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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI 229, Question 02.05.04-20, Stability of Subsurface Materials and Foundations

Reference: Surinder Arora (NRC) to Robert Poche (UniStar Nuclear Energy), "FINAL RAI 229 RGS1 4566" email dated April 30, 2010

The purpose of this letter is to respond to the request for additional information (RAI) identified in the NRC e-mail correspondence to UniStar Nuclear Energy, dated April 30, 2010 (Reference). This RAI addresses Stability of Subsurface Materials and Foundations, as discussed in Section 2.5.4 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 Combined License Application (COLA), Revision 6.

Enclosure 1 provides our response to RAI 229, Question 02.05.04-20. Enclosure 2 provides six DVDs with bearing capacity and settlement calculations, as well as other requested computer files identified during the March 16-17, 2010 CCNPP Unit 3 site audit.

UniStar Nuclear Energy requires additional time to finalize the responses to RAI 229, Questions 02.05.04-17 through 02.05.04-19. A response to these questions will be provided to the NRC by July 9, 2010.

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NRO

Our response does not include any new regulatory commitments and does not impact COLA content.

This letter does not contain any sensitive or proprietary information.

If there are any questions regarding this transmittal, please contact me at (410) 470-4205, or Mr. Wayne A. Massie at (410) 470-5503.

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

Executed on May 20, 2010

Christian Clement for

Greg Gibson

Enclosures:

1) Response to NRC Request for Additional Information RAI 229, Question 02.05.04-20, Stability of Subsurface Materials and Foundations, Calvert Cliffs Nuclear Power Plant, Unit 3

2) Six DVDs containing bearing capacity and settlement calculations and associated computer model files for Calvert Cliffs Nuclear Power Plant, Unit 3

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn, NRC Environmental Project Manager, U.S. EPR COL Application
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Loren Plisco, Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
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GTG/RDS/stt

Enclosure 1

Response to NRC Request for Additional Information
RAI 229, Question 02.05.04-20,
Stability of Subsurface Materials and Foundations,
Calvert Cliffs Nuclear Power Plant, Unit 3

RAI 229

Question 02.05.04-20

In order for staff to conduct confirmatory analyses, please provide bearing capacity and settlement calculation documents, such as: CCNPP unit 3 Power Block Area Settlement (09-4179.01-F22), Bearing Capacity of Safety Related Buildings at CCNPP Unit 3 (09-4179.01-F25) and other documents, as well as computer files, identified during the March 16-17, 2010 site audit as needed for confirmatory analyses.

Response

The bearing capacity and settlement calculations, as well as the computer files identified during the March 16-17, 2010 CCNPP Unit 3 site audit, are contained on the six DVDs provided in Enclosure 2 to this letter.

DVD 1, entitled "14 Calculations Issued for CCNPP 3," includes the electronic copies of the requested calculations given in PDF format. DVDs 2 through 6 contain computer model (Plaxis 3D) files used for the CCNPP Unit 3 Settlement Analysis described in Calculation F22 (ED, LT, MT1, MT2, and HT Models).

A description of the five Plaxis model files, in addition to what is included in Calculation F22 follows:

Excavation/Dewatering Models:
- DVD 2, ED Model

Post Construction (PC) Models:
- DVD 3, LT Model: Considers soil stiffness reduction from E_r to E at the end of 2^{nd} loading step (see discussion below)
- DVD 4, MT1 Model: Considers soil stiffness reduction from E_r to E at the end of 3^{rd} loading step
- DVD 5, MT2 Model: Considers soil stiffness reduction from E_r to E at the end of 4^{th} loading step
- DVD 6, HT Model: Considers soil stiffness reduction from E_r to E at the end of 5^{th} loading step

1.1 Components of ED Model

1.1.1 Geometry: The geometry of the powerblock area is according to Figures 1 and 2 of Calculation F22 of CCNPP3.

1.1.2 Boring Info Used: Data from boreholes B349, B314, B305, B302, B301, B303, B309, B320, B790, B304, B307, B327, B330, B333, B311, B313, B334, B335, B344, and B357A was included to adequately represent the three-dimensional nature of the model. In total, data from 20 boreholes was used. The following assumptions were made while incorporating the soil borings into the model:

Boreholes along sections AA' (Figure 7 of Calculation F22) and BB' (Figure 8 of Calculation F22) were assumed to lie on straight lines.

- Only three borings out of 20 have a part of Chesapeake IIa clay layer below El. 41.5 ft (7.8 ft thick for B313, 2.2 ft thick for B314, and 0.8 ft thick for B335). For these three borings, the section of the Chesapeake IIa clay layer below El.41.5 ft was assumed to be Chesapeake Stratum IIb Sand Layer 1 (for practical purposes).
- Thin clay layers between Chesapeake Stratum IIc Sand Layer and Chesapeake Stratum IIb Sand Layer 3 were occasionally replaced with the Chesapeake Stratum IIc Sand Layer. The comparison of profiles obtained from bore holes and the profile used in Plaxis analysis are given in Figures 7 and 8 of Calculation F22 for profiles AA' and BB', respectively.

1.1.3 Workplanes: Six workplanes are used in the Model at El. 80 ft, El. 63 ft, El. 60 ft, El. 45 ft, El. 41 ft, and El. 38 ft. These workplanes are used to define foundations, water pressures, etc.

1.1.4 Soil Properties: Soil properties shown in Table 7 of Calculation F22 are used in the model. The modulus used was E_r.

1.1.5 Meshing: The global meshing setting in the vertical and horizontal directions are set to very fine and fine, respectively. The loaded clusters (polygons in the model) are refined one more time.

1.1.6 Foundations: No foundations or walls are used in this model.

1.1.7 Groundwater: The groundwater elevation is defined as El. 69 ft on the entire modeled area. This input was changed in the staged construction module.

1.1.8 Boundary Conditions: Default boundary conditions of roller support on the sides of the model, and hinged support at the bottom of the model were used.

1.1.9 Staged Construction Input (Calculation Interface):

1.1.9.1 Initial Phase – Gravity Loads: The gravitational stresses are assumed to be level at El. 80 ft for the entire site.

1.1.9.2 Initial Configuration – Initial Ground Surface Input: The final model geometry of the stage is in accordance with Figure 6 of Calculation F22. The groundwater setting for this stage is in accordance with the following description. Existing groundwater elevations and water pressure profile are summarized in Section 3–1 on pp 7 of Calculation F22. Given the water pressure options available in Plaxis and the groundwater configuration reported for the site, the water pressure distribution shown in Figure 1 (below) is modeled in Plaxis.

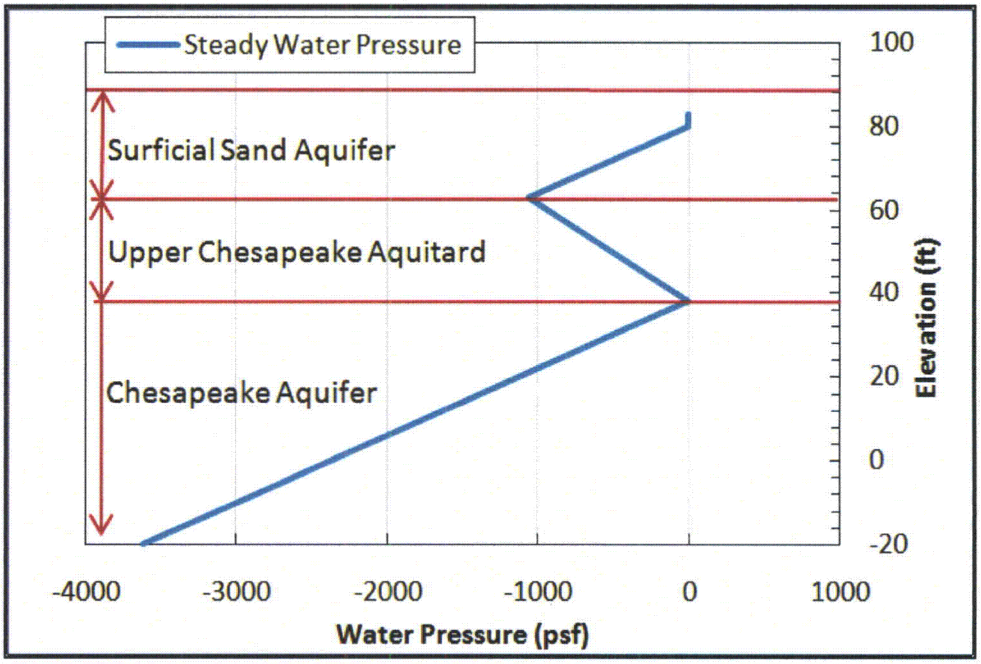

Figure 1. Modeled water pressures in Plaxis (negative sign indicates compression).

Two distinct zones are identified: groundwater table at El. 80 ft (zones II and III in Fig. 6 of Calculation F22) and groundwater table at El. 60 ft (zone I in Figure 6 of Calculation F22, where the ground surface is also at El. 60 ft). Initial water pressures in these two zones are modeled in Plaxis as follows:

- El. 80 ft Workplane (only zones II and III): Zero at El 80 ft, and linearly increases with depth at 62.4 $lb/ft^2/ft$
- El. 63 ft Workplane (only zones II and III): Interpolated according to the adjacent clusters in the vertical direction
- El. 60 ft Workplane: Interpolated according to the adjacent clusters in the vertical direction
- El. 45 ft Workplane: Interpolated according to the adjacent clusters in the vertical direction
- El. 41 ft Workplane: Interpolated according to the adjacent clusters in the vertical direction
- El. 38 ft Workplane: Zero at El. 38 ft, and increase linearly increasing with depth at 62.4 $lb/ft^2/ft$

Final water pressure configuration after excavation includes the removal of all the water above El. 41.5 ft in the excavated power block area. Outside the excavated power block area, the water pressures are equal to the initial pressures.

1.1.9.3 Excavation: The final model geometry of this stage is in accordance with the topography shown in Figure 6 of Calculation F22. The final groundwater profile has zero water pressure at El. 38 ft which increases linearly with depth at 62.4 lb/ft^2/ft in the power block area. Outside the power block area the groundwater profile at each workplane is the same as what is described in Section 9-2. The deformation analysis type for this stage is set to "plastic" which stands for immediate settlements.

1.1.9.4 Consolidation: Every input for this stage is the same as Section 9-3. The calculation type is set to "consolidation" and the time frame is set to ultimate consolidation. This stage is set up to compute the total heave due to dissipation of the negative excess pore pressures generated due to Excavation stage (9-3) (dissipation of positive excess pore pressure results in compression, whereas dissipation of negative excess pore pressure results in heave). The criterion for the end of consolidation is to have the excess pore pressure be less than 1 psf.

1.1.9.5 Consolidation in 6 months: This stage starts after the Excavation stage with every input being the same, and is used to compute the consolidation related heave in 6 months. The calculation type is "consolidation" and the duration is 6 months.

1.1.9.6 Consolidation in 12 months: This stage starts after Excavation stage with every input being the same, and is used to compute the consolidation related heave in 12 months. The calculation type is "consolidation" and the duration is 12 months.

1.2 Components of PC Models

1.2.1 Geometry: The geometry of the powerblock area is according to Figures 1 and 2 of Calculation F22 of CCNPP3.

1.2.2 Boring Info Used: Please see Section 1.1.2 of this response.

1.2.3 Workplanes: Nine workplanes are used in the Model at El. 83 ft, El. 76 ft, El. 66.5 ft, El. 61 ft, El. 60.5 ft, El. 48 ft, El. 47 ft, El. 41 ft, and El. -400 ft. These workplanes are used to define foundations, water pressures, etc.

1.2.4 Soil Properties: Soil properties shown in Table 7 of Calculation F22 are used in the model. Modeled interfaces between two successive soil layers are not necessarily horizontal. The use of Mohr Coulomb (MC) constitutive model assumes a constant stiffness throughout time for each layer. In order to overcome this limitation, the model was set up to run up to the end of a certain step with unloading/reloading soil stiffness, E_r, (please see the discussion below for the definition of this particular loading step), results are saved and the soil stiffness is changed to primary loading stiffness, E, in the input module. This provides a way to change soil stiffness throughout time. The following items summarize the loading step after which each model has a change in soil stiffness from E_r to E:

(a) LT model – at the end of 2nd loading step
(b) MT1 model – at the end of 3rd loading step
(c) MT2 model- at the end of 4th loading step
(d) HT model – at the end of 5th loading step

Since the model input stiffness is changed at the end of these loading steps, the software remembers the latest stiffness and there is no direct way of checking which stiffness was used in the first several loading steps of the run after the calculation is finished, except if the checker is present to witness the change of the stiffness input (another individual than the person running the model). Also, the initial portion of the settlement profile as a function of time (Figure 38 in Calculation F22) indirectly indicates the time step when the stiffness is changed.

In summary, in order to reproduce the attached model results, the soil stiffness should be E_r (Table 7 of Calculation F22) until the time specified for each model, and be changed to E (Table 7 of Calculation F22).

1.2.5 Meshing: The global meshing setting in the vertical and horizontal directions is set to very fine and fine, respectively. The loaded clusters (polygons in the model) are refined one more time in the horizontal direction.

1.2.6 Foundations and Walls: Foundation stiffness is expected to increase as the construction of the structure proceeds. Initial foundation stiffness configuration for all models includes a 6-ft thick foundation with E = $5.8\text{x}10^8$ psf without the reinforcing walls on the nuclear island (Figure 16 of Calculation F22). In each one of the attached PC models, the foundation stiffness is increased at the end of 2nd loading step, and at the end of 3rd loading step in a following manner:

(a) At the end of 2nd loading step – the foundation thickness is increased from 6 ft to 10 ft, E is increased from $5.8\text{x}10^8$ psf to $2.0\text{x}10^{10}$ psf.
(b) At the end of 3rd loading step – keeping the foundation thickness and E the same, reinforcing walls (Table 4 in Calculation F22) are activated on the nuclear island.

Ideally, the second stiffness increase outlined in item (b) should include thickness and E increase. However, numerical problems arise in cases of too different foundation and soil stiffnesses. Having reinforcing walls on top of the foundation element also improves the foundation stiffness. Quantifying stiffness increase is not easy, but the deformation profile with reinforcing walls resembles the rigid foundation behavior more than the flexible foundation behavior. The nuclear island foundation is anticipated to behave more in a rigid manner, thus the reinforcing walls are included only in the nuclear island.

1.2.7 Groundwater: Initial geometry for the PC model involves uniform ground surface elevation at El. 41.5 ft in the power block area, and El. 80 ft outside the power block area. The groundwater table is modeled at El. 38 ft inside the power block area and at El. 69 ft outside the power block area.

1.2.8 Boundary Conditions: Default boundary conditions of roller support on the sides of the model, and hinged support at the bottom of the model were used.

1.2.9 Staged Construction:

1.2.9.1 Initial Phase – Gravity Loads: The gravitational stresses are assigned as if the entire site is level at El. 80 ft.

1.2.9.2 Excavation – Initial Site Topography: The site geometry is modeled so that the ground surface is at El. 41.5 ft inside the power block area and at El. 80 ft uniformly everywhere outside the power block area (please note that having a Mohr Coulomb constitutive model implies stiffness does not depend on the overburden stress in this model). The groundwater elevation is at El. 38 ft inside the power block area and 69 ft everywhere outside the power block area. The calculation type for this stage was "plastic" since the deformations for this stage are not considered.

1.2.9.3 Loading Step 1 - Construction: The building loads are applied according to Table 3 of Calculation F22. The backfill placement needed between El. 41.5 ft and El. 48 ft in the power block area will be according to building foundation elevations given in Table 2 of Calculation F22. The calculation type is "consolidation" and the duration is given in Table 3 of Calculation F22. This type of calculation allows for determining immediate and consolidation settlements together. Consolidation takes place simultaneously as the load is incremented. The foundation parameters are d = 6 ft and E = 5.8 x 10^8 psf.

1.2.9.4 Loading Step 2 - Construction: The building loads are applied according to Table 3 of Calculation F22. The backfill placement needed between El. 48 ft and El. 61 ft in the power block area will be according to building foundation elevations given in Table 2 of Calculation F22. The calculation type is "consolidation" and the duration is given in Table 3 of Calculation F22.

1.2.9.5 Loading Step 3 - Construction: The building loads are applied according to Table 3 of Calculation F22. The backfill placement needed between El. 61 ft and El. 66.5 ft in the power block area will be according to building foundation elevations given in Table 2 of Calculation F22. The calculation type is "consolidation" and the duration is given in Table 3 of Calculation F22. The foundation parameters are changed to d = 10 ft and E = 2 x 10^{10} psf. For LT model, soil stiffness for all layers is reduced from E_r to E.

1.2.9.6 Loading Step 4 - Construction: The building loads are applied according to Table 3 of Calculation F22. The backfill placement needed between El. 66.5 ft and El. 76 ft in the power block area will be according to building foundation elevations given in Table 2 of Calculation F22. The calculation type is "consolidation" and the duration is given in Table 3 of Calculation F22. For MT1 model, soil stiffness for all layers is reduced from E_r to E. Reinforcing walls in the power block area are activated.

1.2.9.7 Loading Step 5 - Construction: The building loads are applied according to Table 3 of Calculation F22. The backfill placement needed between

El. 76 ft and El. 83 ft in the power block area will be according to building foundation elevations given in Table 2 of Calculation F22. The calculation type is "consolidation" and the duration is given in Table 3 of Calculation F22. For MT2 model, soil stiffness for all layers is reduced from E_r to E.

1.2.9.8 Loading Step 6 - Construction: The building loads are applied according to Table 3 of Calculation F22. The calculation type is "consolidation" and duration is given in Table 3 of Calculation F22. For HT model, soil stiffness for all layers is reduced from E_r to E.

1.2.9.9 Loading Step 7 - Construction: The building loads are applied according to Table 3 of Calculation F22. The calculation type is "consolidation" and duration is given in Table 3 of Calculation F22.

1.2.9.10 Loading Step 8 - Construction: The building loads are applied according to Table 3 of Calculation F22. The calculation type is "consolidation" and duration is given in Table 3 of Calculation F22.

1.2.9.11 Rewatering – Groundwater Recharge in Power Block Area: The groundwater elevation in the power block area is increased from El. 38 ft to El. 55 ft to account for the groundwater recharge. The groundwater elevation outside the power block area is constant at El. 69 ft.

COLA Impact

The COLA FSAR will not be revised as a result of this response.

Enclosure 2

Six DVDs containing bearing capacity and settlement calculations and associated computer model files for Calvert Cliffs Nuclear Power Plant, Unit 3