From: Rycyna, John
Sent: Tuesday, July 28, 2009 1:43 PM
To: 'Poche, Robert'; katie.thurstin@unistarnuclear.com; McQueeney, Jennifer; michael.stevenson@unistarnuclear.com
Cc: CCNPP3COL Resource; Stieve, Alice; Karas, Rebecca; Colaccino, Joseph; Arora, Surinder; Biggins, James; Vrahoretis, Susan; Simon, Marcia
Subject: RAI No 130 RGS 2821.doc
Attachments: RAI No 130 RGS 2821.doc

Rob,

Attached please find the subject request for additional information (RAI). A draft of the RAI was provided to you on July 14, 2009. A conference call was held on July 27, 2009 to discuss this RAI. Editorial changes were made to the questions 36 and 49.c as a result of the call. Question 51.c was clarified as a result of the call. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

John Rycyna, PE
Sr. Project Manager
Division of New Reactor Licensing
Office of New Reactors
U.S. Nuclear Regulatory Commission
301-415-4122

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From: Rycyna, John

Created By: John.Rycyna@nrc.gov

Recipients:
"CCNPP3COL Resource" <CCNPP3COL.Resource@nrc.gov>
Tracking Status: None
"Stieve, Alice" <Alice.Stieve@nrc.gov>
Tracking Status: None
"Karas, Rebecca" <Rebecca.Karas@nrc.gov>
Tracking Status: None
"Colaccino, Joseph" <Joseph.Colaccino@nrc.gov>
Tracking Status: None
"Arora, Surinder" <Surinder.Arora@nrc.gov>
Tracking Status: None
"Biggins, James" <James.Biggins@nrc.gov>
Tracking Status: None
"Vrahoretis, Susan" <Susan.Vrahoretis@nrc.gov>
Tracking Status: None
"Simon, Marcia" <Marcia.Simon@nrc.gov>
Tracking Status: None
"'Poche, Robert'" <Robert.Poche@constellation.com>
Tracking Status: None
"katie.thurstin@unistarnuclear.com" <katie.thurstin@unistarnuclear.com>
Tracking Status: None
"McQueeney, Jennifer" <Jennifer.McQueeney@unistarnuclear.com>
Tracking Status: None
"michael.stevenson@unistarnuclear.com" <michael.stevenson@unistarnuclear.com>
Tracking Status: None

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Calvert Cliffs Unit 3
UniStar
Docket No. 52-016
SRP Section: 02.05.01 - Basic Geologic and Seismic Information
Application Section: 2.5.1

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

02.05.01-33

In the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 FSAR, Section 2.5.1.1.1.1, p 2.5-11, the text states, "In the site region and vicinity, geomorphic surface expression is a useful criterion for mapping the contacts between Pliocene and Quaternary units as shown in Figure 2.5-5 and Figure 2.5-6." The figures do not show the contact between Quaternary and Pliocene units nor do they show how geomorphic surface expression correlates with geology. Please clarify or provide another illustration that shows the contact.

02.05.01-34

CCNPP Unit 3 FSAR Section 2.5.1.1.2 describes the regional geologic history beginning with the Grenville orogeny (Precambrian Eon) and ending with the Cenozoic Era. The NRC staff has identified the following information needs for this FSAR section:

a. The geologic history descriptions contained in FSAR Section 2.5.1.1.2 do not cover the entire area within the 200 mile radius of the site. The region covered is essentially limited to the southeastern North American margin. Please revise and further develop the geologic history sections (Sections 2.5.1.1.2.1 through 2.5.1.1.2.8) such that lithotectonic units or geologic terranes are defined by their structural boundaries (suture zones and/or large, regional fault systems) and illustrated in sufficient details. Please include the geology of the entire area within the 200 mile radius of CCNPP.

b. A frequently cited reference for most of FSAR Section 2.5.1.1.2, the geologic history section, is Fichter, 2000, which is a web site that seems to be for a student course and not peer reviewed, published geologic literature. Please justify your use of this web site rather than peer reviewed, published geologic literature.

c. In Figure 2.5-5, “Regional Geologic Map 200 Mile Radius,” the map does not have the Grenville terranes labeled as discussed in text. There are several colored units on the map within the 200 mile radius that do not have any identification. In Figure 2.5-6, “Regional Geologic Map 200-Mile (320-km) Radius Explanation,” the explanation is a mix of geologic age units with stratigraphic units of unidentified age, and with lithologic type with no age or terrane identity. Please revise Figure 2.5-5 to more directly support the discussion of the regional geologic history, and organize the legend (Figure 2.5-6).

d. Specifically for FSAR Section 2.5.1.1.2.1, Grenville Orogeny: Provide a discussion of Grenville massifs within the 200 mile radius of the site including: Reading Prong, Honey Brook Upland, Mine Ridge, Grenville massifs within the Baltimore Terrane, and the non-Laurentian, Grenville-aged Brandywine Terrane massifs such as those provided in Faill, 1997 and GSA Special Paper 330, 1999.

e. Specifically for FSAR Section 2.5.1.1.2.4, Taconic Orogeny: The FSAR text is taken from an introduction section of the Bledsoe and Marine paper, the topic of which is unrelated to the discussion topic in the FSAR. Provide citations from the original research to support the discussion in the text.

f. FSAR Section 2.5.1.1.2.5, Acadian Orogeny, states, "The Acadian orogeny ended the largely quiescent environment that dominated the Appalachian Basin during the Silurian, as vast amounts of terrigenous sediment from the Acadian Mountains were introduced into the basin and formed the Catskill clastic wedge in Pennsylvania and New York as shown in Figure 2.5-5, Figure 2.5-6, and Figure 2.5-8." These figures do not define or illustrate the Catskill clastic wedge. Please define the Catskill wedge and its significance within the Acadian orogeny and illustrate with appropriate scale maps.

g. FSAR Section 2.5.1.1.2.7 describes the Early Mesozoic Extensional Episode (Triassic Rifting). The CCNPP site is located within the extended continental crust with many Triassic rift basins in the surrounding region and vicinity. In FSAR Section 2.5.1.1.4.1, Plate Tectonic Evolution of the Atlantic Margin (p 2.5-28), a completely different version of Mesozoic history is described. Section 2.5.1.1.4.1 is part of the geologic history for the site region and the information in that section needs to be integrated with Section 2.5.1.1.2.7 so that redundant or conflicting presentation of information is resolved and all the pertinent scientific literature is adequately covered. Please revise both Sections 2.5.1.1.2.7 and 2.5.1.1.4.1 to integrate a single Mesozoic historical description and to include the latest research, along with appropriate regional maps and cross sections.

h. FSAR Section 2.5.1.1.2.8 describes the Cenozoic History for the region. The CCNPP sits on Cenozoic Coastal Plain sediments within the current passive margin tectonic setting. Please revise the text in this FSAR section to provide more details about the current state of stress in the eastern North American continental margin.

02.05.01-35

In CCNPP Unit 3 FSAR Section 2.5.1.1.3, Regional Stratigraphy (p. 2.5-18), the text states, "… generalized stratigraphy within a 200 mi (322 km) radius of the CCNPP site is shown on Figure 2.5-5 and Figure 2.5-6." The regional stratigraphy is not illustrated in these figures. Please provide an illustration of regional stratigraphy that supports the discussion in Section 2.5.1.1.3.

02.05.01-36

CCNPP Unit 3 FSAR Section 2.5.1.1.3 describes the regional stratigraphy. The NRC staff has identified the following information needs for this section:

a. CCNPP Unit 3 FSAR Section 2.5.1.1.3.1.1, Pre-Cretaceous Basement Rock (p. 2.5-18), states, "The non-marine and marine sediments deposited in the Coastal Plain Physiographic Province overlie what are most likely foliated metamorphic or granitic rocks, similar to those cropping out in the Piedmont approximately 50 mi (80 km) to the northwest (Figure 2.5-5 and Figure 2.5-6)."   A description of the crystalline rock found in several local basement boreholes is not integrated with the nearby, exposed portion of the Piedmont province immediately to the west of the site and with the locations of several buried Mesozoic rift basins in the site vicinity and region. Also, these crystalline rocks are not part of the Coastal Plain section. Please develop a more integrated discussion of the buried portion of continental margin.

b. On p. 2.5-19 of FSAR Section 2.5.1.1.3.1.1, the text states, "Because of the depth of Coastal Plain sediments, the basement rock type beneath the CCNPP site must be inferred based on surrounding borings and geophysical data." The existence of a Triassic basin beneath the site is important for the regional and vicinity tectonic setting for the site and perhaps for the site response evaluation. Please provide a more detailed development of the regional Mesozoic rift basin regime as it relates to the CCNPP site.

c. In Section 2.5.1.1.3.1.2, Cretaceous Stratigraphic Units (p. 2.5-19), the text states, "In Stafford, Prince William, and Fairfax counties in Virginia Lower Cretaceous Potomac Formation sediments were deposited unconformably on a narrow belt of Ordovician Quantico Slate and on the Cambrian Chopawamsic Formation (Mixon, 2000)." The text also states, "The Lower Cretaceous Potomac Group overlies a complex suite of basement rocks that includes strata as young as Triassic. Jurassic units appear to be missing north of the Norfolk Arch (Hansen, 1978) (Figure 2.5-12). The undulatory and east-dipping basement surface that underlies the Coastal Plain resulted from a combination of downwarping, erosion, and faulting. This has led to local variations in the slope of the bedrock surface." This information is part of the description of Paleozoic crystalline rock that is buried below the Coastal Plain section and not part of Cretaceous stratigraphy. Please integrate this information with the text in the FSAR Section 2.5.1.1.3.1.1, Pre-Cretaceous Basement Rock.

d. Also in Section 2.5.1.1.3.1.2 (p. 2.5-20), the text describes the tectonic evolution of the Salisbury Embayment to begin early in the Cretaceous period and to continue intermittently throughout the Cretaceous and Tertiary periods. This topic is actually discussing young tectonic movements on the continental margin. Please integrate this information with the discussion in FSAR Section 2.5.1.1.4.1.3, Cenezoic Passive Margin Flexural Tectonics (p 2.5-31).

02.05.01-37

CCNPP Unit 3 FSAR Section 2.5.1.1.3.2 describes the regional stratigraphy under the heading Piedmont Physiographic Province (p 2.5-23).

a. Please provide a discussion of Piedmont geologic stratigraphy organized by lithotectonic terrane rather than physiographic province.

b. Please provide a more complete justification to support your statements about the stratigraphy of the crystalline, metamorphic rock within 200 miles of the site, including a discussion and evaluation of more recent interpretations available in current research.

c. In FSAR Section 2.5.1.1.3.2, the text states, ". . .the second is a set of Early Mesozoic (Triassic) age sedimentary rocks deposited locally in down-faulted basins within the crystalline rocks . . . ." Please revise the discussion of these rocks with respect to their own lithotectonic unit within the Mesozoic Rift basins in the regional geology.

d. FSAR Section 2.5.1.1.3.2.1, Crystalline Rocks (Late Precambrian and Paleozoic) states, "The rocks belong to a number of northeast-trending belts that are defined on the basis of rock type, structure and metamorphic grade (Bledsoe, 1980) . . . ." Please provide citations of the original work for these geologic terranes including more recent interpretations and conceptual models based on published, peer-reviewed research.

e. Please revise FSAR Figure 2.5-9 to include the 200 mile radius of the site, including the portions of the Central and Northern Appalachian and New England terranes that fall within the 200 mile radius.

f. In FSAR Section 2.5.1.1.3.2.1.1, Goochland-Raleigh Belt, Spears, 2002 is cited. This citation to an annual conference in Virginia does not appear to be a complete reference. Please provide a complete citation.

g. In FSAR Section 2.5.1.1.3.3, Blue Ridge Physiographic Province (p 2.5-26), please provide additional details and references about litho/stratigraphic information from the various geologic terranes within the 200 mile radius of the site.

h. In FSAR Section 2.5.1.1.3.4, Valley and Ridge Physiographic Province (p. 2.5-26), please provide additional details and references about litho/stratigraphic information from the various geologic formations within the province.

02.05.01-38

CCNPP Unit 3 FSAR Section 2.5.1.1.4.1.1, Late Proterozoic and Paleozoic Plate Tectonic History, states, "Suturing events that mark the welding of continents to form supercontinents and rifting events that mark the breakup of supercontinents to form ocean basins have each occurred twice during this interval." This statement does not reflect the most current conceptual models for the eastern continental margin. From Late Proterozoic through the end of the Paleozoic there are 5 major collisions with at least one continental rifting (Rodinia) (Faill, 1997a, 1997b, and 1998). Please revise the discussion in this section to include the most up to date tectonic evolution models reflected in the professional literature.

02.05.01-39

CCNPP Unit 3 FSAR Section 2.5.1.1.4.1.3 discusses aspects of Cenozoic Passive Margin Flexural Tectonics, including the development and evidence of the continental margin arches and embayments.

a. On page 2.5-31 the text states, "Margin-parallel variations in the amount of uplift and subsidence have created arches (e.g. South New Jersey and Norfolk Arches) and basins or embayments (e.g. Salisbury Embayment) along the Coastal Plain and Continental Shelf (Figure 2.5-12)." Provide an explanation of margin parallel uplift/subsidence creating arches that are perpendicular to the margin. Please substantiate the most recent thought on these features with citations to original work.

b. On page 2.5-32, the text states, "It is suggested (Pazzaglia, 1994) that low rates of contractional deformation on or near the hinge zone documented on Cenozoic faults may be a second-order response to vertical flexure and horizontal compressive stresses." Please provide additional details about this interpretation and the significance for potential seismogenic faults.

c. On page 2.5-32 the text states, "Subsequent studies performed during the North Anna ESP study demonstrates that the fall lines (Weems, 1998) are erosional features and not capable tectonic sources (NRC, 2005) (Section 2.5.1.1.4.4.5.1)." Please provide pertinent details and summarize conclusions from the North Anna work, especially as it relates specifically to CCNPP.

02.05.01-40

In CCNPP Unit 3 FSAR Figure 2.5-23 (p. 2.5-336), which is referred to in FSAR Section 2.5.1.1.4.4.2, Paleozoic Tectonic Structures, there are several overlapping interpretations of fault lines and it is difficult to understand what the double lines mean with respect to the discussion in text. Please simplify and integrate aspects of the figure with the discussion in the text in Section 2.5.1.1.4.4.2.

Also, in FSAR Section 2.5.1.1.4.4.2, the text states, "The northeast-striking Little North Mountain Fault Zone [LNMF] is located within the eastern Valley and Ridge Physiographic Province of western Virginia, eastern Maryland, and southern Pennsylvania (Figure 2.5-16 and Figure 2.5-23)." The LNMF is not actually identified on Figure 2.5-16. Please revise the figure to clearly show the LNMF.

02.05.01-41

The following questions apply to CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.2.1, Appalachian Structures.

a. On page 2.5-42, the text states, "The Hylas shear zone also locally borders the Mesozoic Richmond basin and appears to have been reactivated during Mesozoic extension to accommodate growth of the basin (Figure 2.5-10)." Since the fault was reactivated during Mesozoic time please address this structure in the Mesozoic section rather than in the section about Paleozoic structures. Please provide additional citations including more recent interpretations about this tectonic structure based on published literature.

b. On page 2.5-42, the text states, "Subsequent studies performed during the North Anna ESP (Dominion, 2004a) on the activity of the Everona-Mountain Run fault system indicate that this fault system is not a capable tectonic source (Section 2.5.1.1.4.4.5.2)." Please summarize in FSAR Section 2.5.1.1.4.4.2.1 or 2.5.1.1.4.4.5.2 the pertinent details from that document. Also, please clarify the name and extent of the fault; is it the Mountain Run Pleasant Grove system or is it the Everona Mountain Run fault system?

c. On page 2.5-42, the text states, “The Brookneal shear zone is located within the Piedmont in Virginia and probably extends beneath the Coastal Plain across Virginia and Maryland to within about 50 mi (80 km) of the site (Figure 2.5-16 and Figure 2.5-23).” This feature is not labeled on Figure 2.5-16. Please revise figure to identify the Brookneal shear zone.

d. On page 2.5-42, the text states, “Southwest of the site region, the Mesozoic Danville basin locally coincides with the Brookneal shear zone, suggesting that portions of the Paleozoic fault may have been reactivated as normal faults in the Triassic period.” Please provide more information about how this correlation was determined and provide a reference for this interpretation.

e. On page 2.5-43, the text states, “The fault [Spotsylvania] juxtaposes terranes of different affinity, placing continental rocks of the Goochland terrane to the east against volcanic arc rocks of the Chopawamsic terrane to the west.” Please provide more details about this structure. What is the likely geologic age for movement on this fault? How is it genetically linked with the Central Piedmont suture?

02.05.01-42

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.2.2, Coastal Plain Structures (p. 2.5-43), the text states, “The western fault zone coincides with the margins of the Sussex Terrane of Horton (Horton, 1991) (Figure 2.5-16 and Figure 2.5-17).”

a. The western and eastern fault zones are not indicated on either figure. The Sussex Terrane is barely discernable on Figure 2.5-16. Please revise the figures to support the text.

b. The text also states on p 2.5-43, “The eastern fault zone is shown to extend from coastal North Carolina to southern Delaware, trending north along the eastern part of southern Chesapeake Bay before branching into two splays that trend northeast across the Delmarva Peninsula (Figure 2.5-16 and Figure 2.5-23).” This aspect of the fault is not indicated on either figure. Please revise the figures. In addition, provide a citation for this interpretation.

02.05.01-43

The following questions apply to CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.3, Mesozoic Tectonic Structures.

a. In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.3, Mesozoic Tectonic Structures, the text states (p 2.5-44), “These Mesozoic rift basins, also commonly referred to as Triassic basins, exhibit a high degree of parallelism with the surrounding structural grain of the Appalachian orogenic belt. The parallelism generally reflects reactivation of pre-existing Paleozoic structures (Ratcliffe, 1986).” There are several more recent publications about Eastern United States rift basins, such as Schlische, 2003, *in* The great rift valleys of Pangea in eastern North America, Columbia Univ. Press, pp 21-64; Schlische and Withjack, 2005, GSA Bulletin, v 117, no. 5/6, pp 823-832; Faill, 2003, GSA Bulletin, v.115, pp 406-421; Schlische et al, 2003, AGU Monograph 136, pp. 33-59; Withjack et al, 1998, AAPG Bulletin, v 82, no 54, pp 817-835. Please provide a discussion of the recent research in this area.

b. The text states (p 2.5-44), “The geometry and continuity of buried rift basins beneath the Coastal Plain and Continental Shelf is not clear, but the recognition and interpretation of these basins have expanded since the EPRI (1986) study. In addition to the identification of new basins since 1986, several alternative geometries have been proposed for the site region (Figure 2.5-10 and Figure 2.5 16) (Horton, 1991) (Benson, 1992) (Klitgord, 1995) (Withjack, 1998) (LeTourneau, 2003).” The evidence for and against interpreting rift basin structure beneath the CCNPP is not adequately developed. This is an important part of the site characterization because there are many rift basins all around the site. There is not a single section in the FSAR, supported by figures (maps and or cross sections), that adequately addresses the issue of whether a rift basin exists beneath the CCNPP. Please provide additional discussion of this issue. Further, specific faults have not been identified in this section. Subsurface geometry of the boundary faults for any of these structures and whether or not they lie beneath the site may impact the site response analysis. Please provide additional discussion of the faults associated with the basins.

02.05.01-44

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4, Tertiary Tectonic Structures, the text states, “The 35-million year old Chesapeake Bay impact crater is a 56 mi (90 km) wide, complex peak-ring structure defined by a series of inner and outer ring faults, some of which penetrate the Proterozoic and Paleozoic crystalline basement rocks (Powars, 1999).”

Please provide some illustration of the ring faults and their basement geometry. Provide a discussion about the potential for impact crater faults to become seismogenic within the host tectonic regime.

02.05.01-45

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.1, Stafford Fault of Mixon, et al., the text states (p 2.5-46), “The Stafford fault (#10 on Figure 2.5-31) approaches within 47 mi (76 km) southwest of the site (Figure 2.5-25).” Figure 2.5-31 only shows numerical points on a regional map and doesn't show the traces of the several faults that comprise the Stafford fault system.

a. In Figure 2.5-31, the numbered features from the legend are faults yet it is unclear what map feature (a line, a triangle or a filled circle) the numbers are identifying. Does #8 identify a triangle, a line or a filled circle? Why is the Stafford fault system of Marple a line and the Stafford fault system of Mixon a number (10)? Please provide clarification.

b. Figure 2.5-25 has traces for the Stafford fault but the individual faults are not identified. Please provide a more detailed map of these tectonic features that supports the various discussions in the text. Include the fault geometry information such as movement direction and dip orientation. Describe the evidence supporting the interpretation of these faults. Provide more explanation about the surficial geologic units that are involved with the determination of age of faulting.

c. On page 2.5-46, the text states, "Detailed drilling, trenching, and mapping in the Fredericksburg region by Dames and Moore (DM, 1973) showed that the youngest identifiable fault movement on any of the four primary faults comprising the Stafford fault system was pre-middle Miocene in age" (>16.4 Ma). Please provide more details about how this conclusion was made.

d. The discussion about the Stafford fault system states (3rd paragraph, p. 2.5-46), "Both offsets suggest southeast-side-down displacement (Mixon, 1978)." A previous statement about the Stafford fault system indicated the faults were transpressional faults and dipping to the northwest (1st paragraph, 3rd sentence, p 2.5-46). Please resolve the change in interpretation to a down-to-southeast (and implied normal faulting). What stresses are thought to be responsible for the formation of the fault system active until the late Tertiary period?

e. The text states (p. 2.5-46), "Geomorphic analyses (structure contour maps and topographic profiles) of upland surfaces capped by Neogene marine deposits and topographic profiles of Pliocene and Quaternary fluvial terraces of the Rappahannock River near Fredericksburg, Virginia, indicate that these surfaces are not visibly deformed across the Stafford fault system (Dominion, 2004a)." Please provide more details from the Dominion, 2004a study that resolved uncertainty of movement history on the faults, and support the discussion with illustrations of some of these data and discuss how the final interpretations were drawn.

02.05.01-46

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.2, Brandywine Fault System, the text states (p.2.5-47): "The mapped trace of the Brandywine fault system coincides with the western margin of the Taylorsville basin (Mixon, 1977) (Hansen, 1986) (Wilson, 1990). This observation lead Mixon and Newell (Mixon, 1977) to speculate the origin of the Brandywine fault system may be related to the reversal of a pre-existing zone of crustal weakness (i.e., Taylorsville Basin border fault)."

Please expand on this discussion of the Brandywine fault system that includes the origin and tectonic setting of the fault system. Include whether the Brandywine fault is the Taylorsville basin boundary fault, whether it reactivated in a compressional stress field during Cenozoic time, and whether there is any research that interprets the faults as reactivated Paleozoic (Pz) faults.

02.05.01-47

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.5, Hillville Fault Zone, the text states, "The 26 mi (42 km) long, northeast-striking fault zone is composed of steep southeast-dipping reverse faults that align with the east side of the north-to northeast-trending Sussex-Currioman Bay aeromagnetic anomaly (i.e. SGA, Figure 2.5-22)."

a. Please plot the Hillville fault on Figure 2.5-10 and on Figure 2.5-11.

b. Is there any other data beyond the seismic reflection line supporting the extension/projection of the fault from the seismic line to the northeast of the CCNPP?

c. The text also states (p. 2.5-50), "The fault zone is interpreted as a lithotectonic terrane boundary that separates basement rocks associated with Triassic rift basins on the west from low-grade metamorphic basement on the east (i.e., Sussex Terrane/Taconic suture of Glover and Klitgord, (Glover, 1995a) (Figure 2.5-17) (Hansen, 1986)." Does the seismic reflection data show offset on the basement/Coastal Plain contact? Also, does the seismic reflection profile allow for the interpretation of rift basin reflectors beneath the CP Section either to the east or west of the fault zone?

02.05.01-48

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.6, Unnamed Fault beneath Northern Chesapeake Bay, Cecil County, Maryland (p 2.5-51) the text briefly describes a young fault near CCNPP and cites Pazzaglia's interpretation.

a. Please explain in more detail the basis for Pazzaglia's interpretation and include pertinent figures to illustrate his technical points, including geologic maps and river terrace cross sections. Please include Pazzaglia's latest publications on this feature and the geology of the area (see http://www.lehigh.edu/~fjp3/reprints.html).

b. The text then states, "This fault is unconfirmed based on the lack of direct supporting evidence. First, the fault has not been observed as a local discontinuity on land. Second, the correlation of gravels is permissible based on the data, but has not been confirmed by detailed stratigraphic or chronologic studies. Geologic mapping of the area (Higgins, 1986) shows Miocene Upland gravels along the northeast mouth of the Susquehanna River where Pazzaglia (Pazzaglia, 1993) maps the Quaternary Pennsauken Formation."

Please provide further explanation of your statements that discount Pazzaglia's interpreted fault. Include geologic maps, cross sections or other kinds of figures to illustrate your counterpoints to Pazzaglia's interpretation. Please explain Higgins' 1986 alternative interpretation of the geology in the area. Please provide a small, detailed portion of the available LiDAR (Light Detection and Ranging) data in a figure to show this portion of the Chesapeake Bay shorelines and landscape, with the trace of the interpreted fault trace posted.

02.05.01-49

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.7, Unnamed Monocline beneath Chesapeake Bay, the text states, "Based on these physiographic, geomorphic and geologic observations, McCartan (McCartan, 1995) infer the presence of a fold along the western shore of Chesapeake Bay (Figure 2.5-25)."

a. Please explain how McCartan justifies the monocline on the west shore of the Patuxent river.

b. In the same FSAR section, the text states, “Field and aerial reconnaissance, coupled with interpretation of aerial photography and LiDAR [Light Detection and Ranging] data (see Section 2.5.3.1 for additional information regarding the general methodology), conducted during this COL study, shows that there are no geomorphic features indicative of folding directly along the western shores of Chesapeake Bay.” The LiDAR data presented in the FSAR, Figure 2.5-26, is at the wrong scale to examine the features discussed in this section. Please provide a LiDAR figure at a larger scale to see details of topography and post McCartens monoclines, Pazzaglia's faults, and Hansen's Hillville fault on the LiDAR.

02.05.01-50

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4.8, Unnamed Folds and Postulated Fault within Calvert Cliffs, Western Chesapeake Bay, Calvert County, Maryland, the text states (p. 2.5-54), “The hypothesized fault is not exposed in the cliff face and is based entirely on a change in elevation and bedding dip of Miocene stratigraphic boundaries projected across the fluvial valley of Moran Landing. Kidwell (Kidwell, 1997) postulates that the fault strikes northeast and exhibits a north-side down sense of separation across all the geologic units (Miocene through Quaternary). With regard to the apparent elevation changes for the Pliocene and Quaternary unconformities, these can be readily explained by channeling and highly irregular erosional surfaces (Figure 2.5-30).”

a. Please provide additional explanation, along with illustrations and maps, to illustrate how the Kidwell interpretation can be discounted and must be interpreted as an erosional surface rather than as a tectonic structure.

b. In the same FSAR section, the text states, “Field and aerial reconnaissance, coupled with interpretation of aerial photography and LiDAR [Light Detection and Ranging] data (see Section 2.5.3.1 for additional information regarding the general methodology), conducted during the CCNPP Unit 3 investigation shows that there are no geomorphic features indicative of potential Quaternary activity developed in the Pliocene-Quaternary surfaces along a southeast projection from Chesapeake Bay across the Patuxent and Potomac Rivers (Figure 2.5-26).” Please provide a legible, enlarged version of Figure 2.5-26 so that the specific geomorphic features associated with Pliocene-Quaternary surfaces can be examined.

02.05.01-51

The following requests pertain to CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.5, Quaternary Tectonic Features.

a. On page 2.5-56, the text states, “The Everona-Mountain Run fault zone and Stafford fault of Mixon (Mixon, 2000) also are discussed in detail in previous Section 2.5.1.1.4.4.2 (Paleozoic Structures) and Section 2.5.1.1.4.4.4.1 (Tertiary Structures).“ Please discuss any evidence of Quaternary movement on either of these faults.

b. In FSAR Section 2.5.1.1.4.4.5.1, Fall Lines of Weems (1998), the text states, “In summary, based on review of published literature, field reconnaissance, and geologic and geomorphic analysis performed previously for the North Anna ESP application, the fall lines of Weems (1998) are erosional features related to contrasting erosional resistances of adjacent rock types, and are not tectonic in origin, and thus are not capable tectonic sources." The Dominion (2004b) work challenged of the existence of the northern segment of the fall lines. Please provide more geologic details about the Dominion work, both text and figures, in order for staff to evaluate the impact specifically to CCNPP Unit 3.

c. In FSAR Section 2.5.1.1.4.4.5.2, Everona-Mountain Run Fault Zone, the text states, "The Mountain Run fault zone is located along the eastern margin of the Culpeper Basin and lies approximately 71 mi (114 km) southwest of the site (Figure 2.5-17 and Figure 2.5-31)." Figures 2.5-17 shows the Everona-Mountain run fault zone in relation to the Blue Ridge province and the Potomac melange but does not show relationship to the Culpeper Basin. Figure 2.5-31 shows the fault as a triangle adjacent to the Fall Lines of Weems. Please provide a figure to adequately illustrate the position of this fault in relation to the Culpeper Basin as discussed in this section at an appropriate scale to support the text.

d. On page 2.5-42, in a previous discussion of this fault in FSAR Section 2.5.1.1.4.4.2.1, the fault is described as underlying the Culpeper basin. Please resolve/integrate the descriptions in FSAR Sections 2.5.1.1.4.4.2.1 and FSAR Section 2.5.1.1.4.4.5.2.

e. On page 2.5-57, the text states, "The northeast-striking Mountain Run fault zone is moderately to well-expressed geomorphically (Pavlides, 2000). Two northwest-facing scarps occur along the fault zone, including: (1) the 1 mi (1.6 km) long Kelly's Ford scarp located directly northeast of the Rappahannock River and; (2) the 7 mi (11 km) long Mountain Run scarp located along the southeast margin of the linear Mountain Run drainage." These observations/interpretations appear to be in conflict with more recent work done for the North Anna ESP, in which Dominion (2004a) concluded that the scarps are not fault scarps but resulted from fluvial erosion. Please integrate the earlier interpretations of Pavlides with Dominion's more recent work for the North Anna ESP.

f. On page 2.5-57, the text states, "The Everona fault is located about 0.5 mi (0.8 km) west of the Mountain Run fault zone." Please provide a figure showing the lithotectonic units of the Everona fault and the Mountain Run fault system on the same map to support the discussion in the text. Please locate the CCNPP site on the figure if possible.

g. On page 2.5-58, the text states, "Based on the findings of the previous studies performed for the North Anna ESP and approval by the Nuclear Regulatory Commission (NRC, 2005), it is concluded that the Everona-Mountain Run fault zone is not a capable tectonic source." The NRC made conclusions about the North Anna ESP for the Mountain Run fault zone. The CCNPP Unit 3 FSAR is linking the Everona fault to that system. Please clarify fault zone nomenclature in all relevant FSAR sections.

02.05.01-52

The following requests pertain to CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.4, Tertiary Tectonic Structures and 2.5.1.1.4.4.5, Quaternary Tectonic Features.

a. In CCNPP Unit 3 FSAR Section 2.5.1.1.4.4.5.3, Stafford Fault of Mixon, et al. the text states: "No new significant information has been developed since 1986 regarding the activity of the Stafford fault system with the exception of the response to an NRC RAI for the North Anna ESP (Dominion, 2004a)." The statement above appears to contradict the statements about this fault on p. 2.5-46 that describe ages of movement based on Mixon's 2000 work on various individual faults of this system. Please resolve the apparent discrepancy.

b. FSAR Section 2.5.1.1.4.4.5.4 describes the structural and neotectonic aspects of the Ramapo Fault System. There are many newer papers that describe structural/neotectonic investigations as well as analysis of emerging seismic patterns. Please provide more details about the history of associated seismicity, including a review of the scientific literature for this section such as: Sykes et al, 2008, Bulletin SSA, vol 98, no 4, pp 1696-1719; Withjack et al, 1998 (this FSAR); Schlische, 2003, (this FSAR); Schlische and Withjack, 2005, GSA Bulletin, v. 117, no. 5/6, pp 823-832. Also, please provide more detailed figures than are currently provided in Figures 2.5-10 and 2.5-31.

c. In FSAR Section 2.5.1.1.4.4.5.6, New York Bight Fault, the text (p 2.5-60) states, "Seismic reflection profiles indicate that the fault originated during the Cretaceous and continued intermittently with activity until at least the Eocene." Benson, 1992 shows a fault on the seaward side of a continental shelf Mesozoic basin, named the New York Bight basin. He cites Hutchinson et al, 1986. Please expand the discussion on this fault to include the geologic and tectonic setting. Please explain how the seismic reflection information suggests movement on a fault from Cretaceous through Eocene.

d. In FSAR Section 2.5.1.1.4.4.5.7, Cacoosing Valley Earthquake Sequence, the text states, "Focal mechanisms associated with the main shock and aftershocks define a shallow subsurface rupture plane confined to the upper 1.5 mi (2.4 km) of the crust." Please describe the orientations of the nodal planes and the interpreted fault movement type.

e. In FSAR Section 2.5.1.1.4.4.5.8, New Castle County Faults, the text states, "The New Castle faults are characterized as 3 to 4 mi (4.8 to 6.4 km) long buried north and northeast-striking faults that displace an unconformable contact between Precambrian (PC) to Paleozoic (Pz) bedrock and overlying Cretaceous deposits." Please clarify the meaning of this statement. Does the fault offset PC and Pz rock or does the fault penetrate up to and including Cretaceous layers?

f. In FSAR Section 2.5.1.1.4.4.5.8, the text also states, "On the basis of geophysical and borehole data, coupled with Vibroseis™ profiles, Spolijaric (Spolijaric, 1973) (Spolojaric, 1974) interprets a 1 mi (1.6 km) wide, N25°E-trending graben in basement rock. The graben is bounded by faults having displacements on the order of 32 to 98 ft (10 to 30 m) across the basement-Cretaceous boundary (Spoljaric, 1972)." Please provide more details and figures for this discussion that show the surface projection (map) of the graben structure. Include the Delaware Geo Survey infomation: seismic lines, trench locations and trench cross sections.

g. In FSAR Section 2.5.1.1.4.4.5.14, East Coast Fault System, the following statement is made about the East Coast Fault Zone and the Charleston source (page 2.5-64): "A review of the seismic sources that contribute 99% of the seismic hazard to the CCNPP shows that the Charleston source is not a contributor." This statement seems to be contradicted by another statement in FSAR Section 2.5.2.2 (page 2.5-99), which reads: “Although the Charleston source lies outside the site region (200-mi radius), a preliminary sensitivity analysis performed for the CCNPP Unit 3 site shows that this source is a significant contributor of low frequency (1 Hz) ground motion, and thus the Charleston source has been included in the PSHA study for the site.” Please clarify the apparent contradiction between these two statements and revise the FSAR accordingly.

02.05.01-53

In CCNPP Unit 3 FSAR Section 2.5.1.1.4.5, Seismic Sources Defined by Regional Seismicity, the text provides information on 2 seismic sources within the CCNPP 200 mile radius.

a. Please provide geologic information about the geologic and tectonic setting for seismic sources contributing significantly to the CCNPP evaluation for the new, updated Charleston source, the Newark-Gettysburg Rift basins, and the Connecticut Basin.

b. In FSAR Section 2.5.1.1.4.5.1 the text provides information about the Central Virginia Seismic Zone. Please provide additional illustrations of the various interpretations of several investigators presented by the applicant for this source including: seismicity, locations of Spotsylvania fault, diabase dike swarm, 2 paleoliquefaction sites, Shenandoah fault and Norfolk fracture zone. In addition, illustrate the size and depth distribution of the earthquake catalog for this source, indicating the likely depth of the Appalachian detachment.

c. In FSAR Section 2.5.1.1.4.5.2, the text provides information about the Lancaster Seismic Zone (LSZ). The text states, “The seismic zone is about 80 mi (129 km) long and 80 mi (129 km) wide and spans a belt of allochthonous Appalachian crystalline rocks between the Great Valley and Martic Line about 111 mi (179 km) northwest of the CCNPP site (Figure 2.5-31).” Figure 2.5-31 only shows Earthquakes and a numerical symbol. Please illustrate the tectonic/geologic setting of this seismic zone. Include focal mechanisms, the boundaries of the Great Valley, Martic line and other geo/tectonic features discussed in the text for the LSZ.

d. In FSAR Section 2.5.1.1.4.5.2 (p.2.5-66), the FSAR provides information on the Cacoosing Earthquake sequence and states, “These dikes are associated with many brittle faults and large planes of weakness suggesting that they too have an effect on the amount of seismicity in the Lancaster seismic zone. Most of the seismicity in the Lancaster Seismic Zone is occurring on secondary faults at high angles to the main structures of the Appalachians.” Please provide a reference for this interpretation.

02.05.01-54

CCNPP Unit 3 FSAR Section 2.5.1.2.2 provides information about the site area geologic history. Three quotations out of the text follow. First, the text states, “Sparse geophysical and borehole data indicate that the basement rock beneath the site may consist of exotic crystalline magmatic arc material (Glover, 1995b).” The text also states, “Tectonic models discussed in Section 2.5.1.2.4 hypothesize that the crystalline basement was accreted to the pre-Taconic North American margin during the Paleozoic along a suture that lies about 10 mi (16 km) west of the site (Figure 2.5-17 and Figure 2.5-23)." The text also states, "The Queen Anne Basin was originally postulated by Hansen (1988) and was considered to underlie the site (Horton, 1991). However, this interpretation does not appear to be supported by most of the borehole data and current interpretations (Section 2.5.1.2.4)."

The basement beneath the CCNPP and in the vicinity is geo/tectonically complex because of an extended tectonic history and further complicated by limited data. Please provide a more developed discussion about what is directly below the CCNPP with respect to the concept of extended continental crust and transitional continental crust and about the various interpretations of the positions of Mesozoic rift basins and their boundary faults. Please clarify why the final interpretation of "no basin" below the site is the preferred interpretation. Please verify that the most current research has been taken into account.

02.05.01-55

CCNPP Unit 3 FSAR Section 2.5.1.2.4, Site Area Structural Geology, provides a description of the nearby Hillville fault.

a. The text states on p. 2.5-75, "A seismic line imaged a narrow zone of discontinuities that vertically separate basement by as much as 250 ft (76 m) (Hansen, 1978)." Please provide this seismic reflection line and provide a more thorough discussion about the interpretation of the seismic line.

b. The text states, "The Hillville fault may represent a Paleozoic suture zone that was reactivated in the Mesozoic and Early Tertiary." Please provide the reference for this interpretation. Please explain whether or not the Hillville fault is a basin boundary fault that could dip beneath the CCNPP. Please plot the fault on Figure 2.5-10.

c. The text states, "Based on stratigraphic correlation between boreholes within Tertiary Coastal Plain deposits, Hansen and Edwards (Hansen, 1986) . . . ." Please provide an illustration of the correlated boreholes.

d. The text states, "The unnamed monoclines are not depicted on any geologic maps of the area, including those by the authors, but they are shown on geologic cross sections that trend northwest-southeast across the existing site and south of the CCNPP site near the Patuxent River (McCartan, 1995) (Figure 2.5-25)." Please check the reference to Figure 2.5-25 or whether Figure 2.5.-40 should be listed as the reference.

02.05.01-56

In CCNPP Unit 3 FSAR Section 2.5.1.2.6.3, Deformational Zones, the text states, "Excavation mapping is required during construction and any noted deformational zones will be evaluated." Please elaborate on your plans to map the excavation as any deformation features identified must be assessed for potential surface rupture and ground motion.