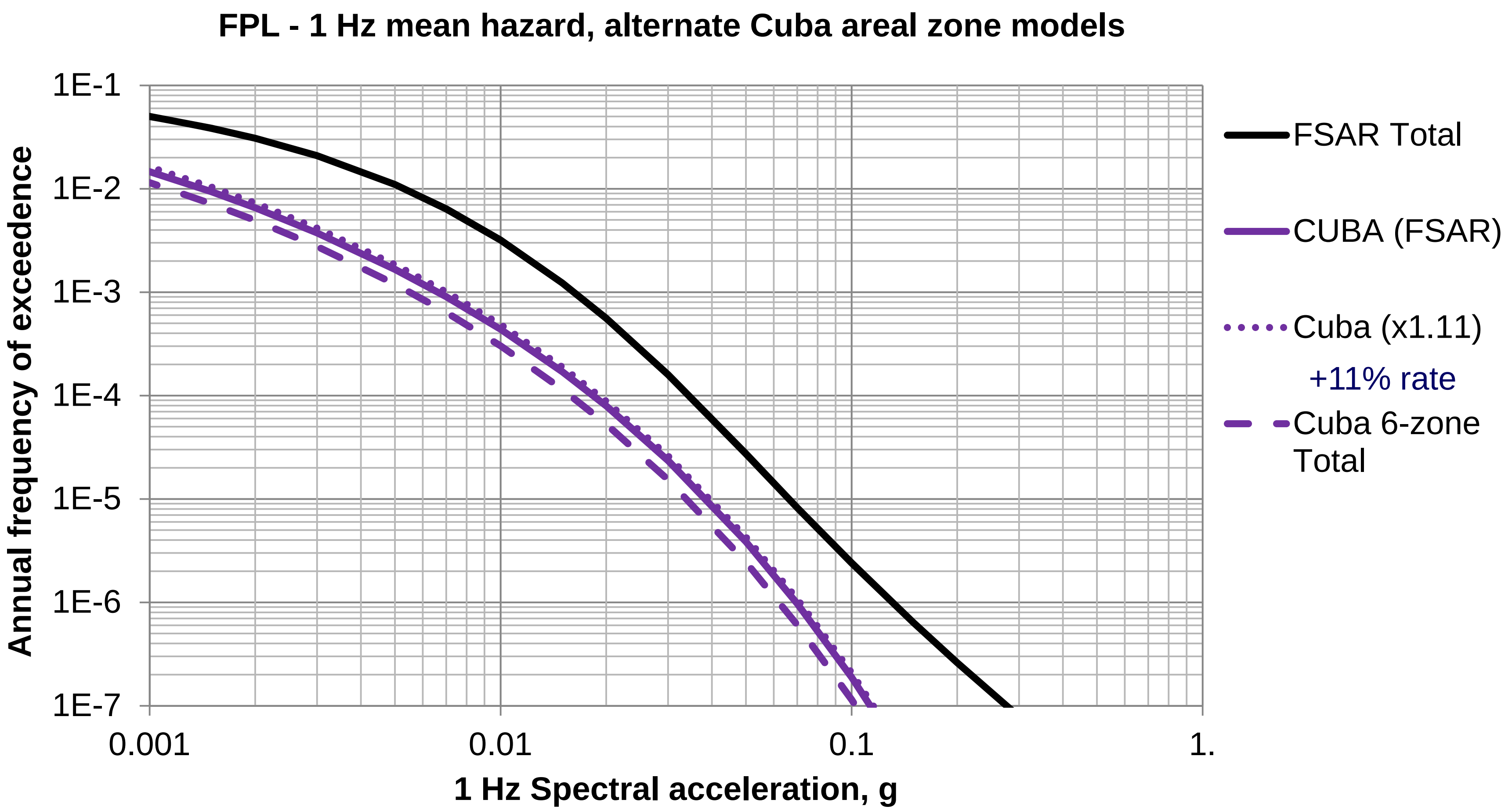
- Cuba northern subzone defined to envelop area of higher seismicity rate nearest the site
- This 11% higher rate is applied to entire Cuba areal source zone
- Results described in response to RAI 2.5.2-4

Cuba six areal sources sensitivity

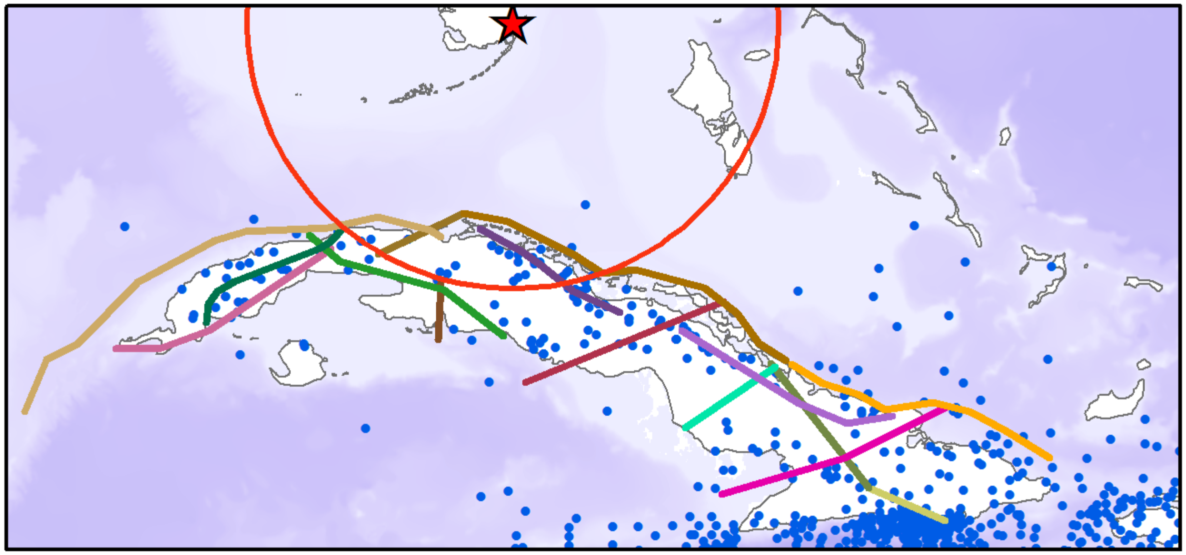


- Cuba subdivided into 6 areal source zones, based on seismicity and tectonics
- Uniform rates for each zone based on seismicity within each zone
- Results will be described in revised response to RAI 2.5.2-4

Sensitivity Results for Alternate Cuba Areal Source Models



Cuba Fault Sources for Sensitivity Analyses



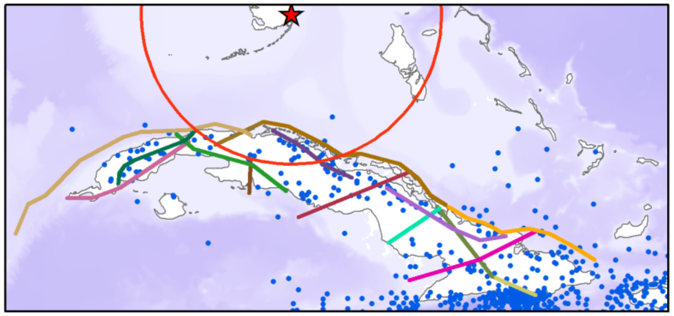
Sources include Cotilla-Rodriguez et al.'s (2007) seismoactive faults in Cuba, plus the Pinar fault.

Results will be described in revised response to RAI 2.5.1-21

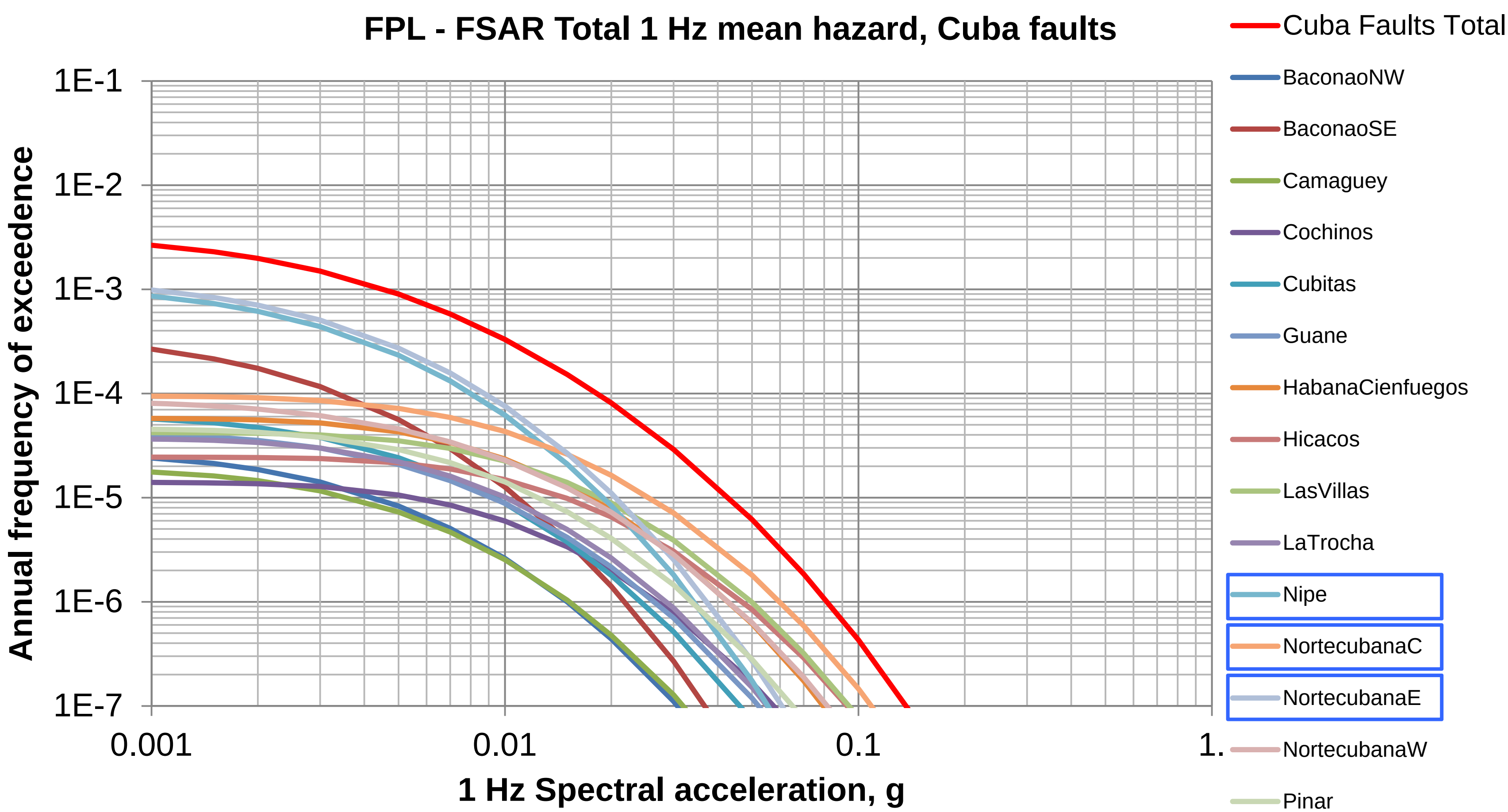
Cuba Fault Source Parameters for Sensitivity Analyses

Fault Source	Pa	Magnitude (Mw) [and weight]	Slip Rate (mm/yr) [and weight]
Baconao SE	1.0	7.0 [0.5] 7.3 [0.5]	0.001 [0.0] 0.01 [0.1] 0.1 [0.5] 1.0 [0.4]
Baconao NW	0.5	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Camaguey	0.5	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Cochinos	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Cubitas	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Guane	0.5	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Habana-Cienfuegos	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Hicacos	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
La Trocha	0.5	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]

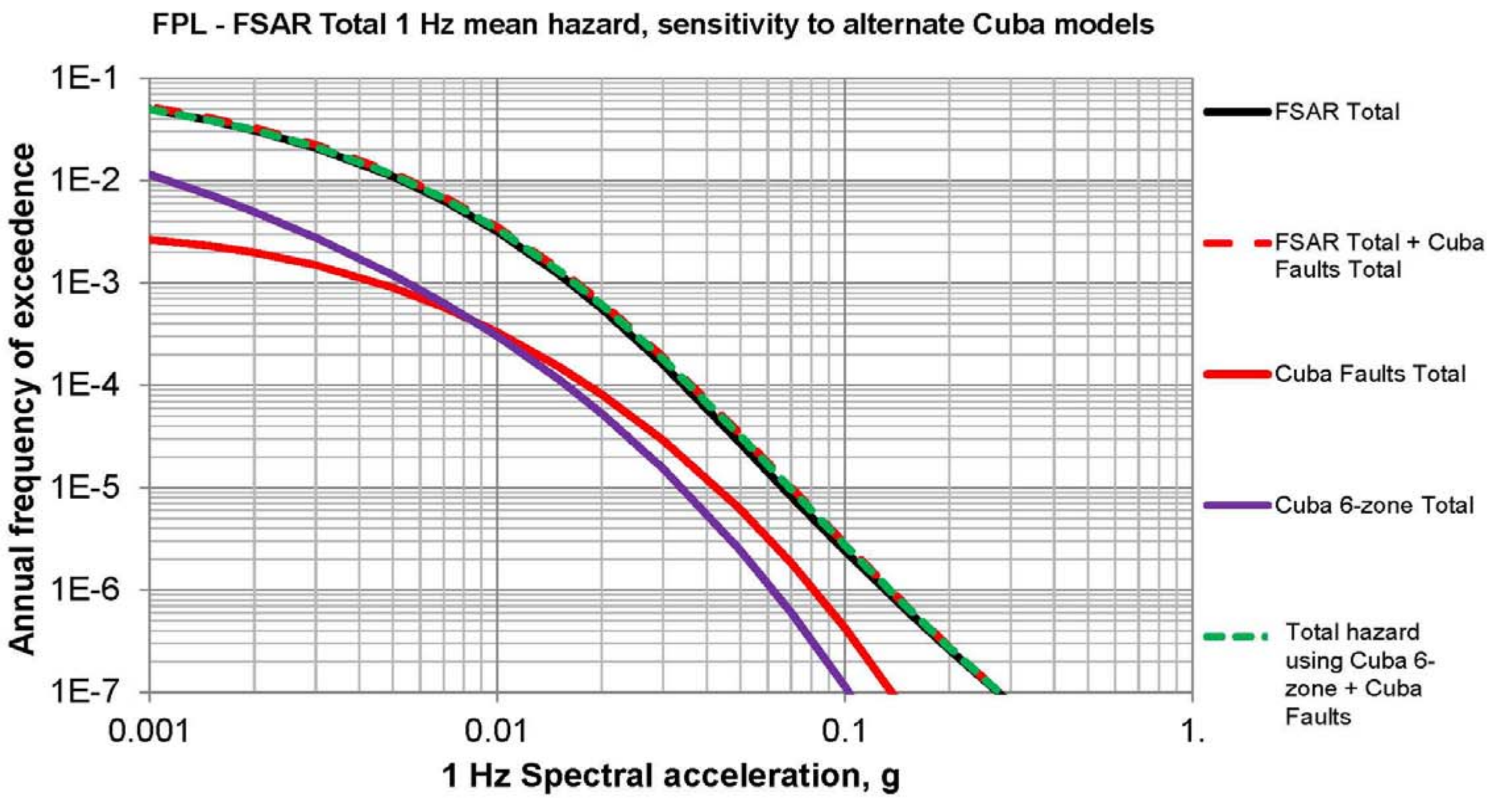
Fault Source	Pa	Magnitude (Mw) [and weight]	Slip Rate (mm/yr) [and weight]
Las Villas	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Nipe	1.0	7.0 [0.5] 7.3 [0.5]	0.001 [0.0] 0.01 [0.1] 0.1 [0.5] 1.0 [0.4]
Nortecubana W	0.5	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Nortecubana Central	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]
Nortecubana E	1.0	7.0 [0.5] 7.3 [0.5]	0.001 [0.0] 0.01 [0.1] 0.1 [0.5] 1.0 [0.4]
Pinar	0.75	7.0 [0.5] 7.3 [0.5]	0.001 [0.33] 0.01 [0.34] 0.1 [0.33]



Sensitivity Results for Cuba Fault Sources



Sensitivity Results for Cuba Areal and Fault Sources

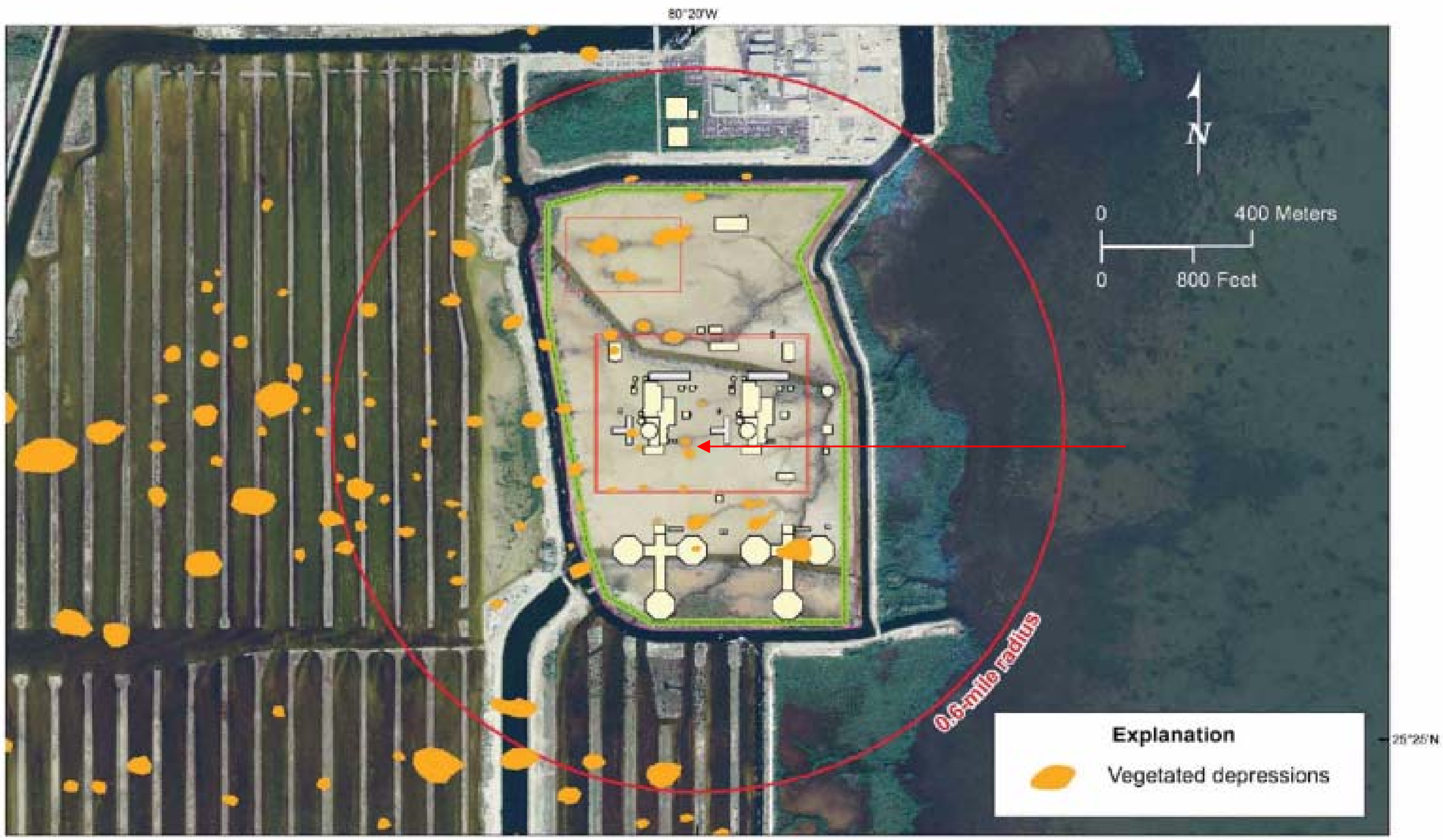


Additional Information will be provided in the RAI responses and FSAR

Potential Dissolution Features at Turkey Point Site & Vicinity

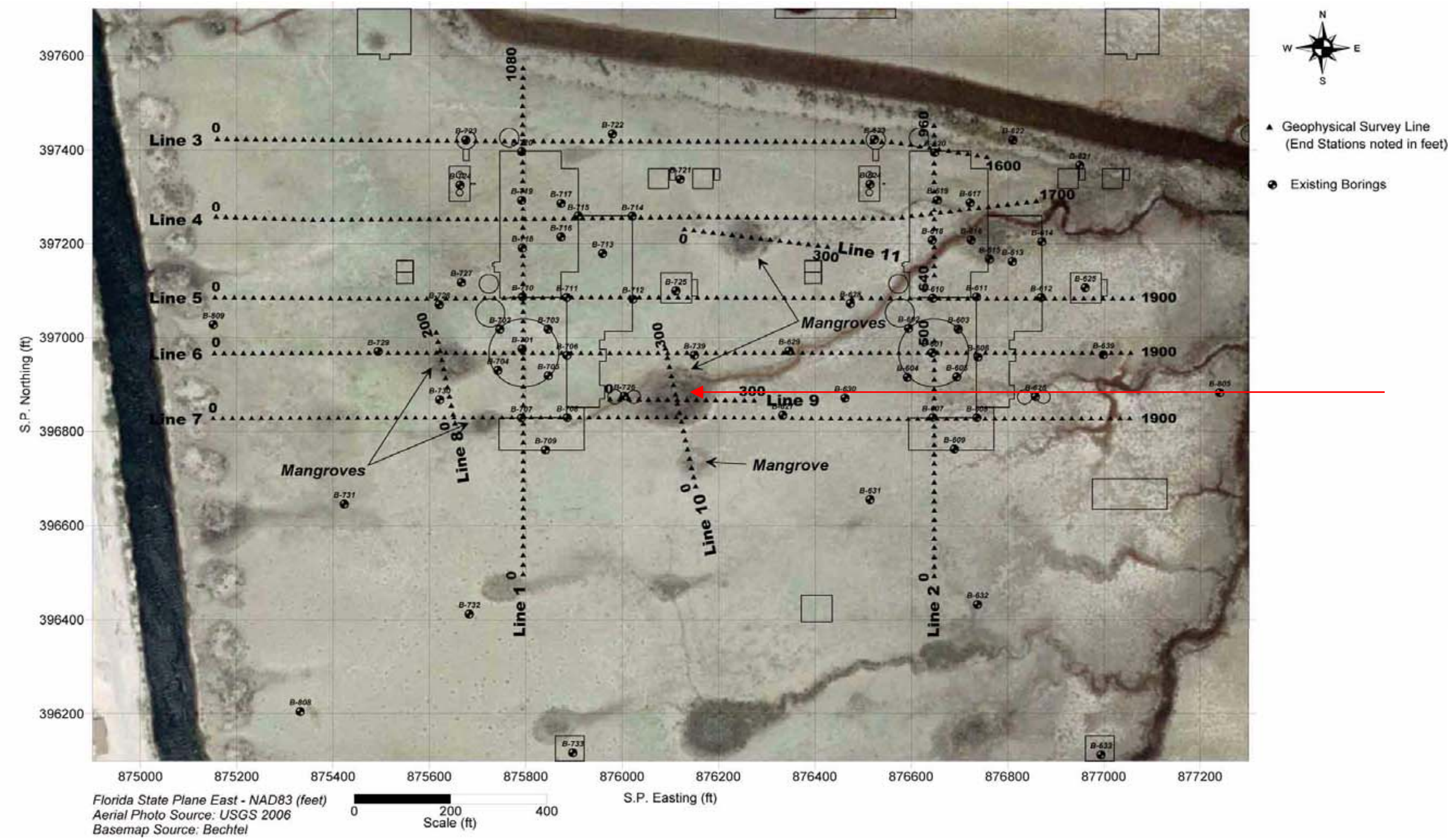
- Explanation of voids in the Turkey Point site limestone
- Dissolution Features - Surface
- Limestone Dissolution Features - Subsurface

Surface Dissolution Features



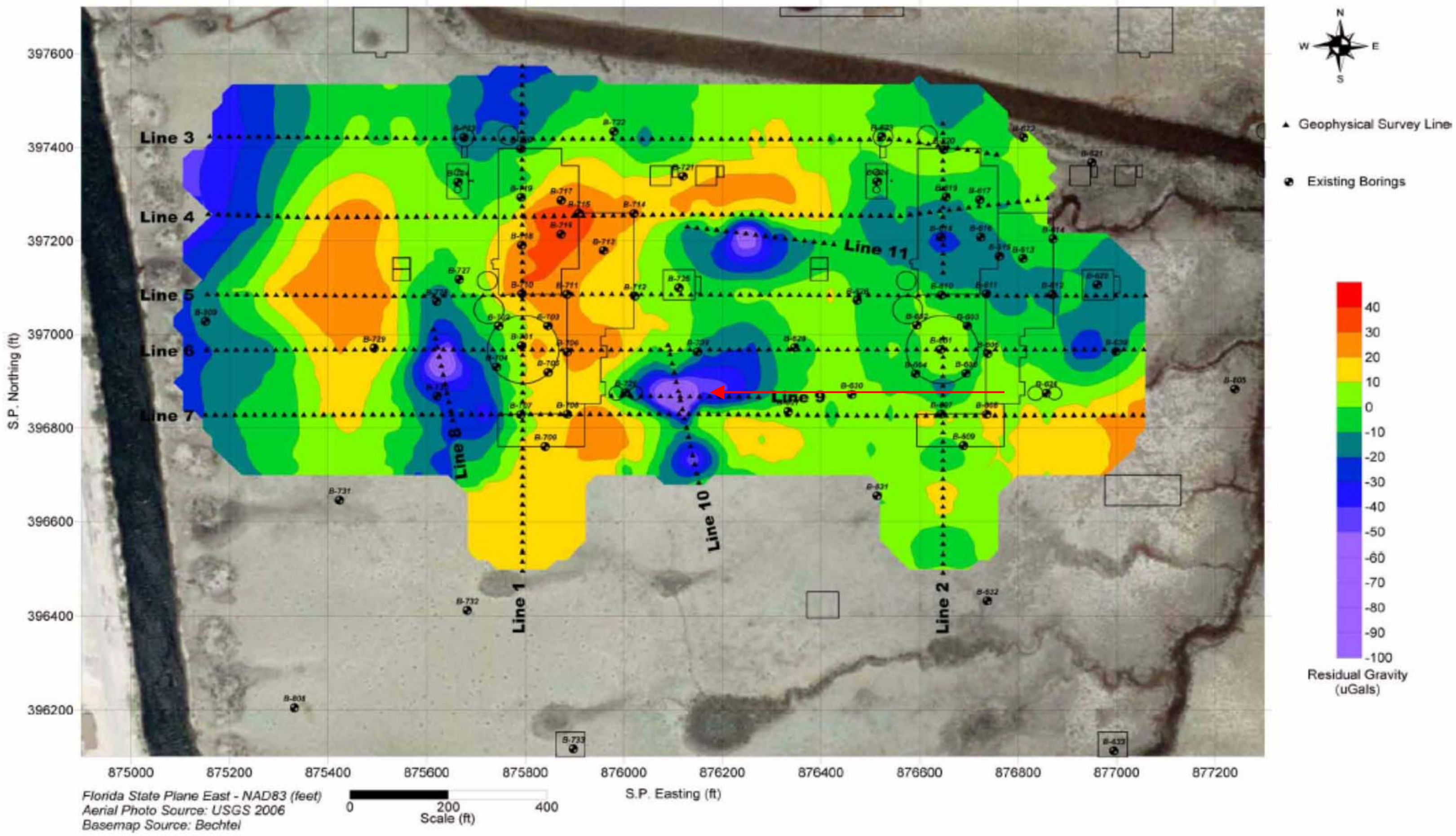
FSAR Subsection 2.5.1 Revision 3, Figure 2.5.1-333

Surface Dissolution Features



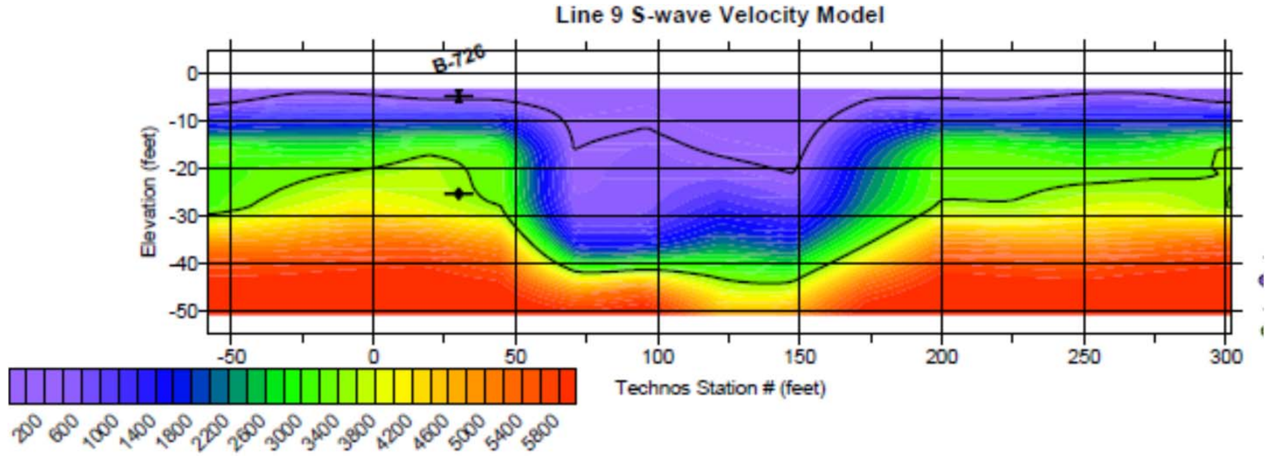
FSAR Subsection 2.5.4 Revision 3, Figure 2.5.4-223

Surface Dissolution Features

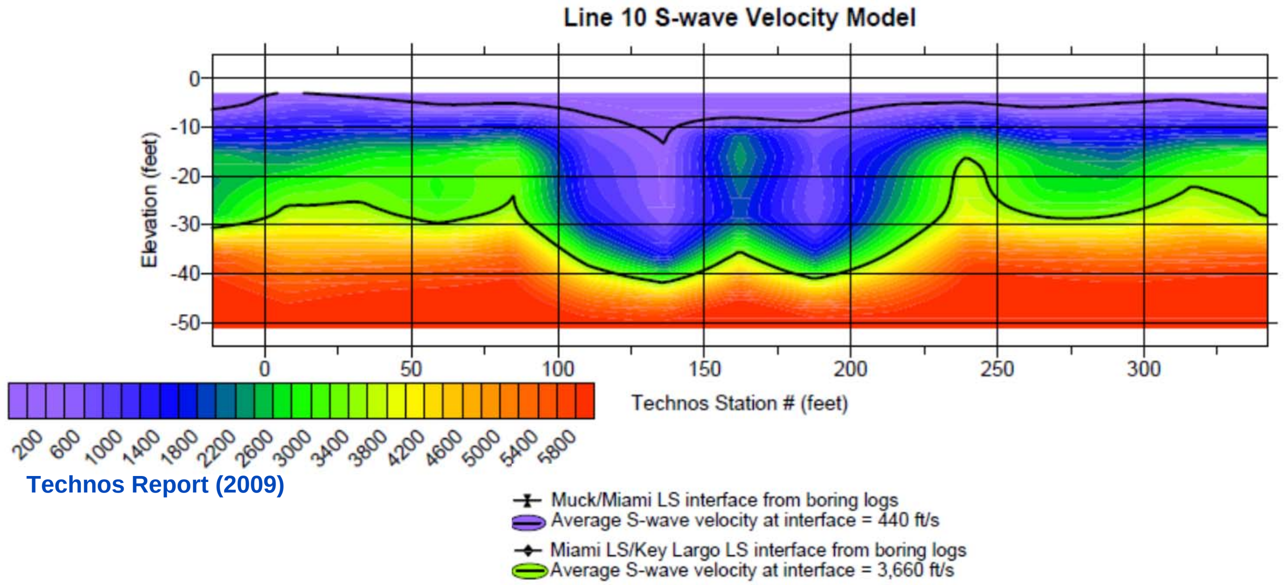


FSAR Subsection 2.5.4 Revision 3, Figure 2.5.4-228

Surface Dissolution Features - MASW

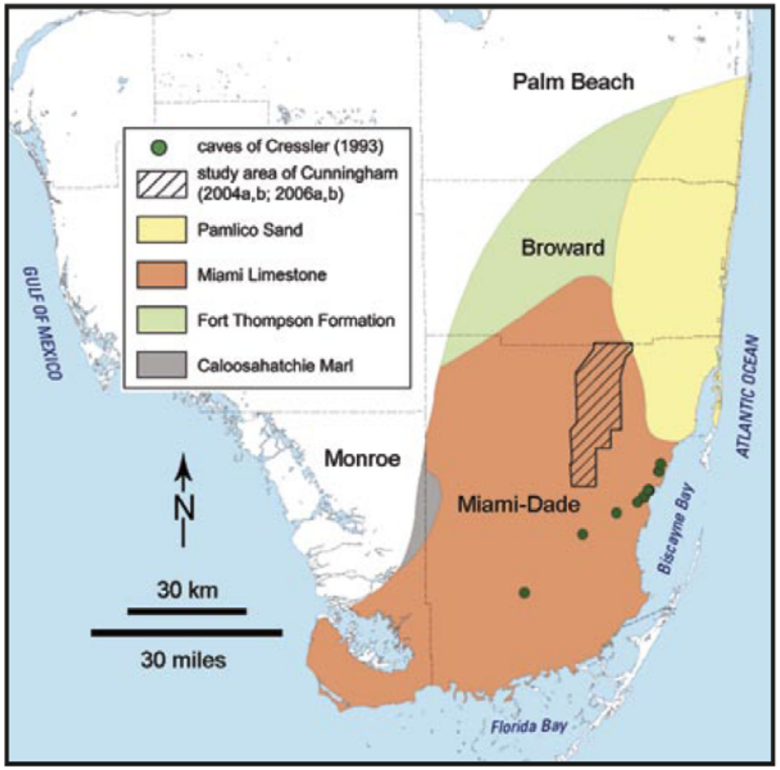


FSAR Subsection 2.5.4 Revision 003, Figure 2.5.4-227

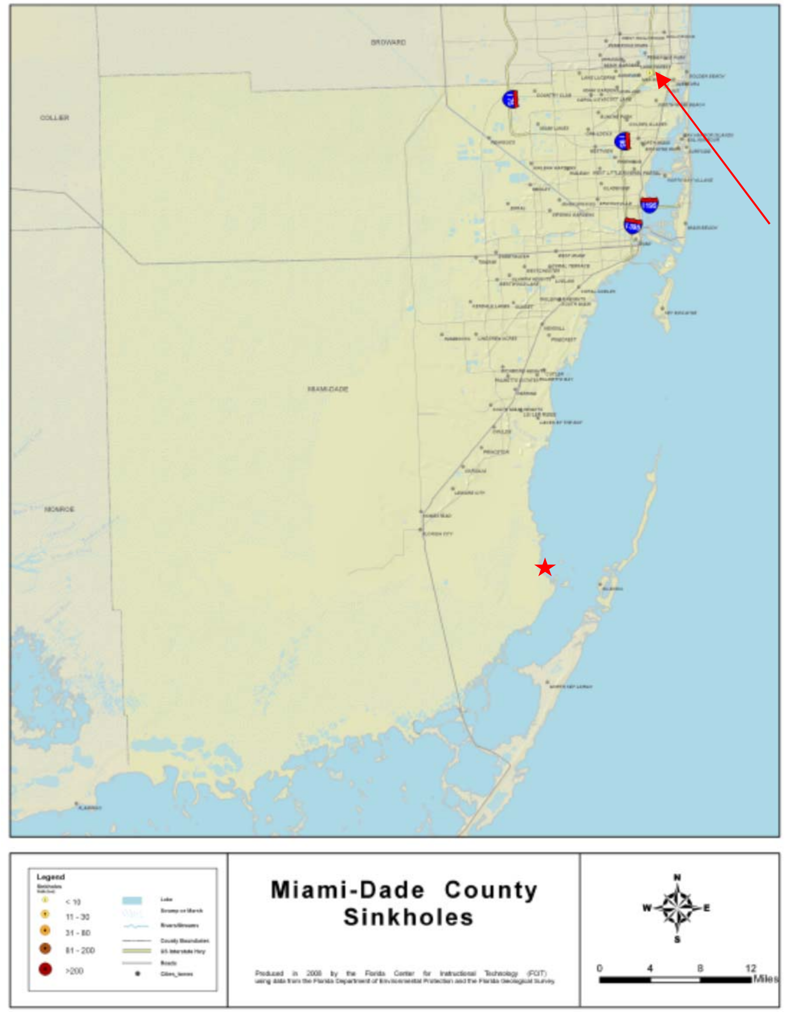


Technos Report (2009)

Site Vicinity Limestone Dissolution Features

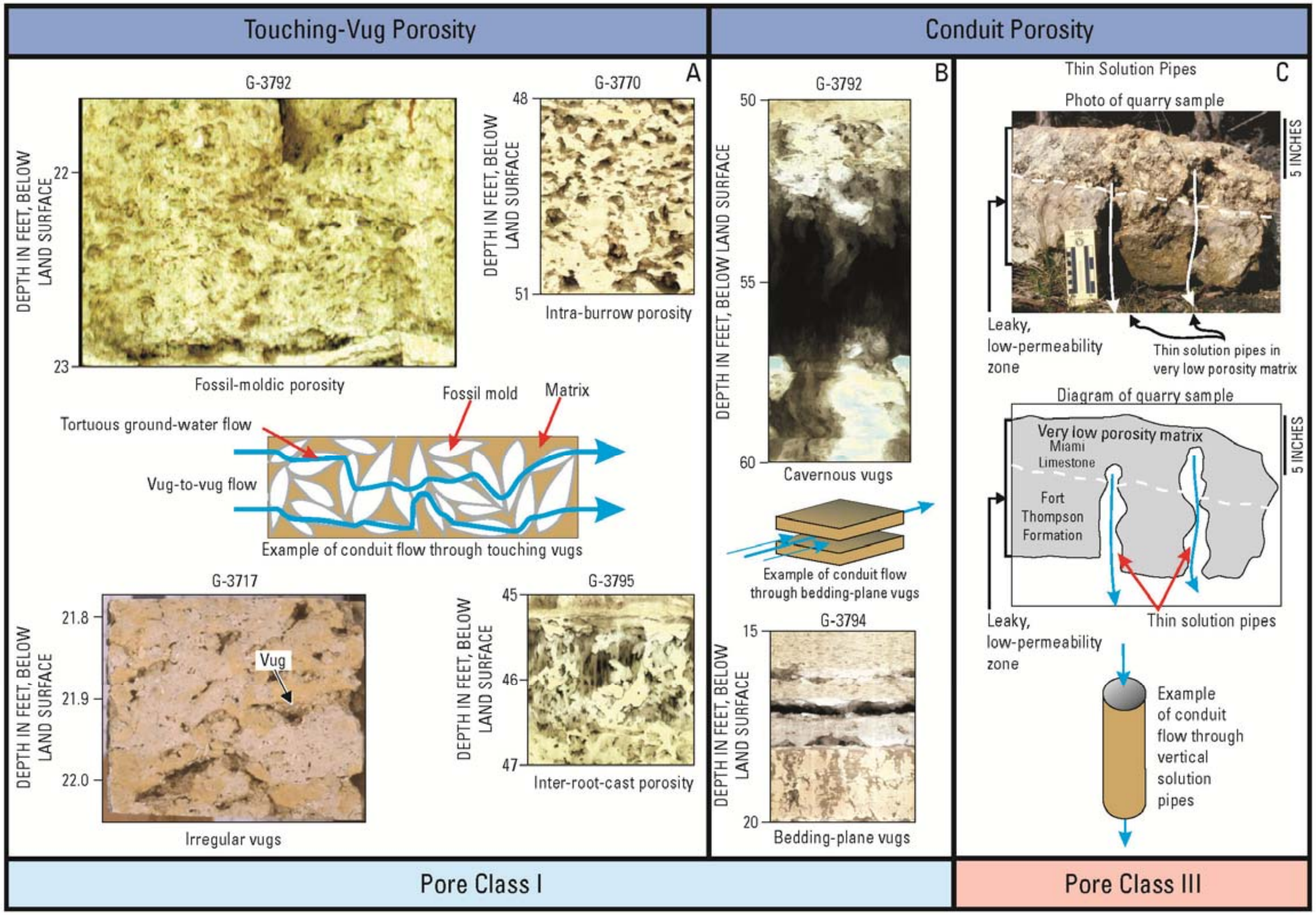


Shallow caves in the Biscayne aquifer (Cunningham and Florea, 2009)



Sinkholes of Miami-Dade County, Florida, 2008
Florida Center for Instructional Technology, *Sinkholes* (Tampa, FL: University of South Florida, 2008)
Downloaded from *Maps ETC*, on the web at http://etc.usf.edu/maps [map #f11144]

Site Vicinity Limestone Dissolution Features



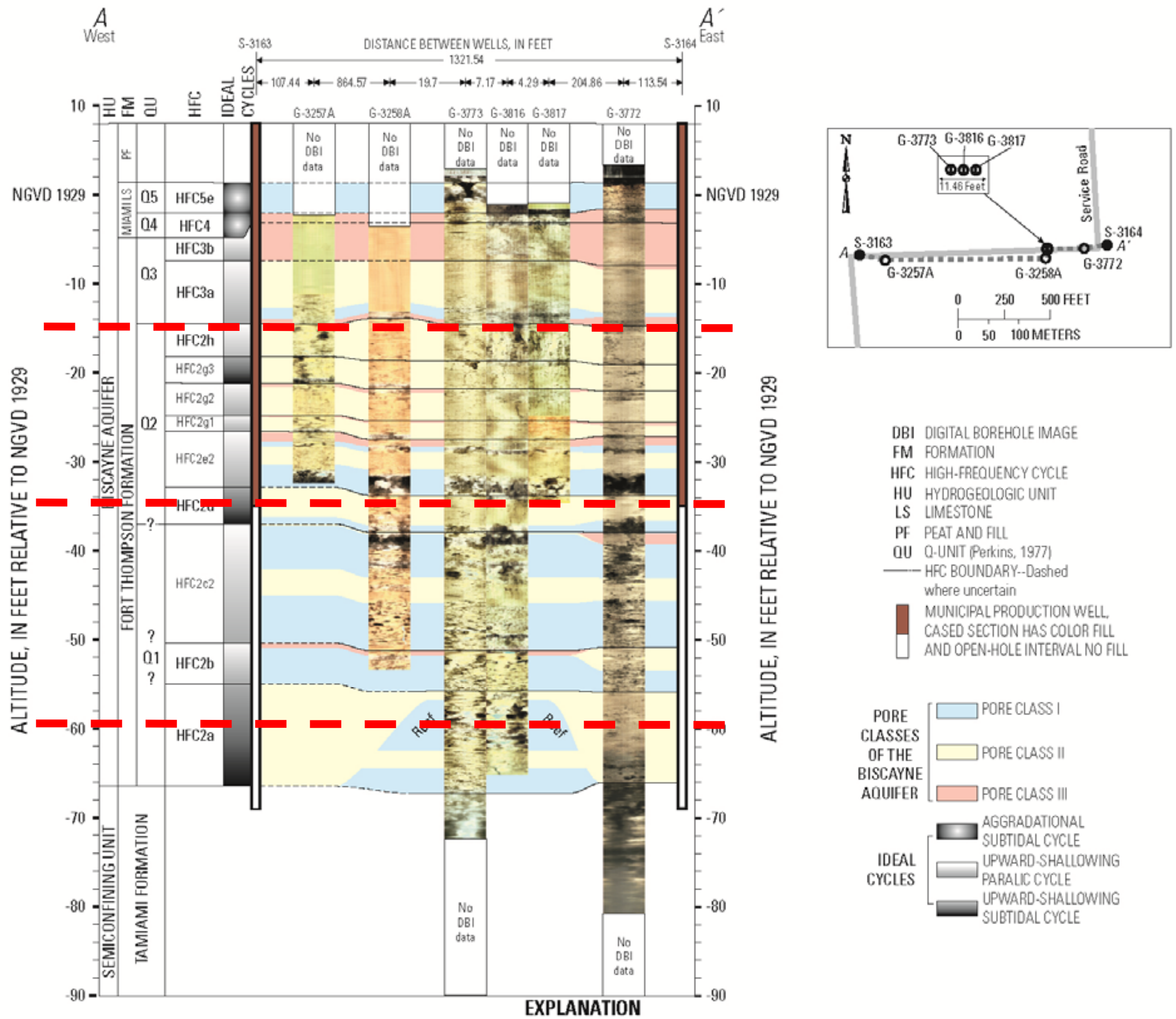
Examples of touching-vug and conduit porosity in the Miami Limestone and Fort Thompson Formation in the Biscayne aquifer (Cunningham et al., 2005)

Site Vicinity Limestone Dissolution Features

Concrete Fill

Base of Excavation

Grouted Limestone



Digital image logs showing vuggy porosity in the Miami Limestone and Fort Thompson Formation (Cunningham et al., 2005)

As a conservative measure FPL is committing to further geophysical surveys during construction

Assessment of Potential Cavities &/or Voids Beneath Safety Related Structures

- **Results from existing geophysical surveys**
- **Rod drops in the power block**
- **Path forward:**
  - Geophysical surveys during construction at bottom of the excavation

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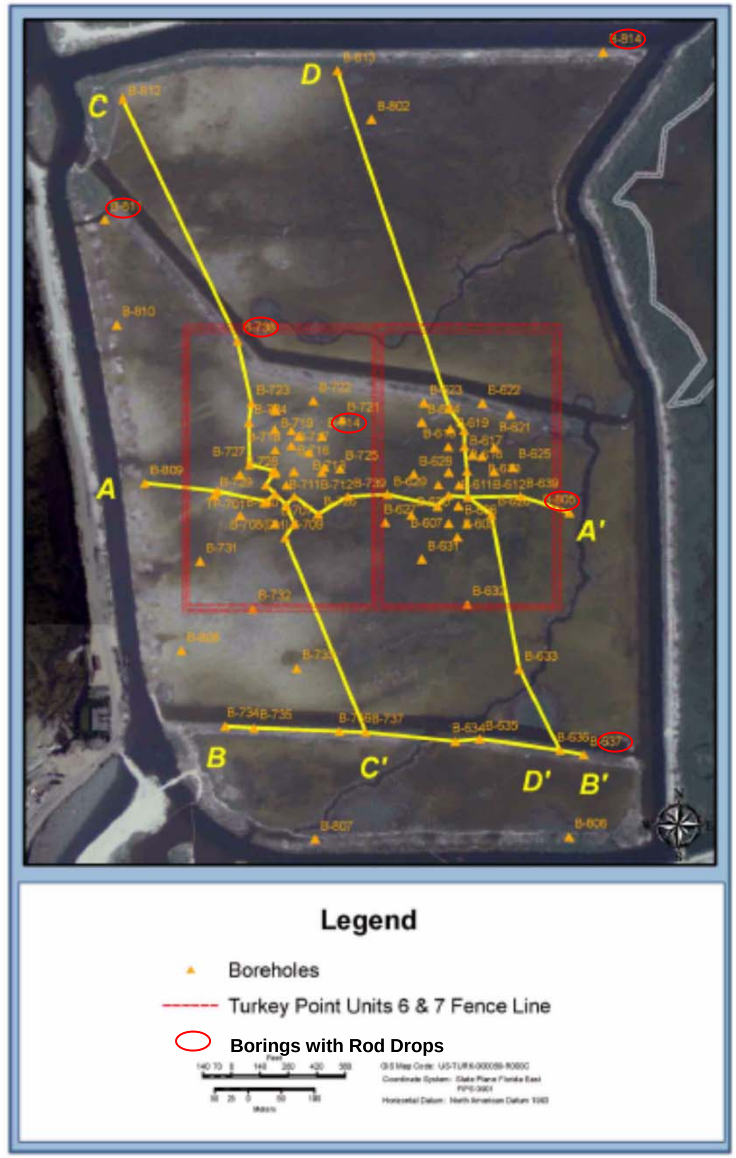
Potential Subsurface Limestone Dissolution Features

Boring ID	From	To	Rod Drop	Stratigraphic Unit
	(Depth, FT)		(Length, FT)	
B-637	28.6	30.6	2	Miami/Key Largo limestones
B-714	112	113	1	Fort Thompson Formation
B-738	71.9	74.5	2.6	Fort Thompson Formation
B-805	27	30	3	Miami/Key Largo limestones
B-811	61.3	65.3	4	Fort Thompson Formation
B-814	87.6	88.1	0.5	Fort Thompson Formation

Notes:

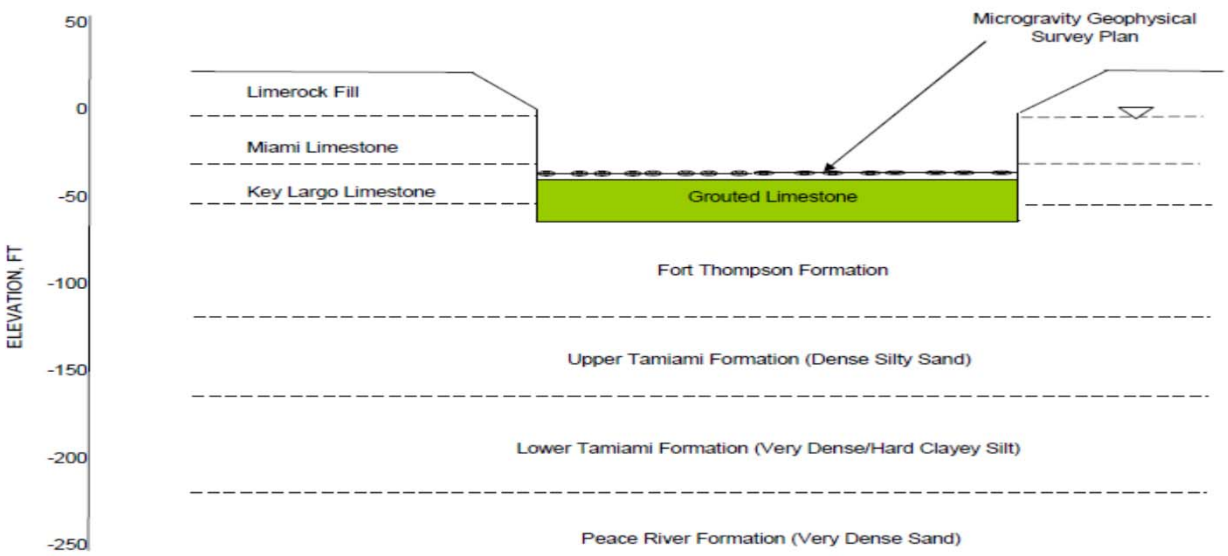
No rod drops in power blocks. B-714 is located in Annex Building footprint.



As a conservative measure, FPL is committing to further geophysical surveys during construction

Assessment of Potential Cavities &/or Voids Beneath Safety Related Structures

- **Locations of existing geophysical surveys**
- **Rod drops in the power block - none**
- **Path forward:**
  - Microgravity geophysical survey at base of the excavation



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Additional details will be provided in re-written RAI responses to enable reviewers to validate how variability and uncertainties were taken into account

Variability & Uncertainties in Key Geotechnical Engineering Properties

- **Field and Lab Data**
- **Site Strata Thickness**
- **Key Rock Properties**
- **Key Soil Properties**

Field and Lab Data

Number of Borings beneath Nuclear Islands (Two Units)

Site	No. of Borings	Total Depth Drilled, Ft	Depth Drilled, Ft		
			Avg.	Min.	Max.
Levy County	41	9,720	237	87	500
Turkey Point	22	4,860	221	150	615
Vogtle	12	2,774	231	150	420
VC Summer	13	2,563	197	150	351

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Field and Lab Data

Down-hole Geophysical Testing beneath Nuclear Islands (2 Units)
(including Suspension P-S Logging in each boring)

Site	No. of Borings	Total Depth Drilled, Ft	Depth Drilled, Ft		
			Avg.	Min.	Max.
Levy County	12	4,219	352	265	500
Turkey Point	8	2,415	302	164	615
Vogtle	6	1,570	262	250	420
VC Summer	4	1,131	283	215	351

Field and Lab Data

Unconfined Compression Testing and Unit Weight Measurements in Rock

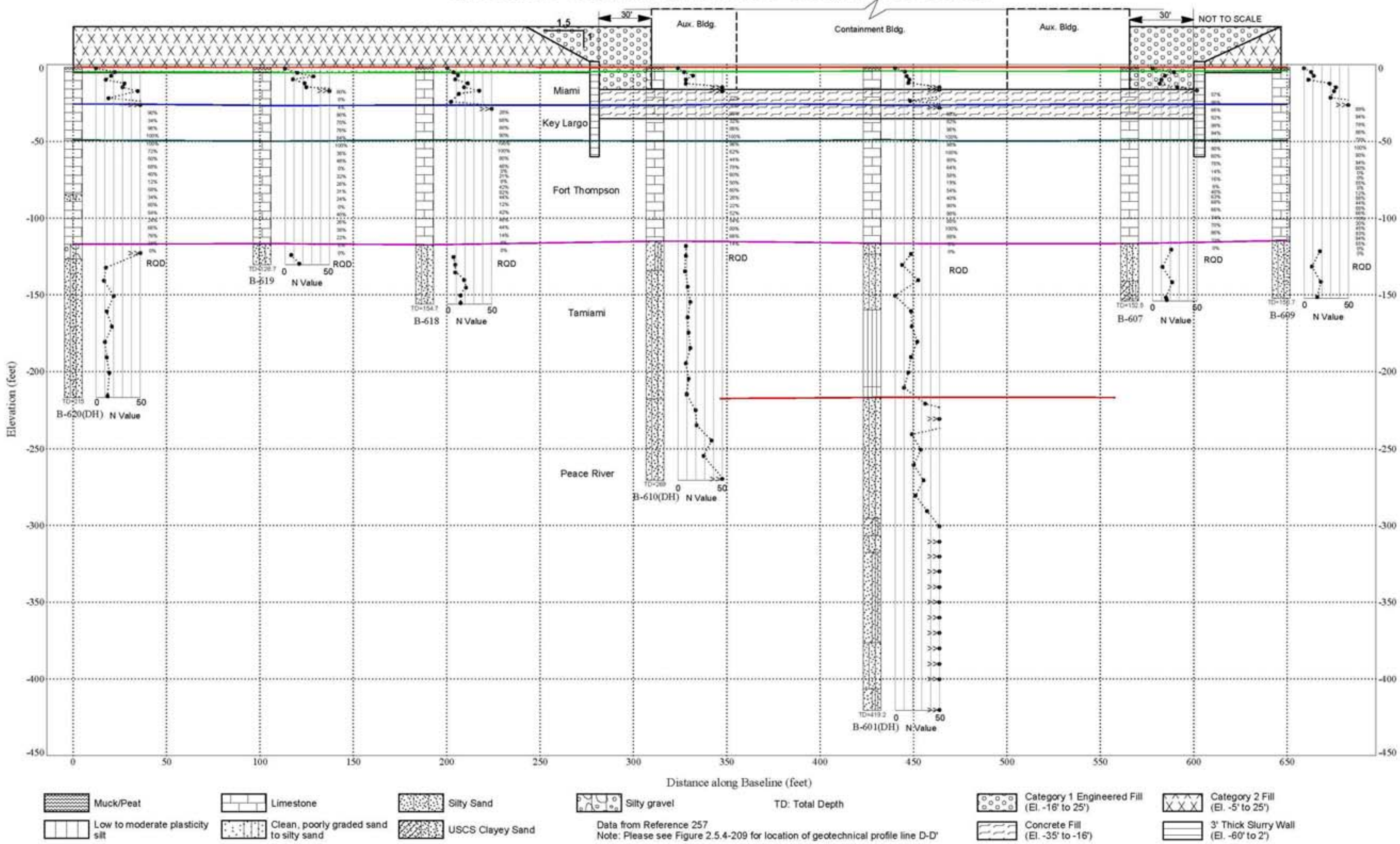
Site	Stratum	Thickness, Ft (approx.)	No. of Tests	
			Compression	Unit Weight
Levy County	Limestone	400	209	209
Turkey Point	Limestone	90	77	88
VC Summer	Granodiorite	300	95	97

Site Strata Thickness

PTN COL 2.5-1
PTN COL 2.5-5
PTN COL 2.5-6
PTN COL 2.5-7
PTN COL 2.5-10

Turkey Point Units 6 & 7
COL Application
Part 2 -- FSAR

Figure 2.5.4-203 Geotechnical Cross Section D-D' Through Unit 6 Power Block

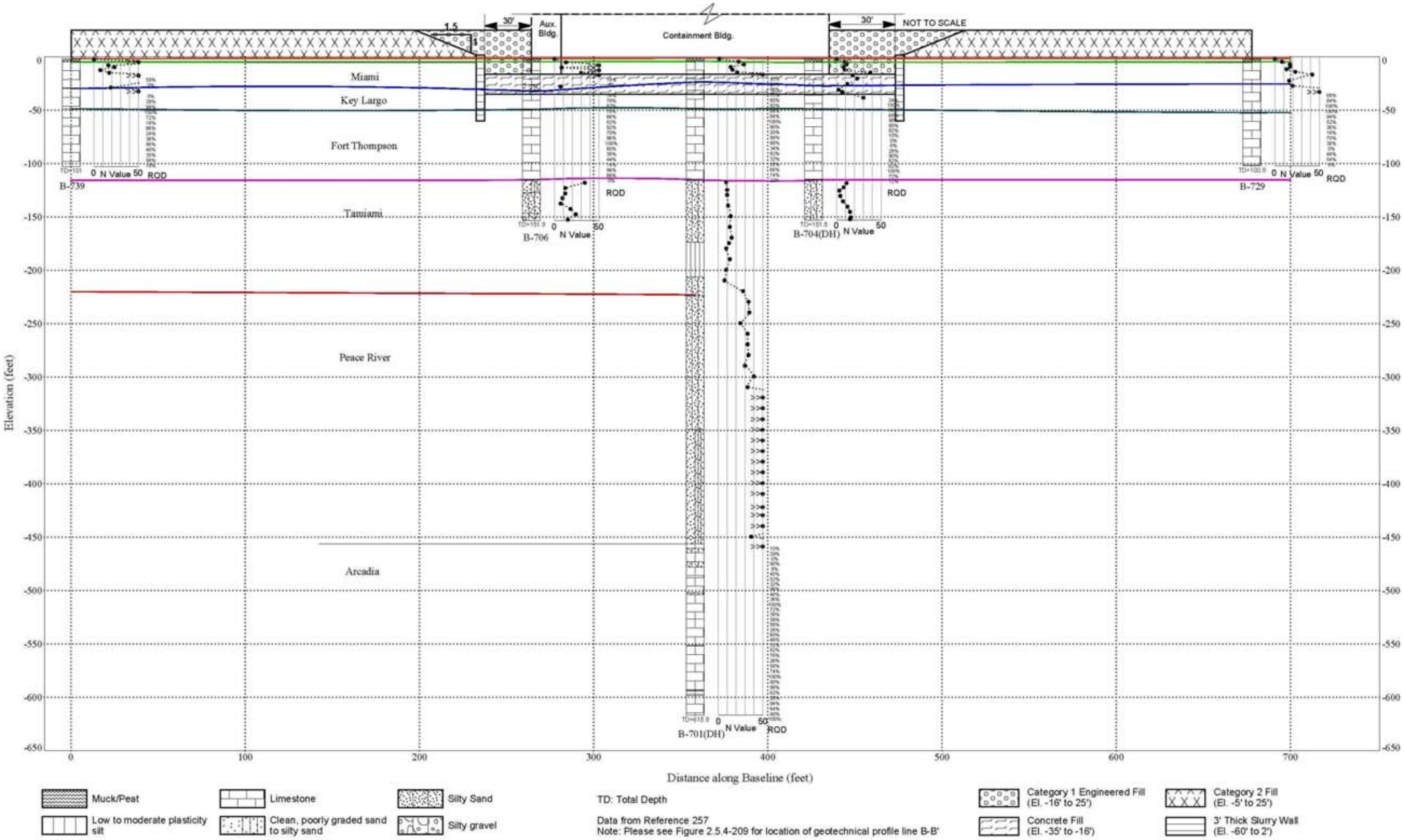


Site Strata Thickness

PTN COL 2.5-1
PTN COL 2.5-5
PTN COL 2.5-6
PTN COL 2.5-7
PTN COL 2.5-10

Turkey Point Units 6 & 7
COL Application
Part 2 -- FSAR

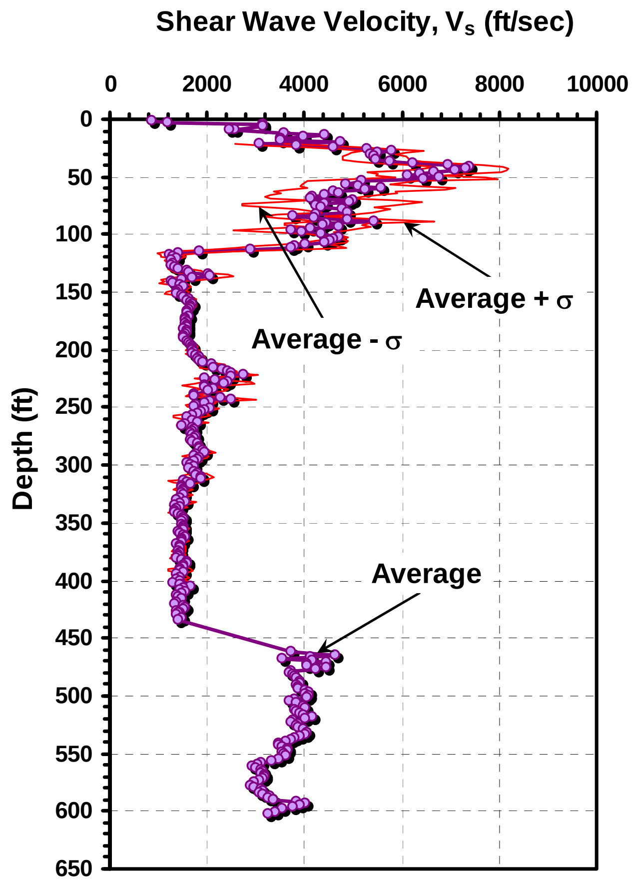
Figure 2.5.4-207 Geotechnical Cross Section B-B' Through Unit 7 Power Block

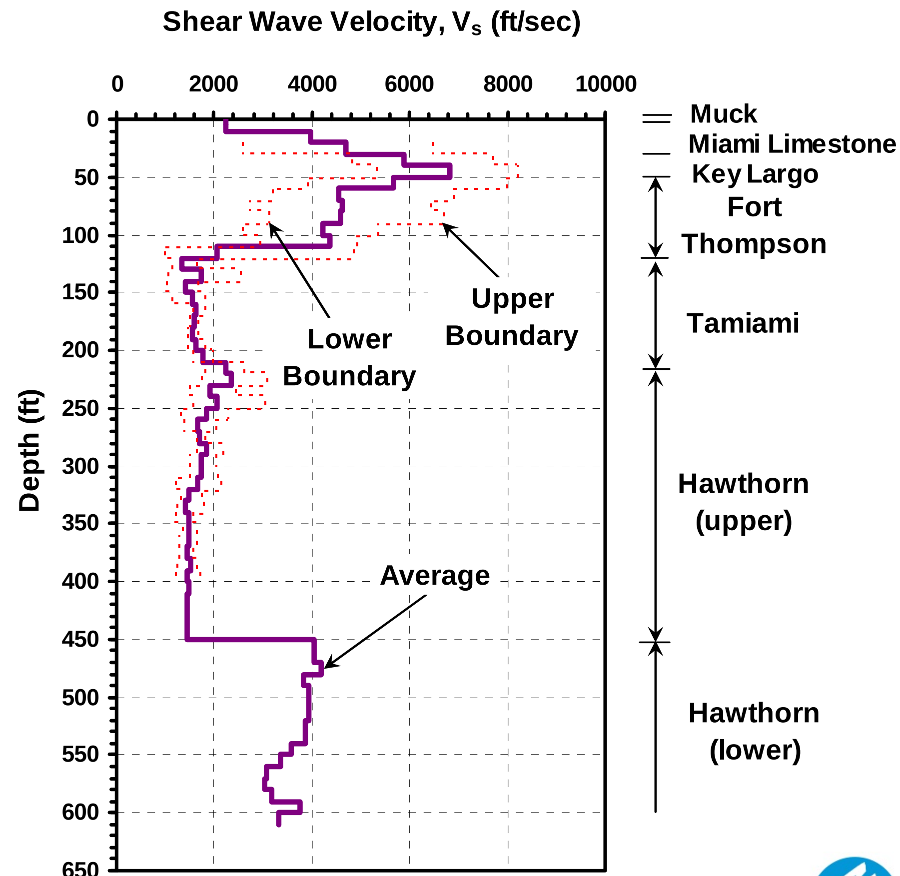


Key Rock Properties

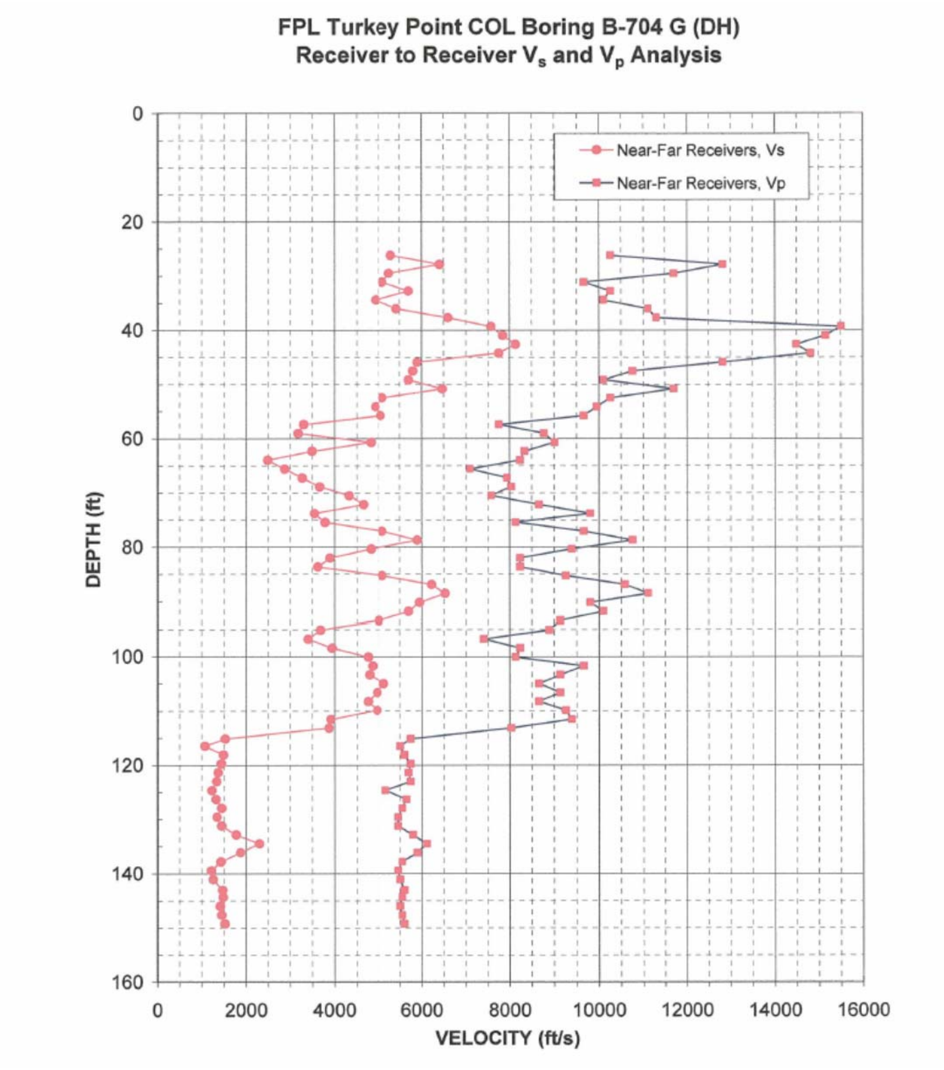
- Shear Wave Velocity, V_s
- Rock Quality Designation, RQD
- Unconfined Compressive Strength

Shear Wave Velocity, V_s

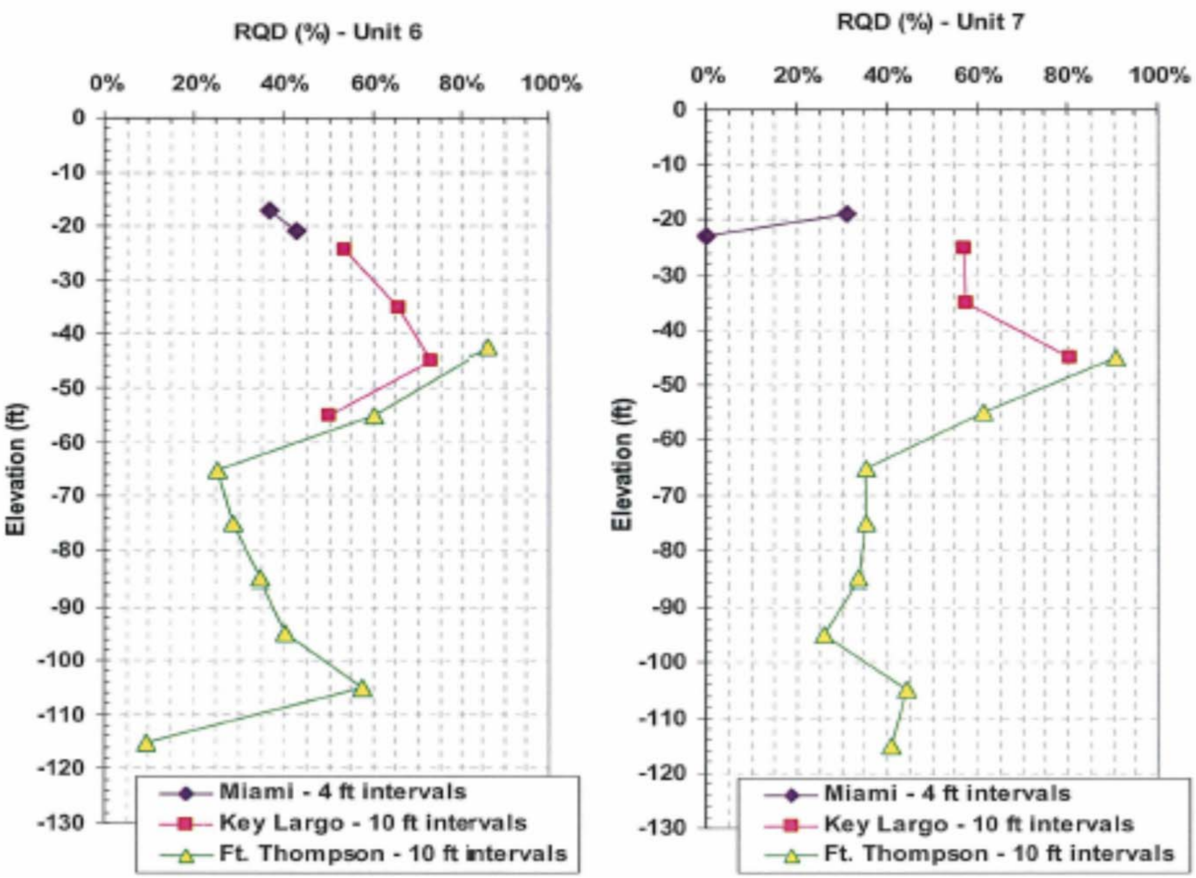




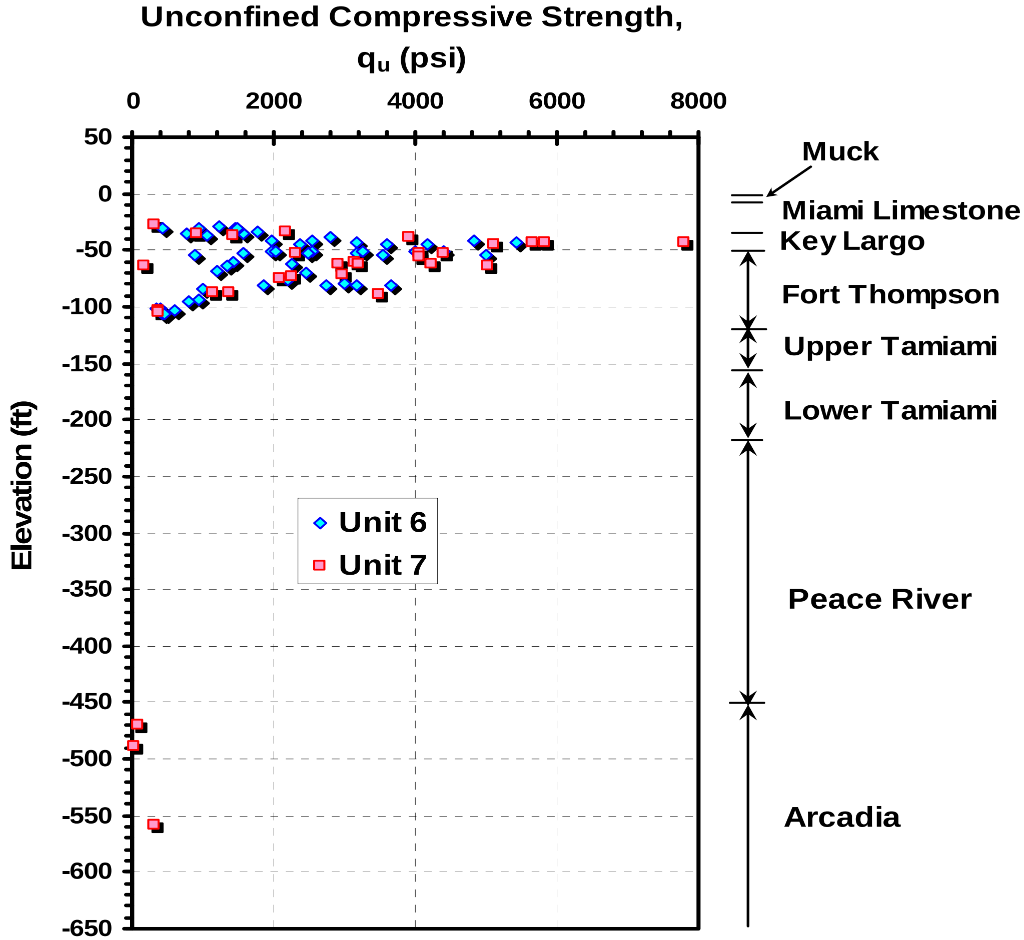
Shear Wave Velocity, V_s



Rock Quality Designation, RQD



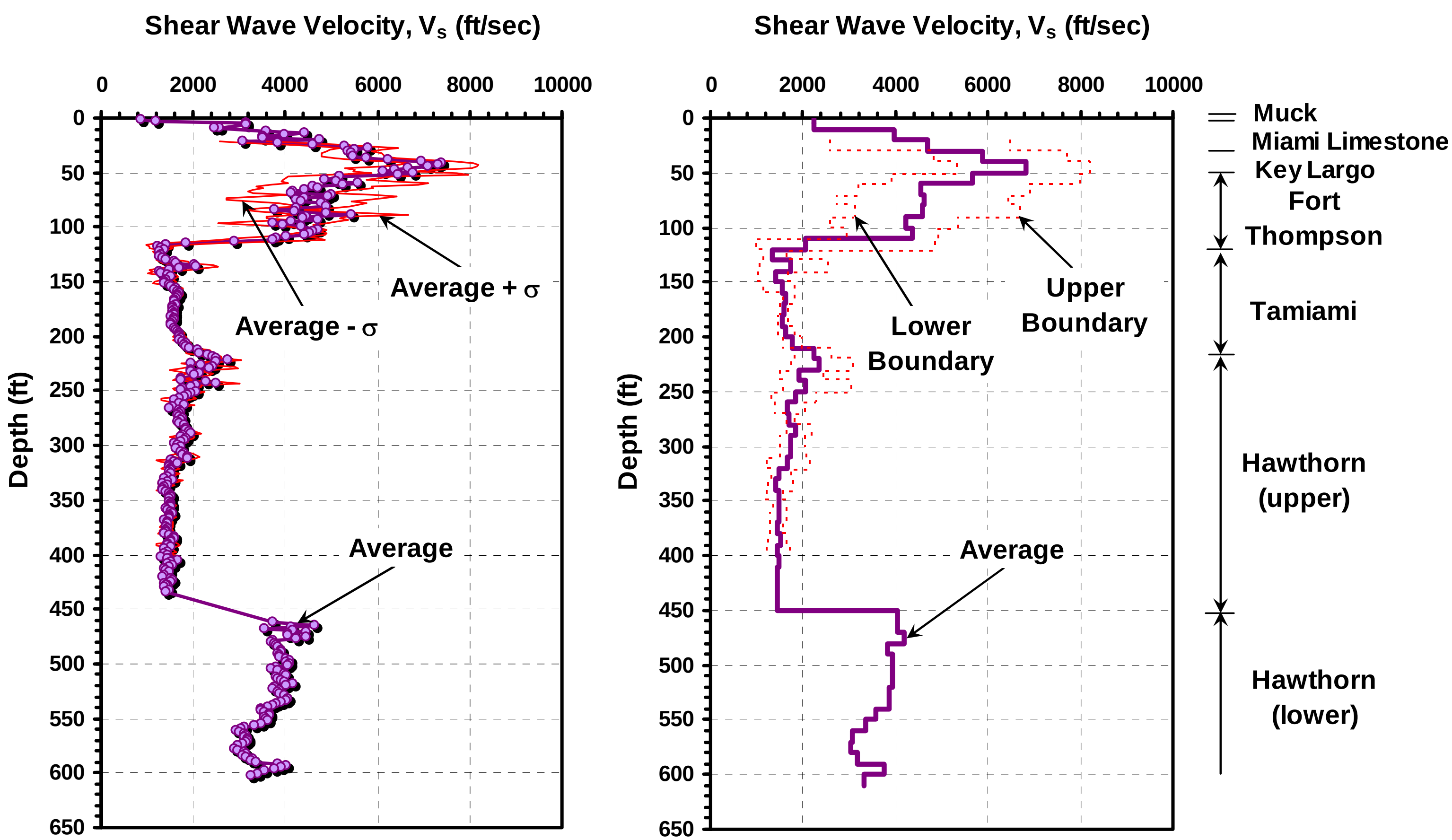
Unconfined Compressive Strength



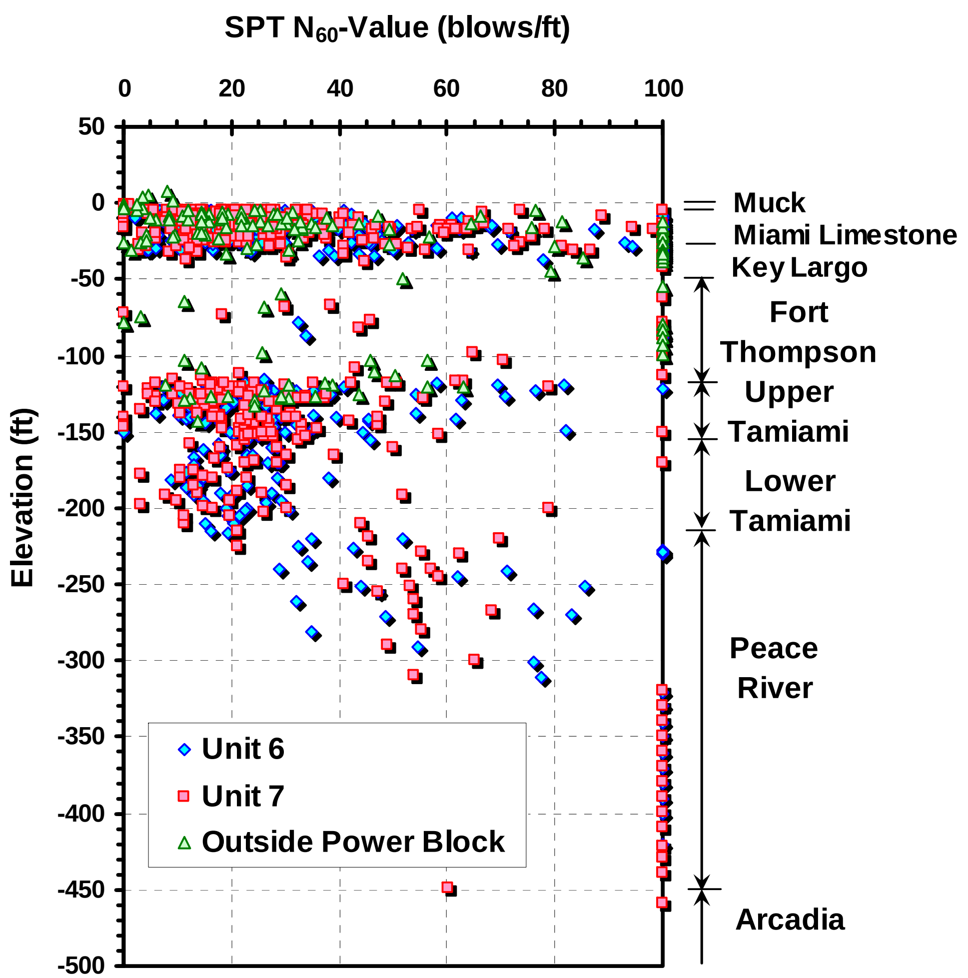
Key Soil Properties

- Shear Wave Velocity
- SPT/CPT Data
- Fines Content
- Angle of Internal Friction
- Undrained Shear Strength
- Shear Modulus and Damping Ratio with Strain

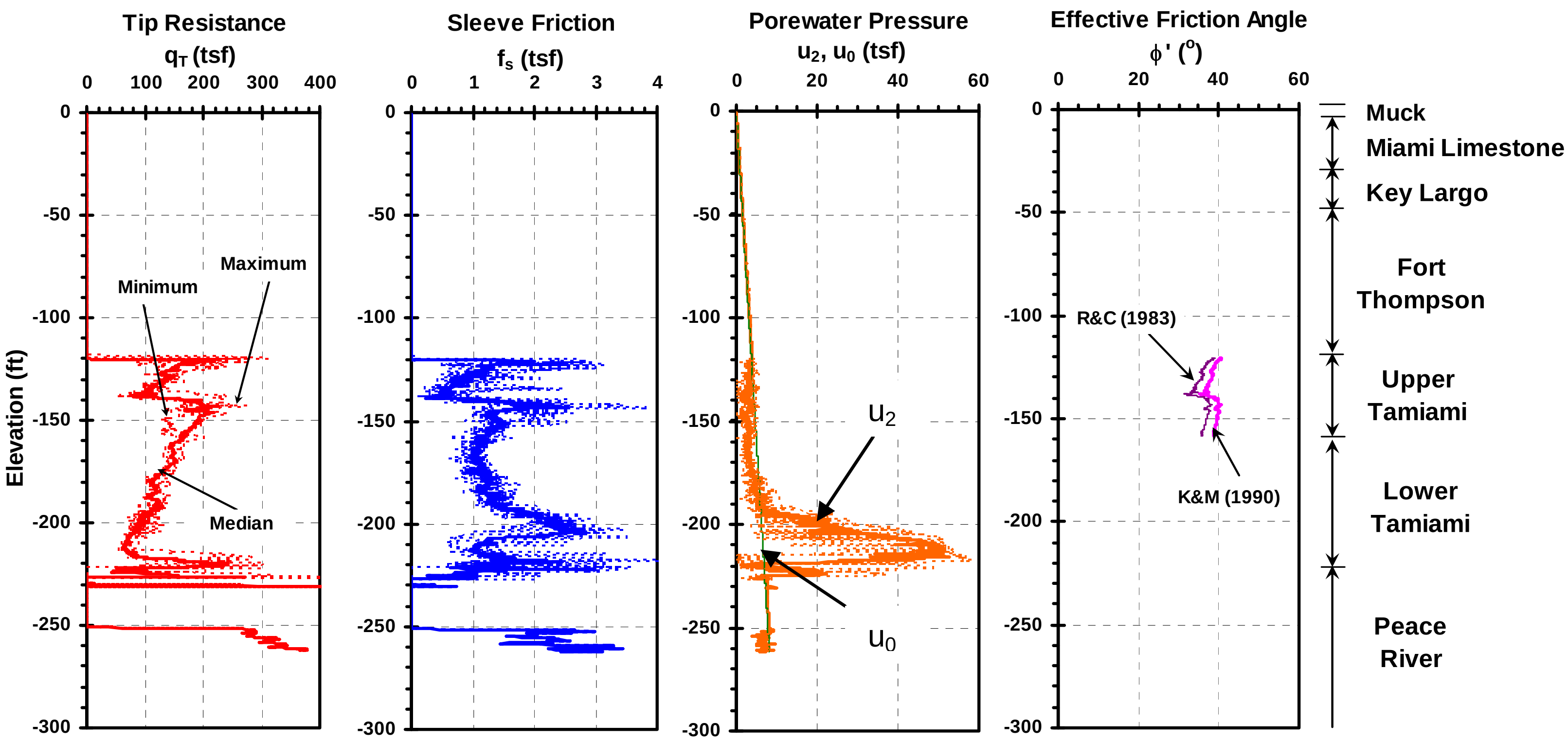
Shear Wave Velocity, V_s



SPT/CPT N-Value



SPT/CPT N-Value



SPT/CPT N-Value

Upper Tamiami

V_S = 1,400 ft/sec q_t = 160 tcf

N_{60} = 27 (average measured) N_{60} = 40 (adjusted based on V_S & q_t)

ϕ = 35 degrees

Lower Tamiami

V_S = 1,600 ft/sec q_t = 110 tcf

N_{60} = 23 (average measured) N_{60} = 32 (adjusted based on V_S & q_t)

c_u = 4 ksf

Peace River

N_{60} = 72 (average measured) N_{60} = 75 (best estimate)

ϕ = 40 degrees

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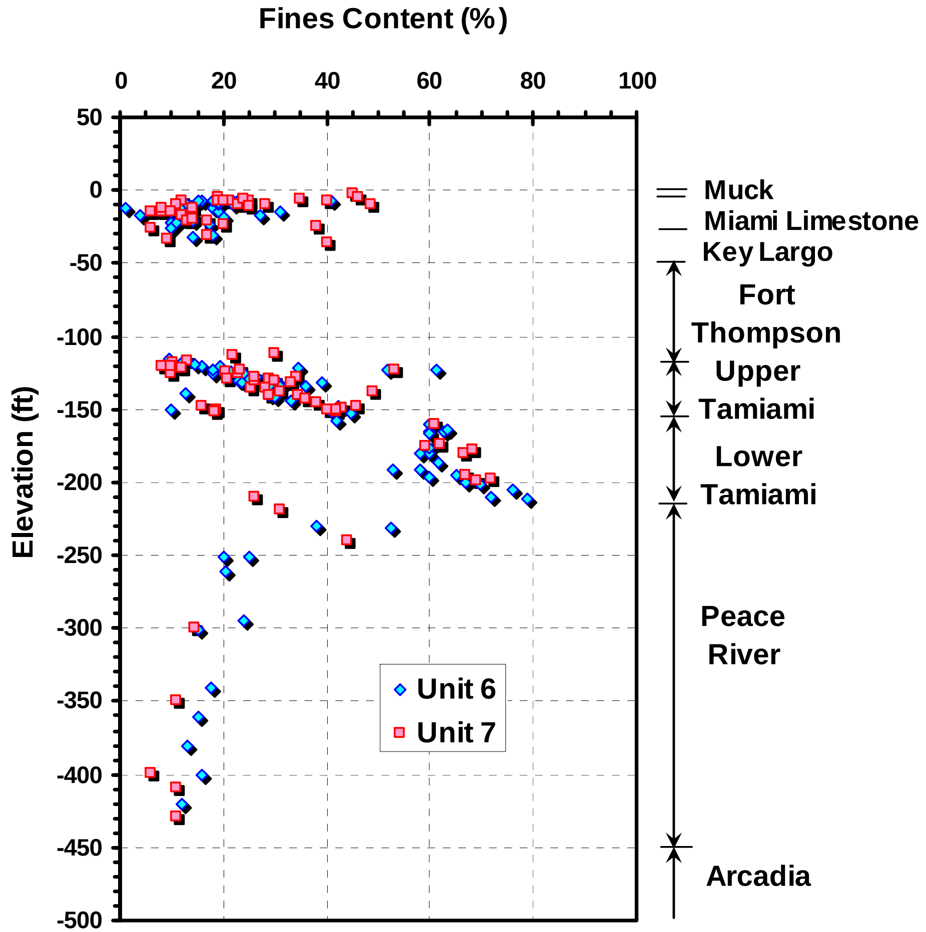
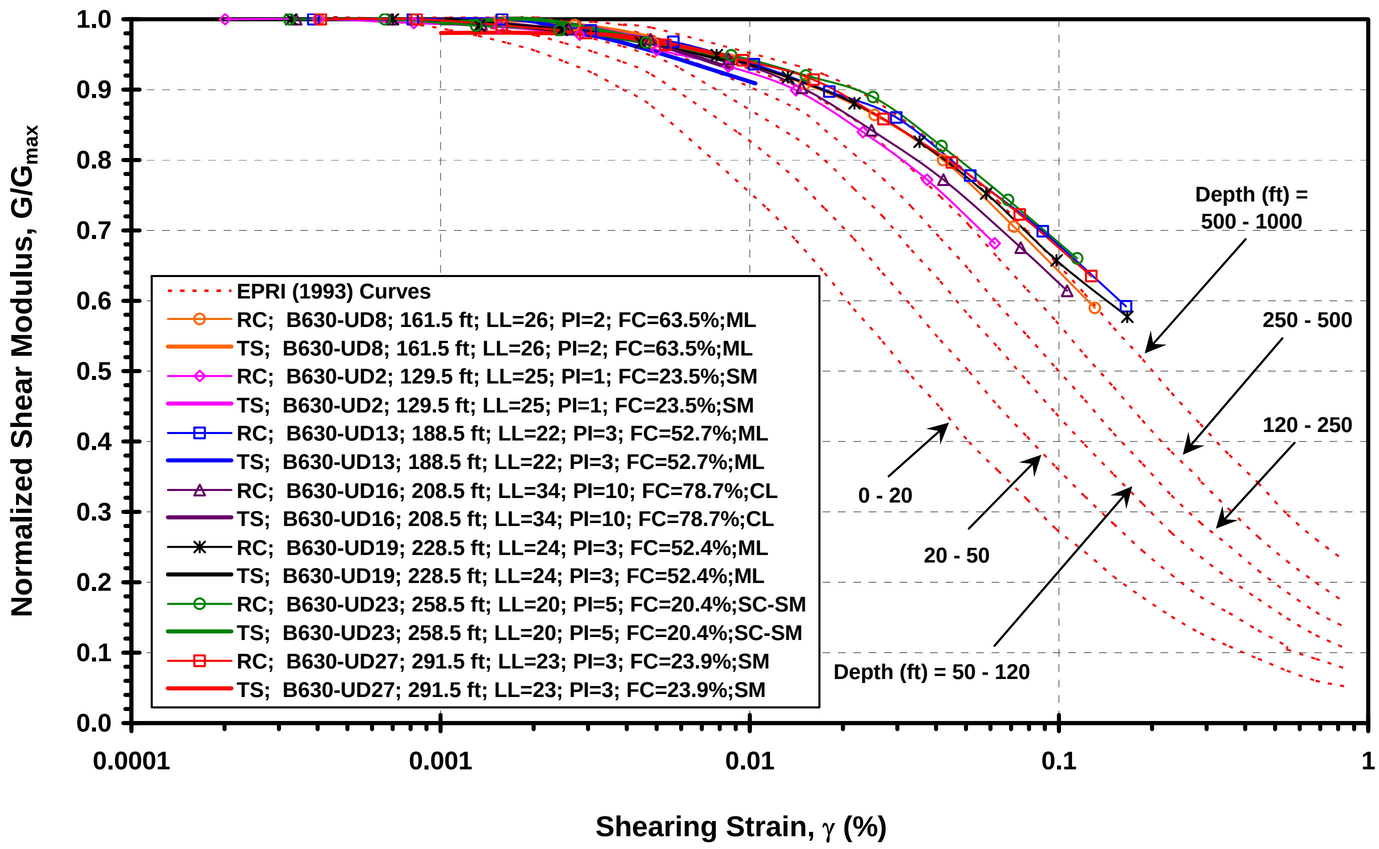
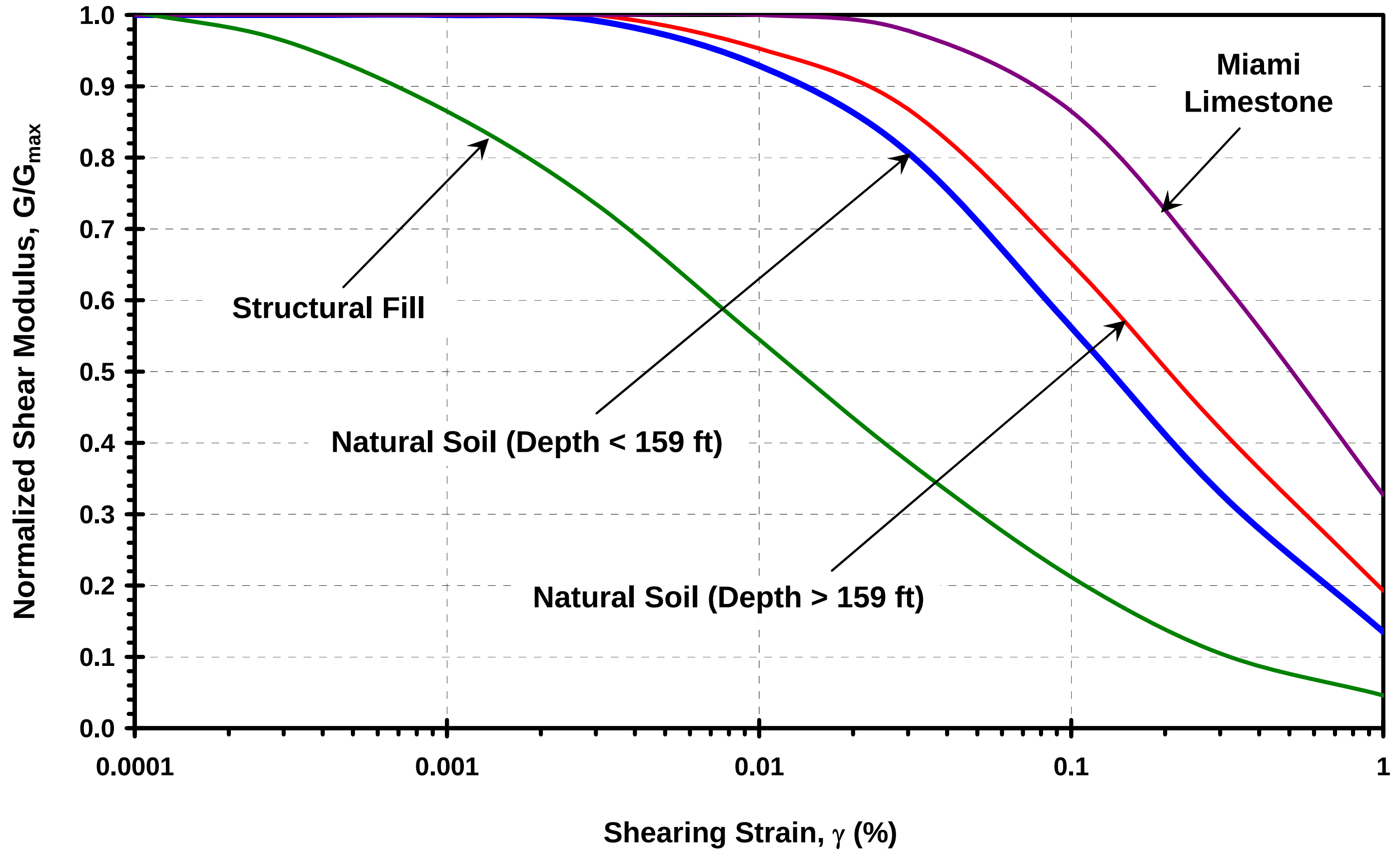
Fines Content



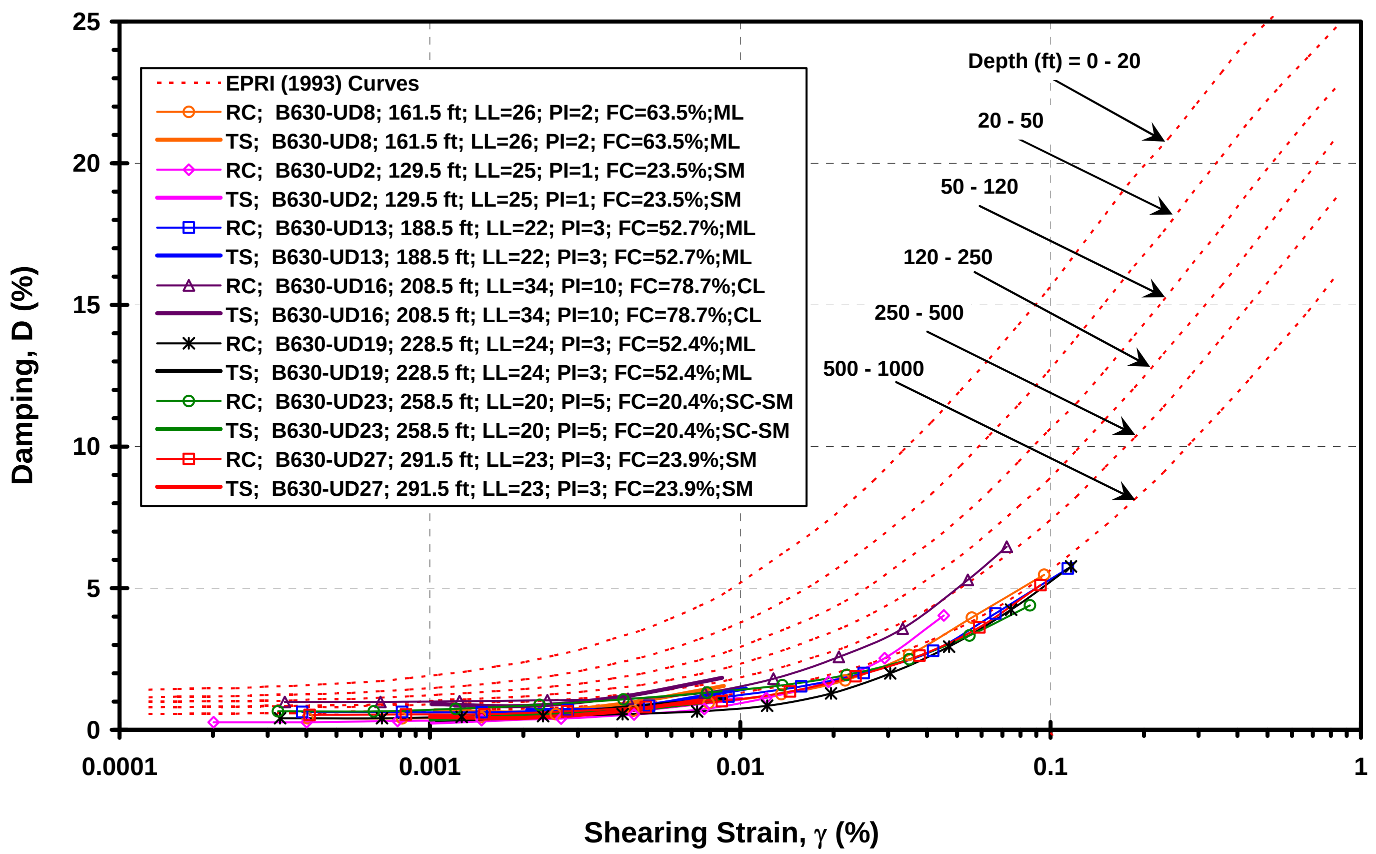
Shear Modulus and Damping Ratio with Strain



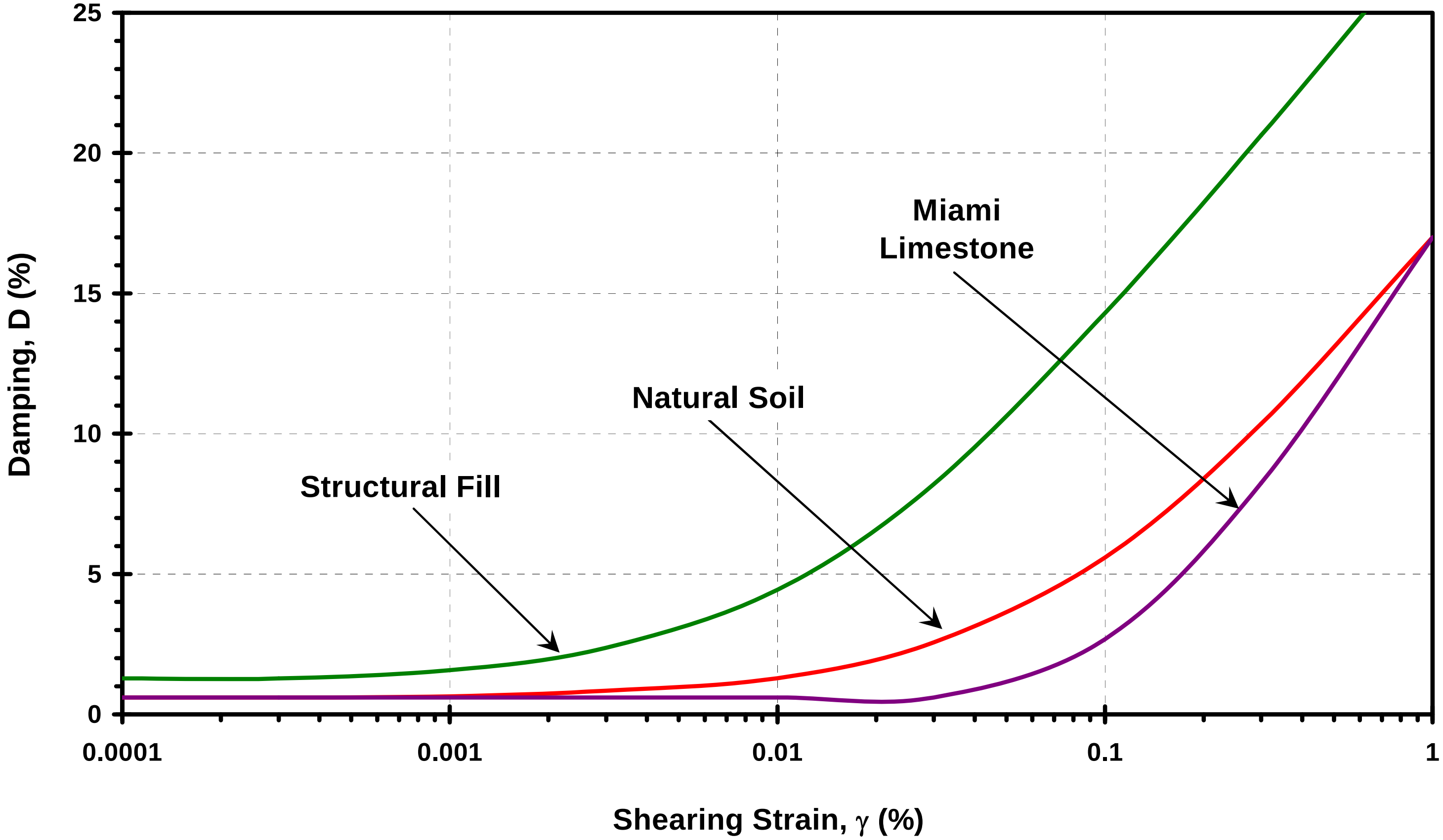
Shear Modulus and Damping Ratio with Strain



Shear Modulus and Damping Ratio with Strain



Shear Modulus and Damping Ratio with Strain

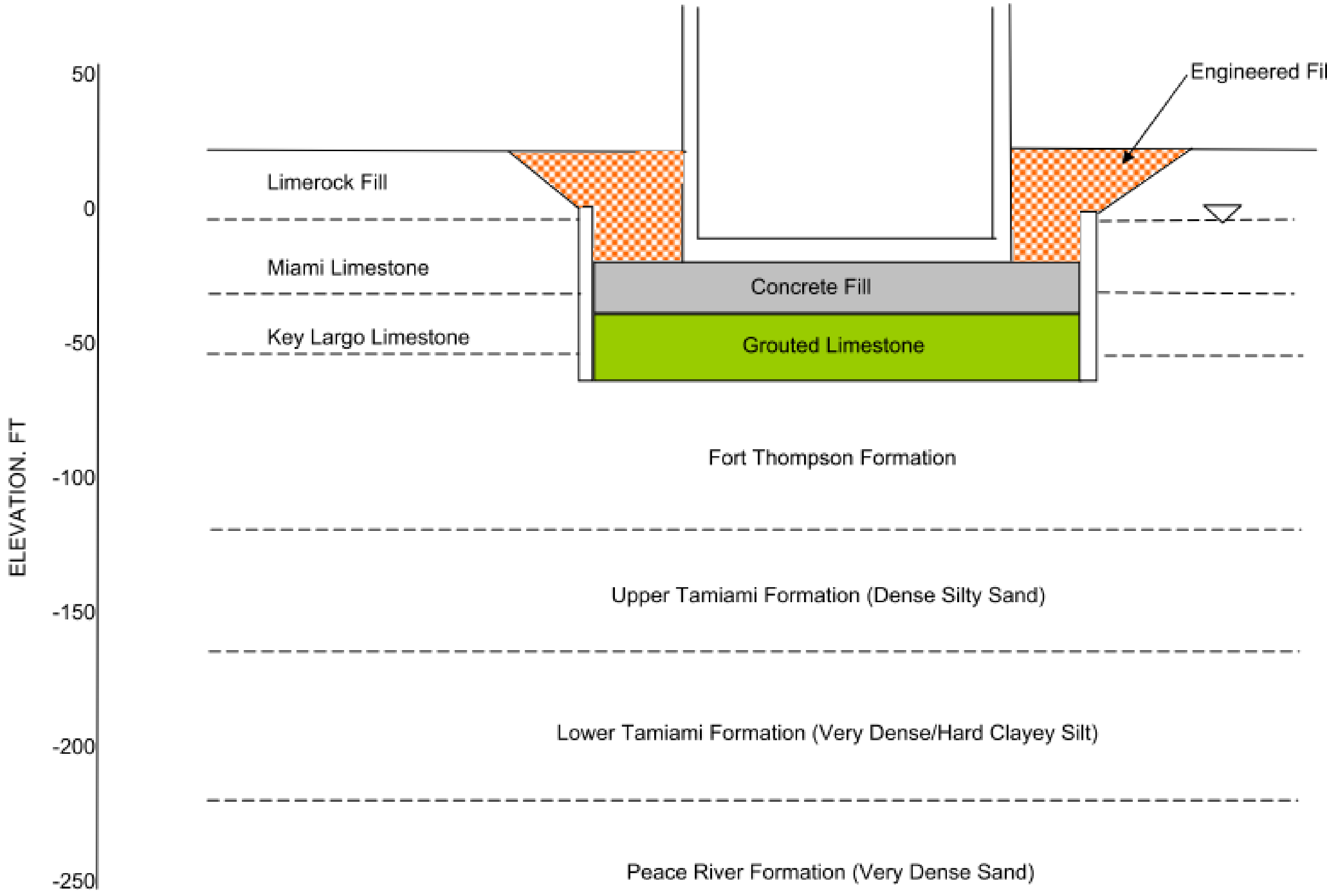


Additional information will be used to show that conservative inputs & assumptions were used in key safety analyses in the geotechnical areas

Key Inputs and Assumptions in the Safety Analysis for the Geotechnical Areas

- **Nuclear Island (NI) Foundation Geometry**
  - Average Width is about 125 Ft
- **Bearing Capacity**
- **Settlement**
- **Lateral Earth Pressure**

NI Foundation Geometry



Bearing Capacity (BC)

NI Design Bearing Pressure (DCD) = 8.9 ksf = 62 psi

Allowable BC of Concrete (ACI) = 0.595 x strength = 0.595 x 1,500 = 892 psi

Allowable BC of Rock (Code) = 0.20 x strength

= 0.20 x 1,500 = 300 psi (Key Largo)

= 0.20 x 2,000 = 400 psi (Ft Thompson)

Minimum Measured Strength in Key Largo (31 tests) = 309 psi at El. -27.5 ft

Allowable BC = 0.20 x 309 = 62 psi

Minimum Measured Strength in Ft Thompson (46 tests) = 172 psi at El. -63.3 ft

Allowable BC = 0.20 x 172 = 34.4 psi

Average bearing pressure at El. -63.3 ft = 52% of 62 psi = 32.2 psi

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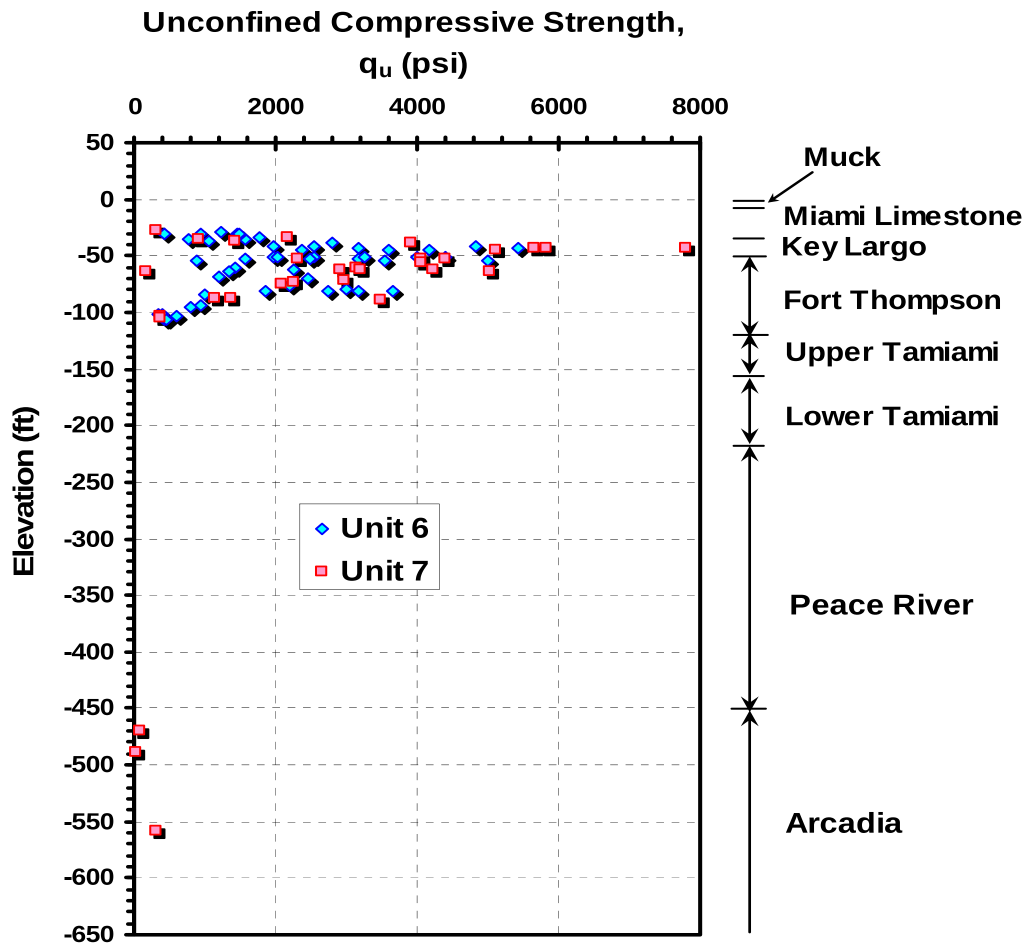
Bearing Capacity (BC)



Settlement

Based on NI Design Bearing Pressure = 8.9 ksf:

Estimated total settlement of concrete fill, Key Largo and Ft Thompson = 0.03 in.

Assume same modulus strain dependency as Miami Limestone, settlement = 0.05 in.

Based on high strain value (0.25% to 0.5%). Actual strain = 0.005%.

At this strain there is no reduction in modulus and thus settlement = 0.03 in.

Estimated total settlement of Tamiami and Peace River Formations = 2.6 in.

Based on Boussinesq distribution with $E_{rock}/E_{soil} = 1$

Actual E_{rock}/E_{soil} (low strain) = 11

From Burmister figure, applied stress on soil is < half using the Boussinesq distribution.

Thus, estimated settlement of soil is conservative.

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Settlement

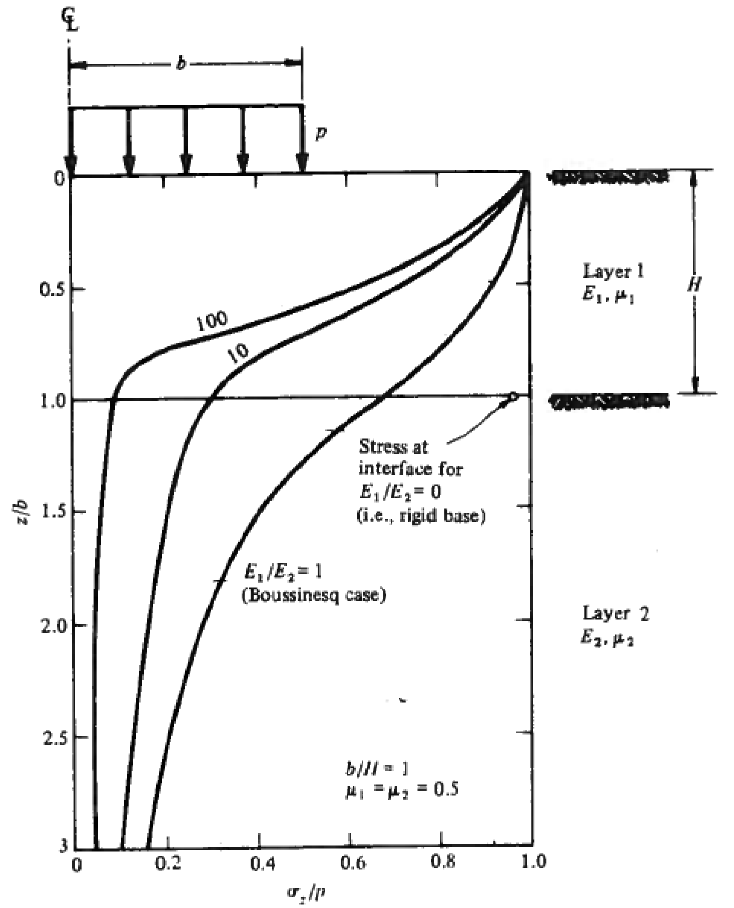
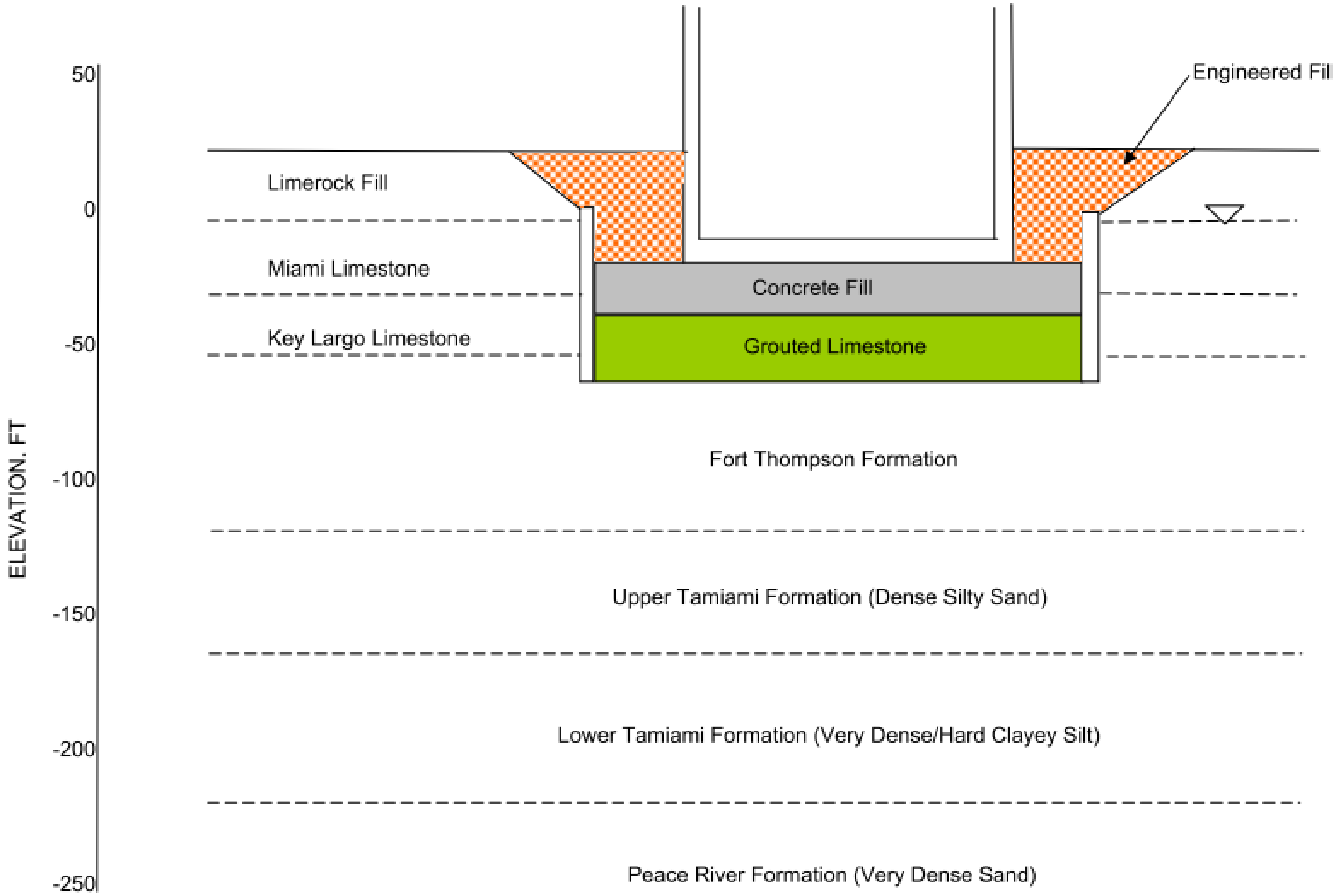


Fig. 4.30 Vertical normal stress beneath center of uniformly loaded circular area at surface of two-layer elastic system. (*Modified from Burmister, 1958.*)

Lateral Earth Pressure



Lateral Earth Pressure

Coefficient of sliding of NI foundation mat on concrete fill = 0.7

Coefficient of sliding of concrete fill on Key Largo Limestone mat on concrete fill = 0.7

Thus, it would take a lateral force of > 0.7g to move the NI

Maximum seismic acceleration (pga) < 0.1g.

Thus, a factor of safety (FS) >7 against sliding due to seismic force.

Agenda

- Summary of Significant Technical Changes
- FPL's Technical Approach & Resolution of Key Issues
- **Meeting Summary & Path Forward**