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UniStar
NUCLEAR ENERGY

10 CFR 50.4
10 CFR 52.79

March 21, 2013

UN#13-018

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 368, Foundations

References: 1) Surinder Arora (NRC) to Paul Infanger (UniStar Nuclear Energy), "CCNPP3 - Final RAI 368 SEB 6569," dated August 27, 2012

2) UniStar Nuclear Energy Letter UN#13-006, from Mark T. Finley to Document Control Desk, U.S. NRC, Updated RAI Closure Plan, dated January 30, 2013

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 August 27, 2012 (Reference 1). This RAI addresses Foundations, as discussed in Section 3.8.5 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 8.

Reference 2 indicated that a response to RAI 368, Question 03.08.05-10 would be provided to the NRC by March 21, 2013. Enclosure 1 provides our response to RAI No. 368, Question 03.08.05-10, and includes revised COLA content. A Licensing Basis Document Change Request has been initiated to incorporate these changes into a future revision of the COLA.

Enclosure 2 provides a Table of Changes to the COLA associated with this RAI 368 response.

Our response does not include any new regulatory commitments. This letter does not contain any sensitive or proprietary information.

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NRO

Revised COLA text and figure changes are marked on pre-submittal CCNPP Unit 3 COLA Revision 9 material. The CCNPP Unit 3 COLA Revision 9 will be submitted by March 29, 2013.

If there are any questions regarding this transmittal, please contact me at (410) 369-1907 or Mr. Wayne A. Massie at (410) 369-1910.

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

Executed on March 21, 2013

Mark T. Finley

Enclosures:
1) Response to NRC Request for Additional Information RAI No. 368, Question 03.08.05-10, Foundations, Calvert Cliffs Nuclear Power Plant, Unit 3
2) Table of Changes to CCNPP Unit 3 COLA Associated with Response to RAI No. 368

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn-Willingham, NRC Environmental Project Manager, U.S. EPR COL Application
Amy Snyder, NRC Project Manager, U.S. EPR DC Application, (w/o enclosures)
Patricia Holahan, Acting Deputy Regional Administrator, NRC Region II, (w/o enclosures)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2,
David Lew, Deputy Regional Administrator, NRC Region I (w/o enclosures)

Enclosure 1

Response to NRC Request for Additional Information
RAI No. 368, Question 03.08.05-10,
Foundations,
Calvert Cliffs Nuclear Power Plant, Unit 3

RAI No. 368

Question 03.08.05-10

Followup RAI for RAI 308, Question Number 03.08.05-8

In RAI number 03.08.05-8, the staff requested that the applicant explain how the new and updated COL Items, regarding the settlement of the NI common basemat structure, will be addressed, and what site-specific conditions will be considered.

The staff reviewed the RAI response to Question 03.08.05-8 provided in UniStar letter UN#12-010 dated February 1, 2012 (ML12037A002).

The response partially addresses some of the staff's concerns regarding models, methodology, procedures and soil spring data inputs utilized in the site-specific settlement analysis of the NI common basemat structure. However, the following additional information is needed to help the staff ensure that, for the settlement of the NI common basemat structure, the related COL items are adequately addressed, and site-specific conditions are adequately considered in the analysis:

(1). Regarding the analysis procedure, U.S. EPR Revision 3 Section 3.8.4.5.2 indicates that two sets of soil springs are developed using Plaxis 3D foundation software. The first set of soil springs is developed with the geometry and loading of the basemat alone, corresponding to the first step of the construction sequence. The second set of soil springs is developed with the geometry and loading of the full NI common basemat structure, corresponding to the last step of the construction sequence. Each set of soil springs is developed by iterating on settlement results between a full 3D finite element structural model with soil springs and a Plaxis 3D model. The set of soil springs which controls the design of forces and moments due to settlement is used in 3D FE structural models for the design. The staff understands that iteration processes are performed for the first and last construction steps, two different sets of soil springs are obtained and the controlling set of soil springs is used for the design. The staff requests that the applicant explain why iteration process to determine soil springs was not done for intermediate construction steps in the site-specific settlement analysis of the NI common basemat structure.

(2). The RAI response states that the site-specific conditions considered conform to the requirements specified in CCNPP Unit 3 FSAR Revision 7 Section 2.5.4.10.2. According to this section of the FSAR, the site-specific settlement analysis of the CCNPP Unit 3 Powerblock Area (including the NI common basemat structure) considers eight construction steps and site-specific conditions including those described in the RAI response, as well as backfill steps, irregular thickness of the subsurface strata, and the symmetry in surface topography, etc. The staff notes that U.S. EPR FSAR Revision 3 Section 3.8.5.4.2 indicates that the U. S. EPR settlement analysis of the NI common basemat structure considers eleven construction steps and a sandy material with laterally uniform soil stiffness. Considering the differences between the construction sequences and site-specific conditions described above, the staff requests that the applicant explain whether the site-specific settlement analysis discussed in CCNPP Unit 3 FSAR Section 2.5.4.10.2 is the same analysis discussed in the RAI response for CCNPP Unit 3 FSAR Section 3.8. If they are not the same, explain why two sets of site-specific settlement analysis are performed and discuss the differences between the two analyses. If they are the same, explain why a construction sequence different from the U.S. EPR settlement analysis is considered in the site-specific settlement analysis, how the two sets of settlement profiles corresponding to the two different construction sequences can be compared, and explain the inconsistency between the construction sequences discussed in CCNPP Unit 3 FSAR Section 2.5.4.10.2 and the RAI response.

(3). As discussed before, the U. S. EPR settlement analysis of the NI common basemat structure considers a sandy material with laterally uniform soil stiffness. It is not clear to the staff whether the analysis considers all the site-specific conditions discussed in CCNPP Unit 3 FSAR Revision 7 Section 2.5.4.10.2. Therefore, the staff requests that the applicant explain in detail how each of the site-specific conditions discussed in Section 2.5.4.10.2 is considered in the site-specific settlement analysis of the NI common basemat structure. If not considered, provide the technical justification in detail for not doing so. Particularly, among the site-specific conditions, lateral variation of soil properties has significant effect on the differential settlement and hence the resulting member forces of a foundation mat. Consequently, the SRP Acceptance Criteria 3.8.5.II.4 discusses the review of the stiff and soft spots evaluation in the foundation soil to maximize the bending moments used in the design of the foundation mat. According to the response to RAI 276 Question 02.05.04-29, the coefficient of variation (COV) of shear wave velocity (Vs) measurements within Stratum IIb is as high as 0.4, and the COVs of Vs at certain elevations of Strata IIc and III are higher than 0.1. Furthermore, CCNPP Unit 3 FSAR Revision 7 Section 2.5.4.2.5.5 indicates that the values of soil elastic modulus utilized in the site-specific settlement analysis are also based on pressuremeter testing data and corrected SPT N-values, which both have high variation. The effect of the variation discussed above may be insignificant for overall settlement, but can be significant for differential settlement of the NI common basemat. Therefore, the staff requests that the applicant explain in detail whether and how the effect of the lateral variation of soil properties within a subsurface stratum has been considered in the site-specific settlement analysis of the CCNPP Unit 3 NI common basemat structure. If not done, provide the technical justification for not doing so. Since soil stiffness also depends on Poisson's ratios and soil densities, provide information on lateral variation for each of these parameters, including the supporting data based on field tests.

(4). In addition, to ensure that structural settlements during and post construction will be within the design envelop, so as to ensure the adequacy of the structural design, the updated U.S. EPR Tier 2 Table 1.8-2 COL Item 3.8-13 requires that CCNPP identify site-specific settlement monitoring requirements for Seismic Category I foundations based on site-specific soil conditions. For the NI common basemat structure, the settlement to be monitored includes the overall settlement, tilt, as well as differential settlements as per U.S. EPR Tier 2 Table 1.8-2 COL Item 3.8-18. CCNPP Unit 3 FSAR Revision 7 Section 3.8.5.7 describes a site-specific settlement monitoring program, and Section 2.5.4.10.2.2 provides more details of the program. However, based on the information provided in the FSAR, the staff cannot determine that the settlement monitoring program identified in the CCNPP Unit 3 FSAR Revision 7 is capable of providing the NI common basemat differential settlement contours similar to those described in the COL Item 3.8-18. To ensure that the COL Item 3.8-13 is adequately addressed, the staff requests that the applicant explain how the settlement monitoring program described in CCNPP Unit 3 FSAR Revision 7 Sections 2.5 and 3.8 is capable of providing the NI common basemat differential settlement contours similar to those described in U.S. EPR FSAR. Otherwise, identify a more detailed site-specific monitoring program, and revise the FSAR accordingly.

The staff needs the information to be able to conclude in the SER that there is reasonable assurance that the foundation design of the Seismic Category I structure is consistent with SRP Acceptance Criteria 3.8.5.II.4, and has been adequately addressed in the CCNPP Unit 3 FSAR.

Response

PART (1)

The settlement of the foundation, and thus the design forces and moments in the structure, are governed by the soil stiffness, structural stiffness and the structural load (not considering the secondary effects due to the soil-structure interface behavior). Springs are used as a modeling tool to obtain the appropriate settlements from the structural model. Such settlements control the forces and moments for the foundation design. Settlements have been analyzed for the "basemat alone," or basemat loads and end of construction cases. As part of this response, additional analysis has been performed for an intermediate step, and its development and results are provided in the following text.

Considering the soil stiffness to be the same for basemat and end of construction cases, the differences in the settlement distribution beneath the foundation are mainly controlled by the magnitude of the structural load, and the structural stiffness. The highest structural stiffness corresponds to the end of construction case, whereas the most flexible foundation case is the "basemat alone" or "basemat" case. The overall settlement for the end of construction case is maximum, and the settlement pattern of the foundation resembles the rigid body rotation (tilt) more than the "dish" shape, i.e., flexure. On the other hand, the settlement profile for the basemat case can represent the largest flexure due to the lowest structural stiffness.

The end of construction case is considered to be most critical in terms of overall settlement and tilt. The basemat case is considered to be most critical in terms of flexure. Initially, iterations were conducted for only the basemat and end of construction cases. To verify that these cases represent bounding conditions, the settlement reconciliation analysis has been repeated for another construction step at about 500 days or when the construction of the Nuclear Island (NI) common basemat area approximately reaches plant grade elevation. This step is referred to as the intermediate construction step.

For the intermediate construction step, the settlement reconciliation between the structural ANSYS model and the geotechnical PLAXIS model was performed in an equivalent form, and the difference in settlement between both models is less than 3.5%. For the reconciliation, the elements below the grade in the NI common basemat are considered.

A comparison of settlement results between the basemat, intermediate, and end of construction cases, for two axes that cross the NI common basemat, is provided in Figure 1 and Figure 2. Figures 1a and 2a present results normalized to the settlement of the center point and Figures 1b and 2b provide the actual settlement values. The normalization allows for a better examination of the flexure behavior. As expected, the largest flexure occurs for the basemat case, whereas the end of construction case resembles the rigid body rotation. The intermediate step settlement profile is between the basemat and end of construction cases, in terms of overall settlement magnitude and tilt.

As previously indicated, settlements control the design forces and moments, and springs are used to model accurate settlements. The springs for basemat and end of construction cases used in the settlement reconciliation analyses represent the most critical cases in terms of settlements. As shown, settlements for the intermediate construction case fall between the settlements for basemat and end of construction cases, in terms of overall settlement magnitude and tilt. Therefore, iterations were conducted for only the basemat alone and end of construction cases.

PART (2)

The construction sequences described in FSAR Section 2.5.4.10.2 and the response to RAI 308 Question 03.08.05-08[1] are not the same. The construction sequence described in Section 2.5.4.10.2 is a sequence developed considering buildings in the power block area, with the purpose of evaluating site-wide settlements at time steps that are frequent at the beginning and less frequent toward the end of the construction. The construction steps described in RAI 308 Question 03.08.05-08[1] are specific for the NI construction and consider the enveloping spring configuration for the design. Part (1) of this response demonstrates that, regardless of the number and distribution of construction steps, bounding conditions are used for the design of the foundation.

PART (3)

The CCNPP Unit 3 input for the settlement analysis is based on site specific soil conditions. The site specific analysis considers the effects of long-term consolidation, adjacent structures and backfill. The three-dimensional model is capable of capturing dipping subsurface conditions, realistic foundation footprint shapes, and asymmetric building loads.

The settlement model discussed in CCNPP Unit 3 FSAR Section 2.5.4.10.2, and the one used for Section 3.8 reconciliation, account for lateral variation of layer thickness. Within a given layer, however, the properties are found to be laterally uniform, with the inherent aleatory scatter encountered in soils. There is no consistent trend for the variation of soil properties based on the footprint location. Therefore, it is not necessary to reduce or increase soil parameters laterally within the same soil layer.

The lateral variability of shear wave velocity clearly supports the lateral uniformity of stiffness properties across the Nuclear Island common basemat. Even though comparison on the basis of equal elevation reveals isolated spots where some degree of variation is observed, this variation is expected, as dipping of cemented sand (Stratum IIb) layers occurs in the subgrade. In other words, if shear wave velocities are compared at an equal elevation plane, some locations may be in the cemented sand layer while others may not.

In order to correlate the distribution of shear wave velocity to the stiffness behavior across the NI common basemat, shear wave velocity is evaluated for a given layer for each boring. The statistics for shear wave velocity obtained as such are shown in Table 1, and indicate acceptable uniform subsurface conditions within the NI common basemat.

Poisson's ratios obtained from PS-Suspension and Downhole tests reflect undrained conditions, with values of 0.45 for soil layers below the groundwater table. The statistical evaluation of a field measured Poisson's ratio is not a useful tool to evaluate uniformity.

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[1] UniStar Nuclear Energy Letter UN#12-010, from Mark T. Finley to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 308, Foundations, dated February 1, 2012

Unit weights are analyzed in a manner similar to shear wave velocities. Table 2 presents statistics computed on unit weights across the CCNPP Unit 3 site. The coefficient of variation is low and attributed to a natural aleatory scatter.

In conclusion, lateral variation of soil properties within a given soil layer beneath the NI common basemat is typical of the natural aleatory scatter and, therefore, the lateral variation of soil properties within a given layer at the CCNPP Unit 3 site does not impact the estimation of differential settlement. The lateral variation of layer thicknesses was accounted for in the settlement analyses referenced in Section 2.5.4 and Section 3.8 models.

PART (4)

Additional settlement monitoring points are proposed as shown in Figure 4. The number of settlement monitoring points is sufficient to check against the predicted settlements. The final location of the monitoring points is subject to modification to adjust for construction limitations. However, the number and distribution of points will be similar to those proposed in Figure 4.

TABLE 1: SHEAR WAVE VELOCITY STATISTICS BY LAYER ACROSS THE NUCLEAR ISLAND COMMON BASEMAT

LAYER (1)	NUMBER OF POINTS	MEAN V_s [fps]	STD DEV V_s [fps]	COV
I	45	842	160	19%
IIa	46	1046	172	16%
IIb-1 A (2)	37	1735	258	15%
IIb-1 B (2)	19	2771	582	21%
IIb-2	34	1112	152	14%
IIb-3	19	2149	391	18%
IIc	209	1283	101	8%

NOTES:

(1) Data analyzed is from survey points B-301, B-304, and B-307, which are within the NI common basemat

(2) Data from Layer IIb-1 was subdivided into two groups, A and B, separated at Elev. +24 ft for a meaningful comparison (See Figure 3)

TABLE 2: UNIT WEIGHT STATISTICS BY LAYER ACROSS THE CCNPP UNIT 3 SITE

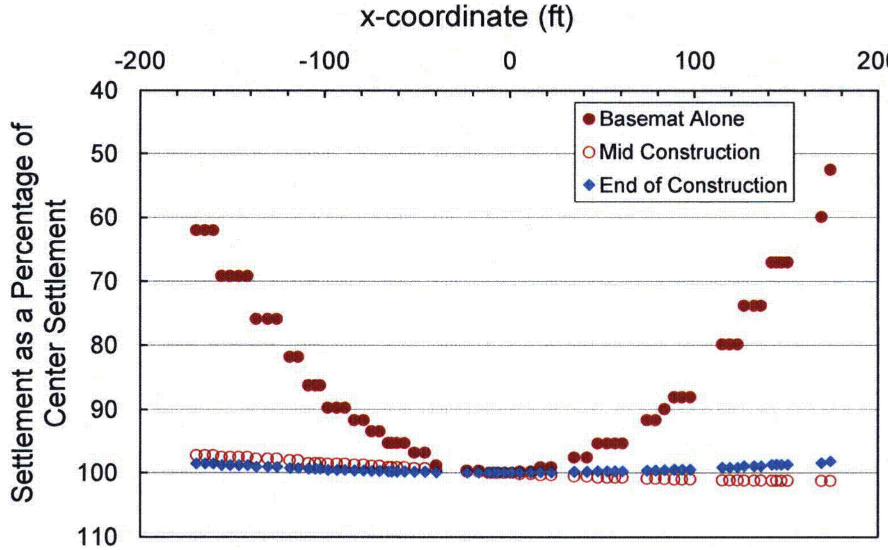
LAYER [1]	NUMBER OF SAMPLES	MEAN γ [pcf]	STD DEV γ [pcf]	COV
I	13	121	3	2%
IIa	43	116	6	5%
IIb-1	12	120	8	7%
IIb-2	8	118	7	6%
IIb-3	8	121	4	3%
IIc	50	105	9	9%

NOTES:

[1] Data analyzed is from survey points across site

FIGURE 1: SETTLEMENT PROFILES ACROSS X-AXIS AT NUCLEAR ISLAND COMMON BASEMAT

(a) NORMALIZED SETTLEMENT



(b) SETTLEMENT

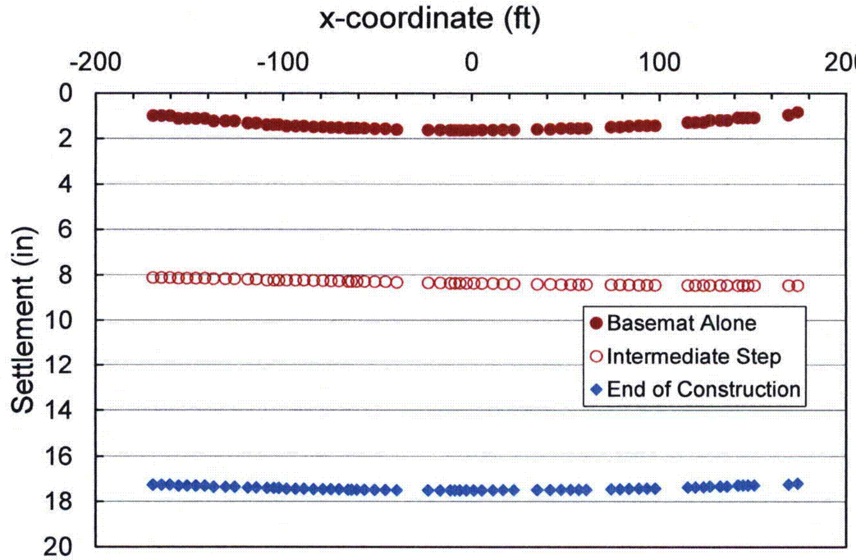
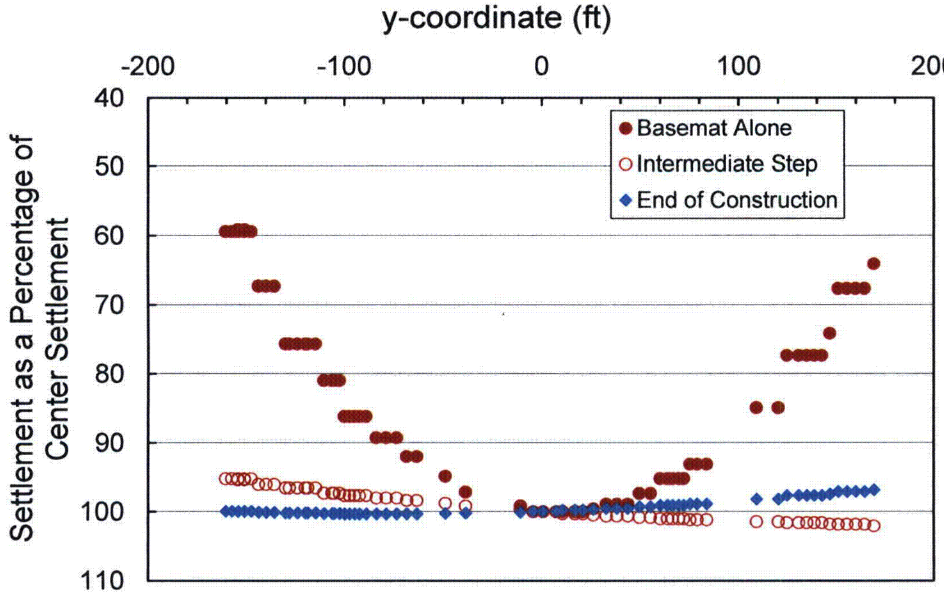


FIGURE 2: SETTLEMENT PROFILES ACROSS Y-AXIS AT NUCLEAR ISLAND COMMON BASEMAT

(a) NORMALIZED SETTLEMENT



(b) SETTLEMENT

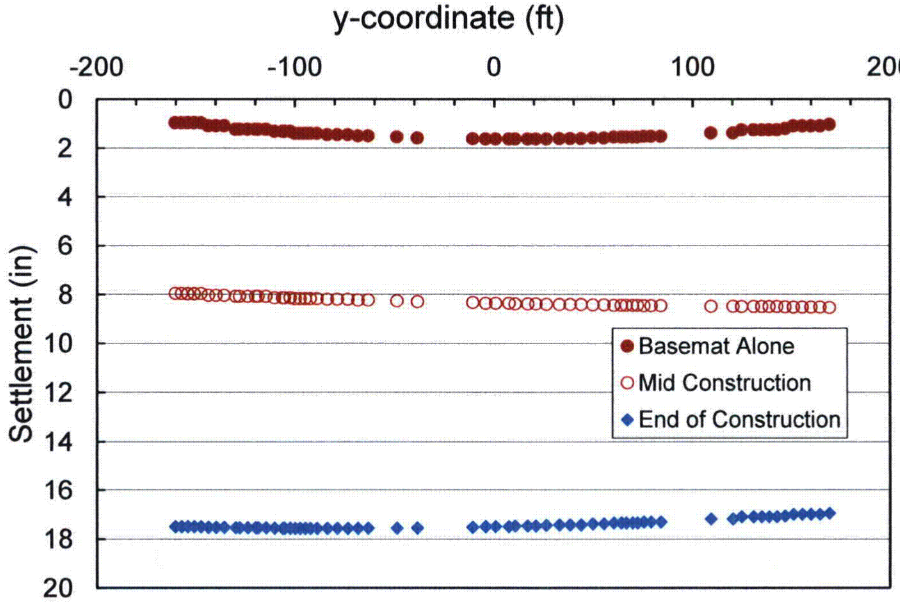


FIGURE 3: SHEAR WAVE VELOCITY DISTRIBUTION ACROSS THE NUCLEAR ISLAND COMMON BASEMAT

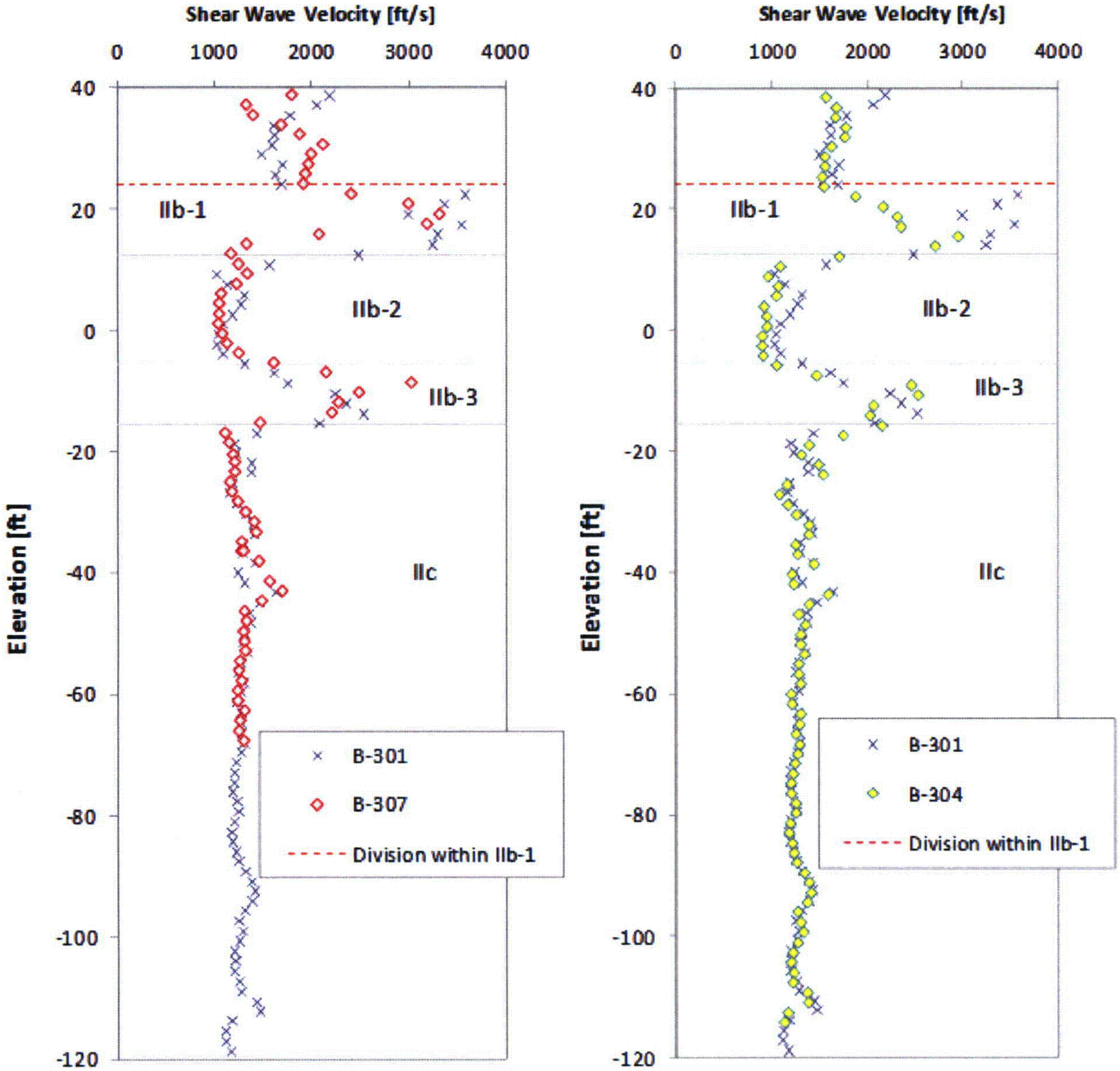
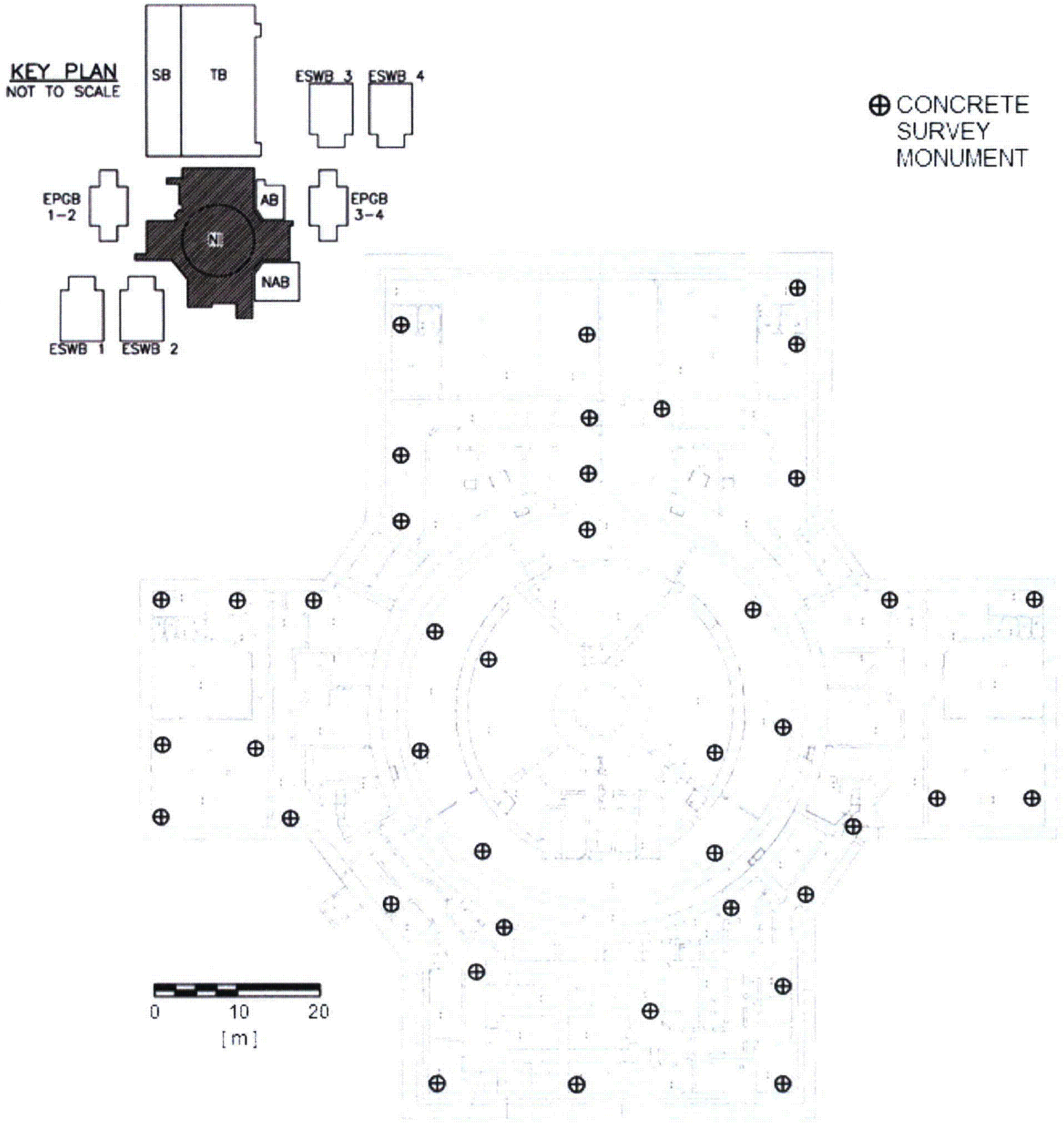


FIGURE 4: SETTLEMENT MONITORING POINTS FOR NUCLEAR ISLAND COMMON BASEMAT



COLA Impact

FSAR Section 2.5.4.10.2.2 has been updated as follows:

2.5.4.10.2.2 Settlement and Heave Analysis in the CCNPP Powerblock Area

...

After the structural backfill has been placed to the final grade, Surface Monuments (SM), bench mark El. 80 shall be placed on the surface of the backfill at approximate locations shown on Figure 2.5-239. The monuments shall consist of a one foot diameter concrete cylinders placed a minimum of three feet below final grade and be fitted with a brass dome cap with a point for survey use.

Additional concrete survey monuments will be placed on the interior of the NI to monitor the settlement throughout the NI common basemat, as shown in Figure 2.5-225b. The number of settlement monitoring points is sufficient to check against the predicted settlements. The final location of the monitoring points is subject to modification to adjust for construction limitations. However, the number and distribution of points will be similar to those proposed in Figure 2.5-225b.

On the side of foundation mats, no later than 28 days after construction, National Geodetic Survey (NGS) (USDC, 1978) survey disks will be placed by drilling a cavity on the side of foundation mats. The cavity will be backfilled with a mortar mix and the survey disk will be anchored into the foundation mat. The disk needs to be located at strategic points of the mat and have a direct view to a benchmark or to other survey points that can relate to a benchmark.

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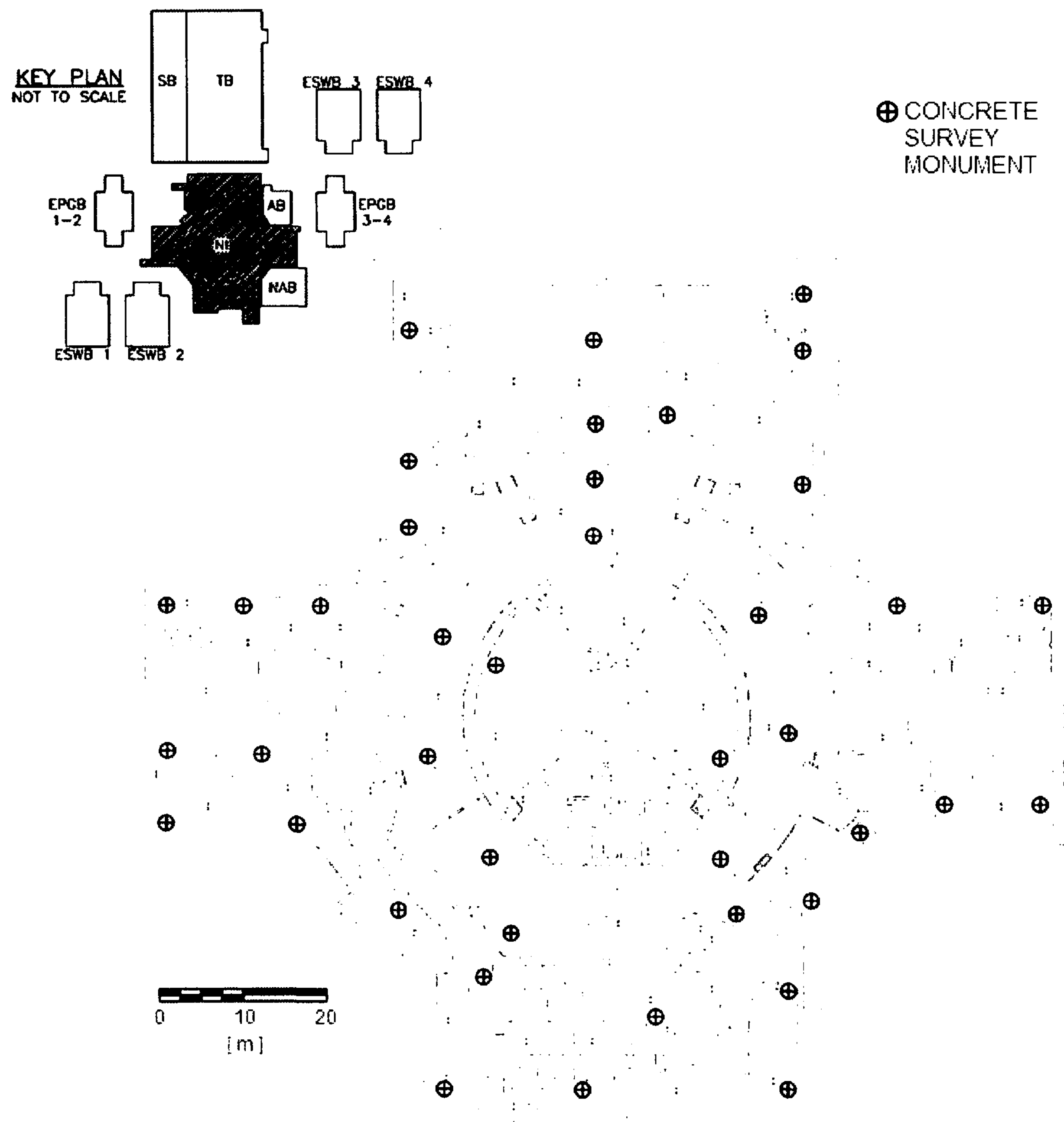
FIGURE 2.5-225b: SETTLEMENT MONITORING POINTS FOR NUCLEAR ISLAND COMMON BASEMAT



Enclosure 2

Table of Changes to CCNPP Unit 3 COLA Associated with Response to RAI No. 368

Table of Changes to CCNPP Unit 3 COLA Associated with Response to RAI No. 368

Change ID #	Subsection	Type of Change	Description of Change
Part 2 FSAR			
CC3-10-0132 and CC3-10-0270	2.5.4.10.2.2	Incorporated COLA markups associated with the response to RAI 218, Question 02.05.04-13[2].	FSAR Section 2.5.4.10.2.2 was revised to include a more detailed discussion of settlement monitoring as part of the RAI 218, Question 02.05.04-13[2] response.
CC3-13-0055	2.5.4.10.2.2, Figure 2.5-225b	Incorporated COLA markups associated with the response to RAI 368, Question 03.08.05-10.	A supplemental paragraph was added to FSAR Section 2.5.4.10.2.2 as part of the RAI 368, Question 03.08.05-10 response. This paragraph addresses the settlement monitoring points in the Nuclear Island. New Figure 2.5-225b, "Settlement Monitoring Points for Nuclear Island Common Basemat" was also added as part of the RAI 368, Question 03.08.05-10 response.

[2]UniStar Nuclear Energy Letter UN#10-177, from Greg Gibson to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI 218, Stability of Subsurface Materials and Foundations Questions 02.05.04-05 and 02.05.04-13, dated June 28, 2010.