FPL

L-2011-525
10 CFR 52.3

December 5, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555-0001

Re: Florida Power & Light Company
Proposed Turkey Point Units 6 and 7
Docket Nos. 52-040 and 52-041
Response to NRC Request for Additional Information Letter No. 041
(eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information

Reference:

1. NRC Letter to FPL dated October 20, 2011, Request for Additional Information Letter No.041 Related to SRP Section 02.05.01 - Basic Geologic and Seismic Information for the Turkey Point Nuclear Plant Units 6 and 7 Combined License Application
2. FPL Letter to NRC dated November 18, 2011, Response and Response Schedule to NRC Request for Additional Information Letter No. 041 (eRAI 6024) SRP Section: 02.05.01 - Basic Geologic and Seismic Information

Florida Power & Light Company (FPL) provides, as attachments to this letter, its responses to the Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) 02.05.01-4, and 02.05.01-22 provided in Reference 1. FPL provided a schedule for the responses to RAI 02.05.01-4, and RAI 02.05.01-22 in Reference 2. The attachment identifies changes that will be made in a future revision of the Turkey Point Units 6 and 7 Combined License Application (if applicable).

If you have any questions, or need additional information, please contact me at 561-691-7490.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on December 5, 2011

Sincerely,

William Maher
Senior Licensing Director – New Nuclear Projects

WDM/RFB

D097
NRO

Attachment 1: FPL Response to NRC RAI No. 02.05.01-4 (eRAI 6024)
Attachment 2: FPL Response to NRC RAI No. 02.05.01-22 (eRAI 6024)

cc:
PTN 6 & 7 Project Manager, AP1000 Projects Branch 1, USNRC DNRL/NRO
Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant 3 & 4

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-4 (eRAI 6024)

FSAR Table 2.5.1-203 "Florida's Marine Terraces, Elevations, and Probable Ages" depict a characterization of nine marine terraces in Florida, however, the staff notes, that the source of this data is 40 years old.

In order for the staff to determine if the information presented in the FSAR represents an up-to-date and accurate characterization of the regional and local geomorphology and in support of 10 CFR 100.23 please address the following: Incorporate information from more recently-published references (such as those cited in Muhs et al., 2011[a]).

[a] Muhs, D.R., et al., 2011, Sea-level history of the past two interglacial periods: New evidence from U-series dating of reef corals from south Florida: Quaternary Science Reviews, doi:10.1016/j.quascirev.2010.12.019

FPL RESPONSE:

As shown on FSAR Figure 2.5.1-220 and in FSAR Table 2.5.1-203, eight marine terraces (Hazelhurst, Coharie, Sunderland, Wicomico, Penholoway, Talbot, Pamlico, and Silver Bluff) are mapped across the state of Florida. The ninth terrace, "Princess Anne" shown in Table 2.5.1-203, is not identified in Florida but is included in the table as it is the ninth terrace cited by Ward et al. (FSAR Reference 260) and included in the discussion in FSAR Subsection 2.5.1.1.1.1.1.1 on age-dating of the terraces in South Carolina. Ward et al. (FSAR Reference 260) indicate that the marine terraces generally correlate with global high sea levels and are Pleistocene in age; the youngest being the Silver Bluff terrace approximately 0.043 Ma and the oldest being the Hazelhurst terrace between 1.66 and 1.98 Ma. The elevations of these terraces range from 1 to 10 feet mean sea level (MSL) for the Silver Bluff terrace and from 215-320 feet MSL for the Hazelhurst terrace, as shown in FSAR Table 2.5.1-203.

Bryan et al. (FSAR Reference 271) identify eight relict terraces in Florida and attribute their formation to rising and falling sea levels. The Silver Bluff terrace, according to Bryan et al. (FSAR Reference 271), was previously referred to as the Princess Anne terrace, and the oldest three terraces are cited as being Pliocene and Miocene in age rather than Pleistocene in age as cited by Ward et al. (FSAR Reference 260). The elevations of the terraces are consistent with the elevations cited by Ward et al. (FSAR Reference 260). According to Schmidt (FSAR Reference 266), Healy (FSAR Reference 261) provides the most recent attempt at statewide correlation of the terraces and depicts the eight terrace intervals on a state map, a modified version of which is shown on FSAR Figure 2.5.1-220. Elevation-zone mapping enabled Healy (FSAR Reference 261) to identify the eight terraces, which according to him represent periods of deposition and sediment reworking during high sea level stands. The terraces are described as Pleistocene in age and the elevations of the terraces are generally consistent with the elevations presented by Ward et al. (FSAR Reference 260).

While there appears to be consistency with respect to the ages and elevations assigned to Florida's eight marine terraces (FSAR References 260, 261, 266 and 271) there remains some debate regarding the appropriate methodology for age estimation of marine terraces in general and hence their formation. According to Schmidt (FSAR Reference 266), numerous methods have been used to delineate Florida's marine terraces, each one providing more information on the development of these landforms. Such methods include correlation of topographic and physiographic maps to identify areas with common elevations (elevation-zone mapping), analysis of stratigraphic, lithologic and granulometric evidence to distinguish marine terraces from deltaic, fluvial or terrestrial sediments and some researchers have used fossils and mapped soil types or drainage patterns and botanical assemblages to date the various terraces surfaces. For example Ward et al. (FSAR Reference 260) correlate the heights of stranded shorelines in Gippsland, Australia to others in South Carolina and based on the differences in altitude of the shorelines calculates absolute ages for the former high sea levels, i.e. the marine terrace intervals (Table 2.5.1-203). Age estimation of marine terraces by one or more of the methods described above, led Ward et al. (FSAR Reference 260) and other early researchers to hypothesize that marine terraces typically develop when rising sea level reaches highstand for a prolonged period. A recent paper by Speed and Cheng (2004) disputes this hypothesis and presents new information that supports the evolution of terrace development by erosion and deposition through the entire eustatic cycle not only during highstands.

Speed and Cheng (2004), as cited from Muhs et al. (2011), investigate the uplifted marine terrace at Cave Hill, Barbados, and present a new model of terrace evolution that contrasts with earlier hypotheses of marine terrace evolution and indeed earlier Barbarian terrace models. Early studies of the Barbarian terraces present models of terrace development that equate terraces with narrow belts of *A. palmata,* the principal shallow-water reef-framework coral of the Caribbean. The belts are interpreted as crests of coast-parallel, ridged barrier-like reefs that had grown up from a deep to shallow seafloor when rising sea level reached highstand for a long period. This "Mesolella model", after Mesolella et al. (1969 and 1970), therefore follows the principle that reef development occurs during high sea levels by catch-up growth. The Speed and Cheng (2004) model however, is based on the premise that fully zoned reefs respond directly to sea level rise producing a keep-up response as opposed to a catch-up response. Speed and Cheng (2004) base their model on the last interglacial Rendezvous Hill terrace at Cave Hill, Barbados because it contains a new roadcut that cuts deeply across the seaward half of the Rendezvous Hill terrace. This roadcut exposes the terrace floor and a basal fringe reef composed of *A. palmata* clasts, in place head corals, and *A. cervicornis* rising laterally upslope beneath a thick reef-front unit of *A. cervicornis*. This basal unit is interpreted by Speed and Cheng (2004) to be a low-energy fringe reef, which kept up with sea level rise and produced a retrogressive and diachronous layer that was progressively buried by an *A. cervicornis* facies forming seaward in deeper water. Hence the reefs did not progress from deep-water into shallow-water communities as they caught up with sea level, but initiated as fully zoned reefs that responded directly to sea level rise producing a clear keep-up response (Blanchon, 2011).

Speed and Cheng's (2004) new model of terrace evolution pertaining only to carbonate islands, for example the island of Barbados, is based on an island-wide study of the geomorphology, stratigraphy, structure of the limestone cap upon which the terraces are preserved and new and existing mass spectrometric ^{230}Th coral dates. The model provides an improved understanding of surficial processes during the emergence of uplifting coral coasts and of global sea level changes in the last interglacial and insight on the previously accepted hypothesis that terrace development occurs during eustatic highstand.

However, the Speed and Cheng (2004) model pertains only to carbonate islands. Other references cited in Muhs et al (2011) do not discuss marine terraces on mainland Florida. The information currently in FSAR Subsection 02.05.01 is consistent with Speed and Cheng (2004).

This response is PLANT SPECIFIC.

References:

Blanchon, P., Last Interglacial and Reef Development. In: Hopley, D. (Ed), Encyclopedia of Modern Coral Reefs: Structure, form and process. Springer-Verlag Earth Science Series, p. 621-639, 2011.

Mesolella, K. J., Matthews, R. K., Broecker, W. S., and Thurber, D. L., The astronomical theory of climatic change: Barbados data. Journal of Geology, v. 77, p. 250–274, 1969.

Mesolella, K. J., Sealy, H. A., and Matthews, R. K., Facies geometries within Pleistocene reefs of Barbados, West Indies. American Association of Petroleum Geologists Bulletin, v. 54,
p. 1899–1917, 1970.

Muhs, D.R., Simmons, K.R., Schumann, R.R., and Halley, R. B., "Sea-level history of the past two interglacial periods: new evidence from U-series dating of reef corals from south Florida," Quaternary Science Reviews, v. 30, pp. 570-590, 2011.

Speed, R.C. and Cheng, H., Evolution of marine terraces and sea level in the last interglacial, Cave Hill, Barbados, Geological Society of America Bulletin, v. 116, no. 1, p. 219-232, 2004.

ASSOCIATED COLA REVISIONS:

Table 2.5.1-203 will be updated in a future revision of the FSAR as follows.

Table 2.5.1-203
Florida's Marine Terraces, Elevations, and Probable Ages

Terrace Name	Elevation Range (feet above MSL)	Notes	Probable Age[a]
Silver Bluff	1-10	—	0.043 Ma
Princess Anne[c]	10-20	—	0.064 Ma
Pamlico	10-25	—	0.095 – 0.145 Ma
Bethera[b] Talbot	25-42	Formed during pause in sea-level retreat from 100-25 feet	0.210 Ma 0.227 Ma
Penholoway	42-70	Formed during pause in sea-level retreat from 100-25 feet	0.393 Ma
Wicomico	70-100	Penholoway-Wicomico form single transgressive-regressive sequence	0.393 Ma
Okefenokee[b] Sunderland	100-170	Okefenokee and Sunderland terraces grouped by some authors	0.763 Ma 1.430 Ma
Coharie	170-215	Coharie-Sunderland form single transgressive-regressive sequence	1.650 Ma
Hazelhurst	215-320	—	1.66 to 1.98 Ma(?)

Source: Modified from References 271 and 260

(a) Probable age is a calculated from $\Delta H = kT$ ($k = 0.135 \times 10^{-3}$) with final correlation of high sea level data with deep-sea core stages (Reference 260). Age is given in millions of years before present (Ma).

(b) Based on terrace recognized in southern Georgia; not recognized as a separate terrace in Florida in Reference 271.

(c) The Princess Anne terrace is not seen in Florida but is the ninth terrace that Ward (Reference 260) observes in South Carolina.

ASSOCIATED ENCLOSURES:

None

NRC RAI Letter No. PTN-RAI-LTR-041

SRP Section: 02.05.01 - Basic Geologic and Seismic Information

QUESTIONS from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.01-22 (eRAI 6024)

FSAR Section 2.5.1.1.1.2.3, the "Stratigraphy of Cuba" passage, states that "Late Miocene to Pliocene deposits are poorly developed and Pleistocene rocks include shelf and coastal carbonates that in places have been uplifted into terraces (Reference 383)". The staff notes that this implies Pleistocene tectonic uplift. The staff further notes that Agassiz (1894)[1] described the extensive marine terraces along the northern coast of Cuba and very young elevated patch reef corals in growth position, forming the lowest terraces. In addition, a suite of Quaternary terraces along the northern edge of Cuba is clearly depicted in available 1:500,000 scale geologic maps of the region.

In order for the staff to assess the tectonic and structural features within the site region and in accordance with 10 CFR 100.23, please address the following:

a) Explain the tectonic context of these uplifted terraces in light of continued seismicity along the northern coast of Cuba.
b) Discuss the ages, lateral extents, morphologies, and origins of the terraces.
c) Discuss the implications of these terraces for assessments of active faulting in the Site Region.

[1]Agassiz, A., 1894, A reconnaissance of the Bahamas and elevated reefs of Cuba: Bulletin of the Museum of Comparative Zoology, v. 26, 203 p.

FPL RESPONSE:

a) Elevated marine terraces were identified along the northern coast of Cuba as early as the late 19th century (Agassiz 1894). These marine terraces likely formed as the result of high sea level stands and regional tectonic uplift. As shown on 1:500,000-scale geologic maps (FSAR Reference 847), these terraces seemingly are cut into deposits as young as Pleistocene to recent in age, and therefore suggest regional uplift as young as Pleistocene to recent in age. However, the association of the uplift of these terraces with individual faults in northern Cuba is uncertain. For example, the relationship between marine terraces and the Hicacos fault is unclear because available publications provide ambiguous, and in some cases conflicting, information on the location, sense-of-slip, and age for the Hicacos fault. FPL's response to RAI 02.05.01-29 provides related information regarding the possible association of uplifted marine terraces and the Hicacos fault. Moreover, the association of seismicity with individual faults throughout northern Cuba is unclear due to the uncertainties associated with the locations of both earthquakes and mapped faults in Cuba. FPL's responses to RAIs 02.05.01-24 through 02.05.01-28 provide related information regarding the association of historical and instrumental seismicity with faults in northern Cuba, including the Nortecubana, Hicacos, Habana-Cienfuegos, La Trocha, Cochinos, Las Villas, and Pinar faults.

b) The terraces and sea cliffs that are composed of Tertiary limestones (Spencer, 1895) occur along the entire north coast except where rivers have eroded gaps in the terraces

(Vaughan and Spencer, 1902). The stair-step morphology of the terraces and sea cliffs suggests that Tertiary reef deposition (Agassiz, 1894) was followed by high sea level stands that cut the bench-like features in the sea cliffs. Tectonic uplift, possibly during the early Eocene to late Paleocene appears to have occurred in response to the collision of the Greater Antilles Arc with the Bahama Platform (see FSAR Subsection 2.5.1.1.3.3) and resulted in raising the terraces from their original near-sea level elevations.

Old sea cliffs or terraces are observed near the cities of La Habana and Matanzas. Four marine terraces have been observed at 200, 100, 10-15 and 4-5 feet above mean sea level near La Habana. Since the lithology (i.e., coral reef rock) of the terraces range in age from the Upper Oligocene to Pleistocene or recent, it is inferred that tectonic uplift has continued from the early Eocene to the Pleistocene or recent. Six terraces have been observed at 400, 300, 200, 140, 30, and 5-6 feet above sea level near Matanzas. The relative terrace elevations imply repeated episodes of tectonic uplift that may have continued into the Pleistocene or recent. The lithologies of the six terraces near Matanzas also consist of coral reef rock (Hill, 1895, Hayes, Vaughan and Spencer, 1901 and Vaughan and Spencer, 1902).

c) The elevated marine terraces along the northern coast of Cuba suggest relatively young, and perhaps ongoing, regional tectonic uplift in northern Cuba. However, the association between uplift of these terraces and individual faults in northern Cuba is unclear. Available mapping provides ambiguous, and sometimes conflicting, information on the locations, fault styles, and ages of faults in northern Cuba. For this reason, the identification of any fault or faults that might be active cannot be accomplished with any certainty and therefore, it could not be determined which fault or faults are responsible for the uplift of these terraces. FPL's response to RAI 02.05.01-31 will provide information regarding geologic and fault mapping in Cuba and its usefulness in neotectonic evaluations and seismic source characterization.

This response is PLANT SPECIFIC.

References:

Agassiz, A., A reconnaissance of the Bahamas and elevated reefs of Cuba: Bulletin of the Museum of Comparative Zoology, v. 26, p. 203, 1894.

Hayes, C.W., Vaughan, T.W., and Spencer, A.C., A Geological Reconnoissance of Cuba, pp. 18-20, 1901.

Hill, R.T., Notes on the Geology of the Island of Cuba, Based Upon a Reconnoissance Made for Alexander Agassiz, Bulletin of the Museum of Comparative Zoology, v. XVI, no. 15, pp. 264-274, 1895.

Spencer, J.W., Geographical Evolution of Cuba, Bulletin of the Geological Society of America, v. 7, pp. 67-94, 1895.

Vaughan, T.W., and Spencer, A., The Geography of Cuba, Bulletin of the American Geographical Society, v. 34, no. 2, pp. 105-116, 1902.

ASSOCIATED COLA REVISIONS:

None

ASSOCIATED ENCLOSURES:

None