PMTurkeyCOLPEm Resource

From: Comar, Manny
Sent: Monday, October 03, 2011 5:13 PM
To: orthen, Richard; Raymond Burski; Steve Franzone; STEVEN.HAMRICK; TurkeyCOL Resource; William Maher
Cc: Comar, Manny
Subject: Draft RAI 6024 related to SRP Section 02.05.01 -Basic Geologic and Seismic Information for the Turkey Point Units 6 and 7 combined license application.
Attachments: draft RAI 6024_TPN.doc

To All,

Attached is the draft of RAI No:6024 regarding section 02. 05.01 Basic Geologic and Seismic Information for the Turkey Point Units 6 and 7 combined license application.

If you need a conference call to discuss the question(s) of the draft RAIs please contact me at 301-415-3863. Unless you request additional clarification we will normally issue the RAI as final within 3 to 5 days, from today.

Thanks

Manny Comar
Senior Project Manager
NRO/DNRL/NWE1
Nuclear Regulatory Commission
301-415-3863
mailto:manny.comar@nrc.gov

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From: Comar, Manny

Created By: Manny.Comar@nrc.gov

Recipients:
"Comar, Manny" <Manny.Comar@nrc.gov>
Tracking Status: None
"orthen, Richard" <richard.orthen@fpl.com>
Tracking Status: None
"Raymond Burski" <raymond.burski@fpl.com>
Tracking Status: None
"Steve Franzone" <steve.Franzone@fpl.com>
Tracking Status: None
"STEVEN.HAMRICK" <steven.hamrick@fpl.com>
Tracking Status: None
"TurkeyCOL Resource" <TurkeyCOL.Resource@nrc.gov>
Tracking Status: None
"William Maher" <William.maher@fpl.com>
Tracking Status: None

Post Office: HQCLSTR01.nrc.gov

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Request for Additional Information No. 6024

Turkey Point Units 6 and 7
Florida P and L
Docket No. 52-040 and 52-041
SRP Section: 02.05.01 - Basic Geologic and Seismic Information
Application Section: 2.5.1

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

02.05.01-***

FSAR Section 2.5.1.1.1.1.1.1, "Florida Peninsula Physiographic Sub provinces" passage, describes general karst dissolution for Florida to be due to an epigenic, sub aerial process of downward flow of slightly acidic groundwater (weak carbonic acid). The FSAR also provides a classification of Florida sinkhole types and a Florida Geological Survey ranking of sinkhole risk based on aerial density of known sinks.

The staff notes that relatively recent studies have recognized a different class of potentially potent carbonate dissolution and karst development in coastal areas that has been linked to mixing disequilibria at freshwater-brine interfaces. Several examples have been identified within the Caribbean region (FSAR Ref 263; and Smart et al., 2006[a]; Mylroie and Carew, 2003[b]).

In order for the staff to determine if the information presented in the FSAR represents an up-to-date and accurate characterization of regional and local limestone formation conditions and in support of 10 CFR 100.23 please address the following :

Discuss any evidence for or against the potential for karst dissolution associated with such fresh-water/brine interfaces in southern Florida, within the site region. Specifically consider the presence of any known water-filled passages and/or potential linking to sub-sea springs that may have formed at current or past fresh-water/brine interfaces based on local and regional stratigraphic studies including the subsurface evaluations completed for this application. Discuss how fresh water/brine zones of dissolution would be expected to migrate in response to sea level changes

[a] Smart, P.L., Beddows, P.A., Coke, J., Doerr, S., Smith, S., and Whitaker, F.F., 2006, Cave development on the Caribbean coast of the Yucatan Peninsula, Quintana Roo, Mexico, in Harmon, R.S., and Wicks, C., eds, Perspectives on karst geomorphology, hydrology, and geochemistry – A tribute volume to Derek C. Ford and William B. White: Geological Society of America Special Paper 404, p. 105–128.

[b] Mylroie, J. E., and Carew, J. L. 2003. Karst development on carbonate islands. *Speleogenesis and Evolution of Karst Aquifers*, V.1 Issue 2
http://www.speleogenesis.info/archive/publication.php?PubID=21

02.05.01-***

FSAR Section 2.5.1.2.4 discusses limestone dissolution features and states that zones of preferential secondary porosity exist within (1) an upper zone within Key Largo Limestone and (2) a lower zone within Fort Thompson Formation, and that these zones include cavities verified from televiewer and caliper logs. Staff notes that the Key Largo LS will be the bearing layer for SSC buildings. In order for the staff to evaluate the dissolution potential at the TPNPP site and in support of 10 CFR 100.23, please address the following:

a) Discuss the possible origins of these subsurface voids and evaluate if this is still consistent with your statement “there is no evidence for sinkhole hazards or for the potential of surface collapse due to the presence of large underground openings” on page 2.5.2-229.
b) Discuss the possibility that these zones of secondary porosity are in the same stratigraphic unit that expresses the karst/sinkhole-like features seen immediately off shore to the east of the TPNPP site.

02.05.01-***

FSAR 2.5.1.1.3.4 discusses the "Quaternary Tectonic History" of the TPNPP region. However, additional, detailed, information is needed to evaluate the Quaternary tectonic history of the site region.

In order for the staff to determine if the information presented in the FSAR represents an up-to-date and accurate characterization of the Quaternary tectonic history of the site region and in support of 10 CFR 100.23 please address the following:

a) Identify and locate features of Quaternary, tectonic deformation in the site region (such as Walkers Cay fault, Santaren Anticline, Straits of Florida normal faults).
b) Summarize all Quaternary tectonic features in the site region, and update Figure 2.5.1-202 to depict all Quaternary active tectonic features in the entire site region.
c) Please revise the text to eliminate the duplicate paragraphs in this section.

02.05.01-***

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

02.05.01-***

FSAR Section 2.5.1.2.4, the **"**Dissolution Features" passage, states that potential hydrostatic stress mechanisms to initiate sinkhole collapse are unlikely at the site area because the water table is presently near the surface and is not expected to fall or rise greatly. The staff notes that there may be a change in hydrostatic stress during dewatering at the site during construction, thus more discussion is needed to evaluate the potential of sinkhole collapse.

In order for the staff to evaluate dissolution potential, and in support of 10 CFR 100.23, please discuss the potential for initiation of sinkhole collapse during site construction or during a potential rise in sea-level during the planned lifetime of Units 6 & 7.

02.05.01-***

FSAR Section 2.5.1.1.1.2.1.1, "Holocene Stratigraphy of the Florida Peninsula" passage states that the general history of sea-level transgression and regression during the Holocene is based on deposits preserved in Blackwater Bay on the southwest Gulf coast of Florida. You state that a significant event, around 1000 to 1090 years before present, is indicated by a sediment layer (Type D) found in all these cores at the same elevation. You suggest that this may be the result of a storm deposit or series of storm deposits. In addition you discuss a model of sea-level transgression, regression, transgression during the Holocene based on Holocene stratigraphy derived from several sources (References 749, 757, 750, 753, 800, 754).

In order for the staff to determine if there is a record of a Holocene tsunami manifested in these deposits and in support of 10 CFR 100.23 please address the following:

a) Discuss the distinction between storm and tsunami deposits. In addition, why are type D sediments not considered a tsunami deposit.
b) Discuss whether the Holocene relative sea level curve in the vicinity of the site correlates or not to the stratigraphic and geographic position of type D sediments and the significant event c.1000 ybp.

02.05.01-***

FSAR Section 2.5.1.1.1.2.1.1, "Holocene Stratigraphy of the Florida Peninsula" states that hurricanes complicate the preservation of Pleistocene and Holocene deposits on the east and west coasts of the Florida Peninsula by eroding these deposits and depositing them elsewhere. In order for the staff to evaluate the Holocene geologic record at the site and in support of 10 CFR 100.23 please address the following:

a) Within the context of the Holocene sedimentary record at the site discuss the nature and extent of paleostorm deposits.

b) Provide a discussion that compares and contrasts deposits of Hurricane Andrew or other historical hurricanes, and any paleostorm deposits preserved in the Holocene stratigraphy, with potential tsunami deposits at the site.

c) Provide a figure or a map that illustrates these deposits.

02.05.01-***

FSAR Section 2.5.1.1.5, "Tsunami Geologic Hazard Assessment," Section 2.5.1.2.1, "Site Physiography and Geomorphology," and Section 2.5.1.2.4, "Site Geologic Hazards," state that an extensive review of scientific literature resulted in no evidence of Quaternary seismically induced or landslide-generated tsunami deposits within the 200-mile radius of the Units 6 & 7 site region. The FSAR adds that sampling performed as part of the subsurface investigations at the Turkey Point site encountered about 1 meter (3 feet) of organic muck overlying Pleistocene and older carbonate strata and that the muck is the dominant surficial sediment type varying in thickness across the site from 2 to 6 feet (0.6 to 1.8 meters). FSAR Figure 2.5.1-332 shows the organic muck section as Holocene. Finally, the FSAR states that examination of Units 6 & 7 has provided no evidence of known tsunami deposits. In light of the foregoing conclusion, the staff notes that the FSAR does not provide an analysis of the Holocene section (muck layers) in the site vicinity with respect to paleo-tsunami or paleo-storm surge events and core data regarding the muck layers is absent from the FSAR.

In order for the staff to understand the Holocene geologic setting of the TPNPP and in support of 10 CFR 100.23 please address the following questions:

a) Provide justification for your conclusion that there are no tsunami deposits at the site with a detailed presentation of the Holocene section, including how it varies across the site in terms of thickness and internal structure.

b) Discuss the organic sediment (“muck”) and included silt layers within an appropriate framework for the description of biogenic deposits, such as the Troels-Smith sediment classification system. Provide sufficient detail to illustrate how you evaluated silt layers as either potential storm or tsunami-derived sources.

02.05.01-***

FSAR Figures 2.5.1-243 and -262 illustrate seismic reflectors of the Florida and Bahamas Platform, and a large slump offshore from the site area is labeled “HOLO.-UP. OLIG.” on Figure 2.5.1-243. This feature is located at kilometer 50 on Line 71 and 73 on Figure 2.5.1-262. However the staff notes that there is no discussion in the FSAR regarding this feature.

In order for the staff to fully understand site-specific geology and in support of 10 CFR 100.23, please clarify if this feature is a slump and if it bears upon the tsunami hazard of the site area.

02.05.01-***

FSAR Section 2.5.1.1, Regional Geology, describes Large Igneous Province (LIP) magmatic events and the East Coast Margin Igneous Province (ECMIP) which includes the eastern edge of the Blake Plateau and Bahamas Platform. The FSAR states that the

LIPs are massive crustal emplacements of mafic rock that include oceanic plateaus. Conceivably this would be an area of thickened oceanic crust. FSAR Figure 2.5.1-224 illustrates a schematic cross section of the crust and overlying carbonate bank system that changes from extended, transitional continental ultimately to normal oceanic crust (presumably), but also illustrates a zone of apparently thin oceanic crust with a thick, overlying carbonate bank system. In order for the staff to understand the variability in the nature and thickness of the underlying crust of the TPNPP region and in support of 10 CFR 100.23, please provide information for the following:

a) Discuss the location of the ECMIP with respect to transitional continental, thickened and normal oceanic crust; the location of the carbonate bank system and; the current platform bathymetry.

c) Discuss the impact of crustal thickness variations on the ground motion models and subsequent impacts on the seismic hazard curves of the Caribbean sources.

d) Discuss the possibility that the magnetic highs located along the eastern Bahamas Platform and Little Bahamas Bank reflects the location of a southern extension of the ECMIP and thickened oceanic crust.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2 “Principal Tectonic and Structural Features” states that the site region has generally recorded only sedimentary processes since Mesozoic rifting, with the exception of tectonic activity associated with the collision of the Greater Antilles Arc with the Bahamas Platform during Cretaceous to Eocene time. The staff notes that this suggests that there has been no tectonic activity in the site region since the end of the Eocene (~34 Ma). However, the north coast of Cuba, the Walkers Cay fault, the Santaren Anticline, and the Straits of Florida normal faults all occur within the site region and show evidence for post-Eocene tectonic activity.

In order for the staff to fully understand site region specific geology, and in support of 10 CFR 100.23, please address the following: Update this discussion to clarify the timing and location of all tectonic features in the site region and place into the regional tectonic setting.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.1, “Structures of the Florida Peninsula and Platform” states that occasional variations in pre-Miocene stratigraphy recorded in boreholes due to erosion-based paleo-topography or karst have sometimes been interpreted as possible faulting; for example, the queried fault in Figure 2.5.1-234 (between wells Park W-2404 and Gulf W-3510) appears to displace the base of the Long Key and Arcadia Formations at approximately 100 m and coincides with nearly a doubling in thickness of the Long Key Formation on the downthrown (southern) side. The staff notes that the fault juxtaposes the Long Key Formation against the Arcadia Formation and the Arcadia Formation against the Avon Park Formation. Cunningham et al., 1998 (Reference 373) also provides a structural contour map of the top of the Arcadia formation and a map of

net thickness of Miocene-to-Pliocene siliciclastic sand that appears to be consistent with faulting (Figure 17 of Cunningham et al., 1998).

In order for the staff to fully understand site region geology and in support of 10 CFR 100.23, please address the following:

a) Substantiate your interpretation with specific evidence that the stratigraphic relations across the queried fault shown in Figure 2.5.1-234 and depicted in Reference 373 are a result of paleo-topographic or karst processes, rather than tectonic offset.
b) If the queried fault is indeed a fault, please discuss the timing and spatial extent of faulting and update the FSAR discussion accordingly.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.2 states with respect to Mesozoic Normal Faults of the Bahamas Platform, that the basement of the Bahamas Platform is depicted as a series of fault blocks with syn-tectonic Triassic to Jurassic strata, draped by undeformed Cretaceous strata. However, the staff notes that in FSAR Figure 2.5.1-264, Lower Cretaceous strata are faulted.

In order for the staff to evaluate the site region geology and in support of 10 CFR 100.23, please clarify the age of latest movement in light of faulted lower Cretaceous strata.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.2, “Bahamas Platform Tectonic and Structural Features” states with respect to Walkers Cay Fault, that although strata above the Oligocene horizon have been interpreted as both faulted and unfaulted, Harwood and Towers (1988) indicated that the Walkers Cay fault has minimal effect on middle Miocene and younger strata. In addition the FSAR states that because of the minor deformation of Miocene and younger strata, the Walkers Cay fault is concluded to be a Tertiary structure, and consequently, not a capable tectonic structure.

In order for the staff to understand the geologic setting of the TPNPP site and In support of 10 CFR 100.23 please address the following:

1) Label Walkers Cay fault on FSAR figure 2.5.1-276.
2) Explain the basis for Harwood and Towers (1988) conclusion within the limits of resolution for marine seismic reflection data.
3) Discuss the earlier interpretation of fault offset to the sea floor in light of the Austin et al 1988 a and b papers.
4) Discuss site-survey profiles LBB-17 and LBB-18 of ODP Leg 101, which show the Walkers Cay fault displacing the seafloor(see Austin et al., 1988 *a* and *b)*.

a. Austin, J. A., Jr., Schlager, W., et al, 1988, Proceedings of the Ocean Drilling Program, Scientific Results (1988) 101: 455-472. Paper number 29, by the "Leg 101 Scientific Party." Copyright 1988, Ocean Drilling Program.

b. Austin, J. A., Jr., Schlager, W., et al., 1988, Proceedings of the Ocean Drilling Program, Scientific Results (1988) 101: 455-472. Paper number 26, by Austin et al." Copyright 1988, Ocean Drilling Program.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.2 states, with respect to the Santaren Anticline, that stratigraphic analysis (References 477 and 479) used to infer Pliocene or potential Quaternary activity on the structure, suggests this structure is Tertiary in age and predominantly active during the Eocene, with diminishing activity throughout the Miocene. The staff notes that References 477, 479, and 501 present evidence that the Santaren Anticline (within the 200 mi radius of the site) is cored by a thrust fault and is undergoing present-day shortening.

In order for the staff to determine the potential for activity on this structure and in support of 10 CFR 100.23 please address the following questions:

a) In light of evidence for ongoing deformation (References 477, 479, and 501), discuss the present day rates of shortening calculated across the anticline (see also Masaferro et al, 1999).

b) Plot regional seismicity on a close-up view of the Santaren Anticline and comment whether the Santaren Anticline is a capable tectonic structure.

c) Provide a discussion regarding the possibility that the Santaren Anticline and the Nortecubana fault system are linked.

[a] Masaferro, J.L., Poblet, J., Bulnes, M., Eberli, G.P., Dixon, T.H., and McClay, K., 1999, Palaeogene-Neogene/present day(?) growth folding in the Bahamian foreland of the Cuban fold and thrust belt: Journal of the Geological Society of London, v. 156, Part 3, 617–631.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.2 states, with respect to the Straits of Florida Normal Faults, that middle to late Eocene to early middle Miocene strata were deposited uniformly over most of the southern Straits of Florida and that similarly; continuous, unfaulted strata drape the edges of the Florida and Bahamas Platforms along the Straits of Florida. The staff needs more details with respect to the timing and location of the Straits of Florida Normal Faults.

In order for the staff to completely understand the geologic setting of the TPNPP site and in support of 10 CFR 100.23, Provide a discussion of the structural and stratigraphic evidence for the location and timing of deformation along the Mitchell, Pourtales, and Miami escarpments, the Las Villas and the Sierra de Jatibonico fault zones, and other tectonic features present in the bathymetry of subsurface of the Straits of Florida within

the site region, including those located offshore northern Cuba, and in light of references such as Uchupi, 1966[a] and Malloy and Hurley, 1970[b] .

[a] Uchupi, E., 1966, Shallow structure of the Straits of Florida, Science, New Series, Vol 153, no.3735, pp.529-531, published by AAAS.

[b] Malloy and Hurley, 1970, Geomorphology and Geologic Structure: Straits of Florida, Geological Society of America Bulletin, v. 81, p. 1947-1972, 19 figs., July 1970

02.05.01-***

FSAR Figures 2.5.1-342, -343, and -344 illustrate isopach and structure contour maps of the Key Largo Limestone and Fort Thompson Limestone stratigraphic units. The staff notes, however, that additional information is needed on the maps to understand the nature of the Key Largo and Fort Thompson limestone units.

In order for the staff to evaluate depositional structures or potential tectonic deformation in the bearing layer formation within the site area and in support of 10 CFR 100.23, please address the following:

a) Indicate the elevation on the structure contour maps and thickness values on the isopachs.

b) Indicate thin areas on the isopachs and low areas on structure contours.

c) Plot the location of cross section lines A, B,C, and D on the isopach and structure contour maps.

d) Provide a structure contour for the Key Largo formation.

e) The FSAR describes the Fort Thompson Formation as vuggy, and solution-riddled. In light of this characteristic in the underlying Fort Thompson, discuss the implication of the numerous closed circles shown on the Key Largo isopach.

02.05.01-***

FSAR Figures 2.5.1-274 through 278 and 280, 281, and 287 shows annotated seismic sections, however the staff notes that more information is needed in order to evaluate the relative ages of deformation shown in these seismic cross sections.

In order for the staff to fully understand the regional site geology area and in support of 10 CFR 100.23, please indicate the ages and formation names, if known, of the various sedimentary strata on these figures. Please clarify what is the interpreted depth to faulted strata.

02.05.01-***

FSAR 2.5.1.1.1.3.2.2, "Structures of the Bahamas Platform" passage, states that because the Bahamas platform is largely submerged, all information about potential structures is gained from interpretations of seismic lines, and consequently is subject to limitations. The FSAR adds that the majority of the inspected and available seismic lines confirm the unfaulted nature of Cretaceous and younger strata across the Bahamas Platform and southern Florida Platform. The staff considers, however, that more assessment is needed to understand the tectonic structures in the Bahamas platform.

In order for the staff to determine the adequacy of the regional geologic characterization and in support of 10 CFR 100.23, please asses the following questions:

a. Describe the limitations that apply to the detection of active tectonic structures deduced from seismic reflection data within the Bahamas Platform.

b. Discuss the uncertainties in resolution and age control of the seismic interpretations, especially in cases where seismic data is used to infer the unfaulted nature of Cretaceous and younger strata.

02.05.01-***

FSAR Section 2.5.1.1.4, states with respect to the “Contemporary Stress Regime within the Site Region”, that “the boundary between the mid-plate and Gulf Coast stress provinces terminates in the northern Florida Peninsula, but there is a lack of stress data from areas near the Florida Peninsula and most of Cuba. Because the southern Florida Peninsula doesn’t exhibit the geologic features (such as salt-rooted normal faults) associated with the Gulf Coast stress province, the site region is generally interpreted to be part of the mid-plate stress province (Reference 705) (Figure 2.5.1-330).”

In order for the staff to determine the configuration of the state of stress within the site region and in support of 10 CFR 100.23, please address the following:

a) Address the focal mechanism for the Sept 10, 2006 Gulf of Mexico earthquake with respect to the Gulf Coast stress province and show stress orientation indicated by this focal mechanism on Figure 2.5.1-330.

b) Indicate on Figure 2.5.1-330 the boundary between the Gulf coast and mid plate stress provinces as it is currently interpreted within the TPNPP site region.

c) Explain if analyses were performed to characterize the stress direction and magnitude in northern Cuba in light of the abundant seismicity along the northern parts of Cuba. Indicate on Figure 330 how the boundaries of the Gulf Coast and the mid plate stress provinces resolve in the vicinity of northern Cuba.

02.05.01-***

FSAR Section 2.5.2.4.4.3.2, states that an area source model is used for Cuba because of the lack of knowledge on fault behavior and slip rates for Cuban faults with which to support assessment of fault-specific sources. In order to evaluate the possibility of capable tectonic sources within the site region and in accordance with 10 CFR 100.23 please provide a discussion that compares the impacts to the PSHA based on characterizing fault-specific sources as opposed to characterizing an area source.

02.05.01-***

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.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2, under the Cuban Fold-and-Thrust Belt passage states: **"**On the basis of well-dated Eocene syn-tectonic strata, published structural interpretations indicating unfaulted Quaternary strata above these structures offshore, and unfaulted Pleistocene and younger terraces along the northern edge of Cuba (Reference 847) (FSAR Figure 2.5.1-282), these faults are concluded to be Tertiary in age and not capable tectonic structures." However, FSAR Figure 2.5.1-279 (S-SE end of seismic profile) shows mapped basement faults of the Cuban Fold and Thrust belt with overlying and laterally continuous reflectors that appear to be deformed and folded up to and including the seafloor. Additionally, the unfaulted, but uplifted, Pleistocene and younger marine terraces along the northern edge of Cuba may actually demonstrate a capable tectonic structure. Lastly, FSAR Figure 2.5.1-282 shows Tertiary, post-tectonic deposits (Unit 6) as faulted. The uppermost Tertiary deposits appear to lap-onto, rather than drape, an underlying fold on the same FSAR Figure 2.5.1-282. Both relations are consistent with deformation that continues to present day.

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) Discuss the tectonic implications of the seismic reflection features above the mapped faults for Plio-Pleistocene activity in the Cuban Fold and thrust belt.
b) Clarify how the unfaulted and uplifted Pleistocene marine terraces demonstrate a lack of capable tectonic feature.
c) Discuss the suitability of using the schematic diagram (FSAR Figure 2.5.1-282) to conclude that faults of the Cuban Fold-and-Thrust Belt are Tertiary in age and not capable tectonic structures.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, discusses Structures of Cuba; however, the staff needs more information regarding the various fault systems within the Cuba areal source.

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) Identify the Nortecubana fault or faults on seismic reflection sections and provide a map showing the surface trace or projection of the Nortecubana fault or faults with respect to topography and bathymetry.
b) Clarify the relationship between the Nortecubana fault system and the Cuban Fold and Thrust Belt.
c) The FSAR states “Cotilla-Rodríguez et al. (Reference 494) indicate that the Nortecubana Fault Trench is expressed in the bathymetry north of Cuba, but this does not constitute direct evidence for activity." Please clarify what processes give rise to a bathymetric expression of an inactive fault in a sedimentary basin.
d) Discuss the February 1914 (Mw 6.2) earthquake offshore northeastern Cuba near the Nortecubana fault in light of the FSAR Section 2.5.1.1.1.3.2.4 that states that “there is no direct evidence that these earthquakes occurred on the Pinar and Nortecubana Faults”. Please clarify what direct evidence is required to establish a connection between the earthquake and the faults.
e) Discuss the location of the Nortecubana fault as depicted in the reflection profiles (i.e. dip, depth).

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4 discusses the Hicacos, Surcubana, Habana-Cienfuegos, La Trocha and the Sierra Maestra faults; however the staff notes that more information is needed to assess the potential activity of these faults.

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) Provide a map of the Hicacos fault and seismicity, including earthquake location errors, and discuss the relationship of the Hicacos fault to nearby seismicity.

b) Provide a map and discussion of the activity of the Surcubana fault zone.
c) Provide a map of the surface trace of the Habana-Cienfuegos fault (including the undersea extension proposed in Cotilla-Rodriguez et al. Reference 494), including seismicity with location uncertainties. In addition, Discuss other nearby active faults that might have been the source of the "associated earthquake epicenters" referred to by Cotilla-Rodriguez.
d) Provide a map of the La Trocha fault trace and nearby seismicity, including location uncertainties and discuss potential sources of the observed seismicity.
e) Provide map and discussion of the faults associated with the Sierra Maestra. Consider for example Taber (1931)[1] which describes a scarp associated with the Sierra Maestra as "so fresh that its age must be measured in hundreds of years rather than tens of thousands." In addition discuss the relationship of these faults to nearby seismicity.

[1] Taber, S., 1931, The structure of the Sierra Maestra near Santiago De Cuba: The Journal of Geology. v. 39, n. 6, 532–557

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4 states, in the “Cochinos Fault" passage, that Cotilla Rodriguez et al. (2007) provided no geologic evidence for activity in this fault and described it as covered by young sediments. The FSAR also indicates that the Cochinos fault appears to be geographically associated with sparse instrumental seismicity, but that these earthquakes are poorly located and no focal mechanisms are available.

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) Provide a map of the Cochinos fault with respect to topography and bathymetry, and discuss if the association of the Cochinos fault with bathymetric relief provides geologic evidence for activity.
b) Map seismicity with respect to the Cochinos fault trace, showing location uncertainties, and discuss the relationship of the fault to seismicity.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, “Las Villas Fault” passage, states that according to Cotilla-Rodríguez et al. (2007), the Las Villas fault has ‘young eroded scarps’, but it is not clear if these features represent erosional fault scarps or if they were formed directly by recent slip on the Las Villas fault. The FSAR also described, quoting Cotilla Rodriguez et al. (2007), “a single instrumental event (1939) in the vicinity of the Las Villas fault for which no focal mechanism is available, and historical accounts of four events of intensity MMI V and less, are all poorly located”. The staff notes however, that Cotilla-Rodriguez et al. (1997) states in the same paragraph as the above quoted statement, that the Las Villas fault “is of Pliocene-Quaternary age. The associated seismic events are: 15.08.1939 (*Ms* = 5.6); 01.01.1953 (*I* = 5 MSK); *I* = 4 MSK (03.02.1952 and 25.05.1960), 22.01.1983(*I* = 3 MSK); and noticeable without specification 04.01.1988”.

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) Provide more detail from the Cotilla-Rodríguez et al. (2007) paper regarding the young eroded scarps of the Las Villas fault and specifically address Cotilla's conclusion that the fault is Pliocene-Quaternary in age.
b) In the context of the chronology of geomorphic surfaces on Cuba, clarify the distinction between erosional processes that may have recently created "young" fault-line scarps along the Las Villas fault and Quaternary tectonic fault scarps.
c) Discuss bathymetric evidence for the offshore location and recency of faulting along the Las Villas fault.
d) Address the alignment of epicenters shown on Figure 2.5.1-267 along the Las Villas fault with respect to its tectonic activity. Please plot the uncertainties in event locations and include this information in the discussion.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, "Seismicity of Cuba", states that two of the largest earthquakes in the central and western region of Cuba occurred in January 1880 (MMI VIII and magnitude 6.0 to 6.6) near the Pinar fault in western Cuba, and February 1914 (Mw 6.2) offshore northeastern Cuba near the Nortecubana fault. However, the FSAR also states that there is no direct evidence that these earthquakes occurred on the Pinar and the Nortecubana faults.

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 questions:

a) Provide a thorough discussion of the Pinar fault zone including plotting seismicity, and location uncertainties, with respect to the Pinar fault.
b) Discuss the possible sources of the January 22, 1880 M 6.0 - 6.6 San Cristobal earthquake and clarify what evidence is required to establish a connection between the 1880 earthquake and the Pinar fault. If the 1880 earthquake did not occur on the Pinar fault, please provide a detailed discussion of other faults or tectonic features that might have been responsible for the 1880 event.
c) If the Pinar fault is not active, please discuss geological processes that might lead to preservation of the continuous, linear fault trace through map units of variable ages and lithologies.

02.05.01-***

FSAR Figure 2.5.1-251, "Lithostratigraphic Map of Cuba", depicts the Matanzas fault zone within the site region; however, the staff notes that the Matanzas fault zone is not discussed in the FSAR.

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 questions:

a) Provide a discussion of the Matanzas fault zone in the FSAR, including a larger-scale map showing the fault trace.
b) Clarify if there is a relationship between the Matanzas fault zone and elevated Pleistocene terraces along the coast near Matanzas.
c) Discuss the relationship of the Matanzas fault zone to nearby seismicity.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, the “Seismicity of Cuba” passage, states that “In summary, many faults have been mapped on the island of Cuba…only a few detailed studies of the most recent timing of faulting are available and conflicting age assessments exist for many of the regional structures (Table 2.5.1-204). Nonetheless, available geologic mapping (at 1:250,000 and 1:500,000 scales; References 846, 847, and 848) provides some information regarding the timing of activity for some of the regional structures and largely indicates that the Pleistocene and younger strata are undeformed throughout the island.” The staff notes that this statement appears to contradict other statements in FSAR Sections 2.5.1.1.1.3.2.4 and FSAR 2.5.1.1.2.1.3 that suggest recent tectonic deformation such as:

- “Garcia et al. (Reference 489) note the Pinar fault is grossly expressed as a prominent escarpment and suggest the Pinar fault ‘was reactivated in the Neogene-Quaternary’ and may have produced the January 22, 1880 M 6.0 earthquake.”
- “…the Cubitas fault is a northwest-striking normal fault that forms the southern boundary of an area of higher topography (Figure 2.5.1- 288). It is … suggested to be partially responsible for up to 200 meters uplift of hills, possibly after the deposition of Plio- Pleistocene fluvial terraces (Reference 500). Cotilla-Rodríguez et al. (Reference 494) note that the Cubitas fault is associated with large scarps and assign it a Pliocene-Quaternary age.”
- “The La Trocha fault strikes east-northeast in Cuba, within the Greater Antilles deformed belt province, and continues southwest as the Trans Basin fault across the Yucatan Basin (Figure 2.5.1-286).…the onshore La Trocha fault (in the Greater Antilles deformed belt geologic province) is considered Pliocene- Quaternary seismoactive by Cotilla-Rodríguez et al. (Reference 494), who correlate five macroseismic events with the fault. Additionally, only two Phase 2 earthquake catalog earthquakes of Mw ≥ 7 are located within the Yucatan Basin, one of which (Mw 7.7) is located well within the province margins and nearly coincident with the Trans Basin fault mapped by Rosencrantz (Reference 529).”

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 clarify the statement: "...the timing of activity for some of the regional structures and largely indicates that the Pleistocene and younger strata are undeformed throughout the island” within the context of the mentioned FSAR statements.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, the “Seismicity of Cuba” passage, states that available geologic mapping (at 1:250000 and1:500000 scales) "largely indicates that the Pleistocene and younger strata are undeformed throughout the island." The staff notes that the same paragraph in the FSAR states that, "The scales of available geologic mapping do not provide sufficient detail to adequately assess whether or not individual faults in Cuba can be classified as capable tectonic structures." These two statements are seemingly contradictory.

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) Clarify if available geologic mapping in Cuba is suitable for neotectonic fault evaluation.
b) If available geologic mapping is insufficient for the assessment of active faulting as stated above, clarify the first statement that mapping "largely indicates that the Pleistocene and younger strata are undeformed throughout the island."
c) If available geologic mapping is insufficient for the assessment of active faulting, as stated above, further discuss your fault-activity-conclusions based on small scale mapping.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4 states: “In an effort to explain seismicity that continues on intraplate Cuba, 12 faults on the island of Cuba have been designated as ‘active’ (Reference 494), but that published analysis does not provide sufficient information to conclude that a structure is capable”. The staff notes that this statement does not corroborate conclusions made by published experts in the area (e.g. Cotilla-Rodríguez et al. 2007, Garcia et al. 2003) regarding active faults in Cuba.

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) Clarify the distinction between active and capable fault.

b) If the 12 faults are not capable tectonic sources, please discuss what is the structure or source of the seismicity of northern Cuba in light of Cotilla-Rodríguez et al. 2007 and Garcia et al. 2003 alternative conclusions.

02.05.01-***

FSAR Section 2.5.1.1.1.3.2.4, "Structures of Cuba", cites FSAR Figures 2.5.1-247, 2.5.1-251 and 2.5.1-268, which illustrate Cuban tectonic features at present, however, many faults appear to be omitted entirely from figures including the Habana-Cienfuegos fault, Cubitas fault, Guane fault, Nipe fault, and Baconao fault.

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 provide a single figure, or composite figures that clearly depict all tectonic features discussed in FSAR Section 2.5.1.1.1.3.2.4.