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UniStar
NUCLEAR ENERGY

10 CFR 50.4
10 CFR 52.79

November 12, 2010

UN#10-277

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 265, Groundwater

References:
1) Surinder Arora (NRC) to Robert Poche (UniStar Nuclear Energy), "FINAL RAI 265 RHEB 5103" email dated October 7, 2010

2) UniStar Nuclear Energy Letter UN#10-277, from Greg Gibson to Document Control Desk, U.S. NRC, Submittal of Response to RAI 265, Groundwater, and RAI 266, Accidental Release of Radioactive Liquid Effluents in Ground and Surface Waters, dated November 8, 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 October 7, 2010 (Reference 1). This RAI addresses Groundwater, as discussed in Section 2.4.12 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.

Reference 2 provided a November 12, 2010 schedule for the response for RAI 265, Question 02.04.12-13. The enclosure provides our response to RAI 265, Question 02.04.12-13, 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.

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NRO

Our response does not include any new regulatory commitments. 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 November 12, 2010

Greg Gibson

Enclosure: Response to NRC Request for Additional Information RAI 265, Question 02.04.12-13, Groundwater, 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
Getachew Tesfaye, NRC Project Manager, U.S. EPR DC Application (w/o enclosure)
Loren Plisco, Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
U.S. NRC Region I Office

GTG/RDS/mdf

Enclosure

Response to NRC Request for Additional Information RAI 265, Question 02.04.12-13, Groundwater, Calvert Cliffs Nuclear Power Plant, Unit 3

RAI 265

Question 02.04.12-13

In order to make safety conclusions and determine compliance with regulatory requirements in 10 CFR 100.20(c), 10 CFR 50, Appendix A - GDC 2, and 10 CFR 52.79(a)(1)(iii) Staff requests the following:

1. In response to RAI 101, Question 02.04.12-11, the Applicant provided a Groundwater Model Study report and associated model input files for a multi-layer groundwater flow model used to assess post-construction groundwater elevations, transport pathways, and radionuclide transport (in COL FSAR 2.4.13). The model provides a detailed representation of the excavation and building foundations of CCNPP Unit 3, but does not represent the use of lean concrete as a fill material. As described in COL FSAR Section 2.5.4.5, Rev. 6, excavation in the power block area is to the Stratum IIb Chesapeake Cemented Sand and "excavations are backfilled with compacted structural fill to the foundation level of structures or lean concrete is placed as a leveling mat," (FSAR pg 2-1241). As noted at COL FSAR pg. 2-1261, "Lean concrete, in lieu of compacted structural fill, with a minimum unconfined compressive strength of 2,000 psi is used under the Common Basemat," which supports the reactor, fuel, and safeguards buildings (as shown in COL FSAR Figure 2.5-104). The emplacement of the lean concrete is shown in the excavation profiles of COL FSAR Figures 2.5-130 to 2.5-134. Provide a revised analysis of groundwater flow that includes the use of lean concrete in the excavation or the technical basis for omitting the lean concrete from the groundwater flow analysis.

2. In response to RAI 144, Question 03.08.04-4, the Applicant provided a description of the waterproofing system to be used to protect concrete foundations. Provide the technical basis for omitting the waterproofing materials from the groundwater flow analysis.

3. In response to RAI 144, Question 03.08.04-12, the Applicant described groundwater monitoring in the powerblock area to ensure that unprotected concrete is not exposed to low pH groundwater. Provide in COL FSAR 2.4.12, a description of, or a reference to, the groundwater monitoring discussed in the response to RAI 144, Question 03.08.04-12.

4. Provide a reference supporting the values of hydraulic conductivity used for the structural fill material.

5. In the responses to RAI 101 Question 02.04.12-11 and RAI 103, Question 02.04.13-4, new effective porosity values are used. The origin of these effective porosity values appears to be solely discussed in Section 5.2.2 of the Groundwater Model Report. Provide a discussion of the origin of the effective porosity values in COL FSAR 2.4.12 or 2.4.13.

6. In the response to RAI 103, Question 02.04.13-4, the COL FSAR markup for Section 2.4.13.1.4.10 contains two errors related to the effective porosity. In the first paragraph of the discussion "Dimensions of the Contaminant Slug", the contaminant slug volumes presented in that section were derived from the use of the prior effective porosity value, not the new value of 0.145. Staff notes that the slug volumes given in Table 2.4-200 are correct, however. Correct the text in COL FSAR 2.4.13.1.4.10 and verify that the correct contaminant slug volumes were used in the transport calculations.

Response

Part 1

The lean concrete in question refers to concrete mud mats approximately 6 to 12 inches thick emplaced below the foundation subgrades (Figure 1). Mud mats provide a clean and level working surface and prevent the subgrade soil from being disturbed due to precipitation and rutting from construction traffic. The mud mats will underlie the concrete foundations and will not extend laterally beyond the outer perimeter of the foundations (UniStar, 2010). Therefore, in the post-construction groundwater environment, the thin low permeability mud mats below the base of the reactor, fuel, and safeguards buildings foundations will have little to no effect on the post-construction groundwater elevation, flow velocity, gradients, or flow direction.

In the multi-layer groundwater flow model used to assess the post-construction groundwater environment, cells that include building foundations were set as inactive cells in Layer 1 of the model. Increasing the thickness of these inactive cells by 6 to 12 inches to represent the mud mats will similarly have little to no effect on the predicted post-construction groundwater elevation, flow velocity, gradients, or flow direction. Therefore, the mud mats were not included as a feature in the post-construction groundwater flow analysis.

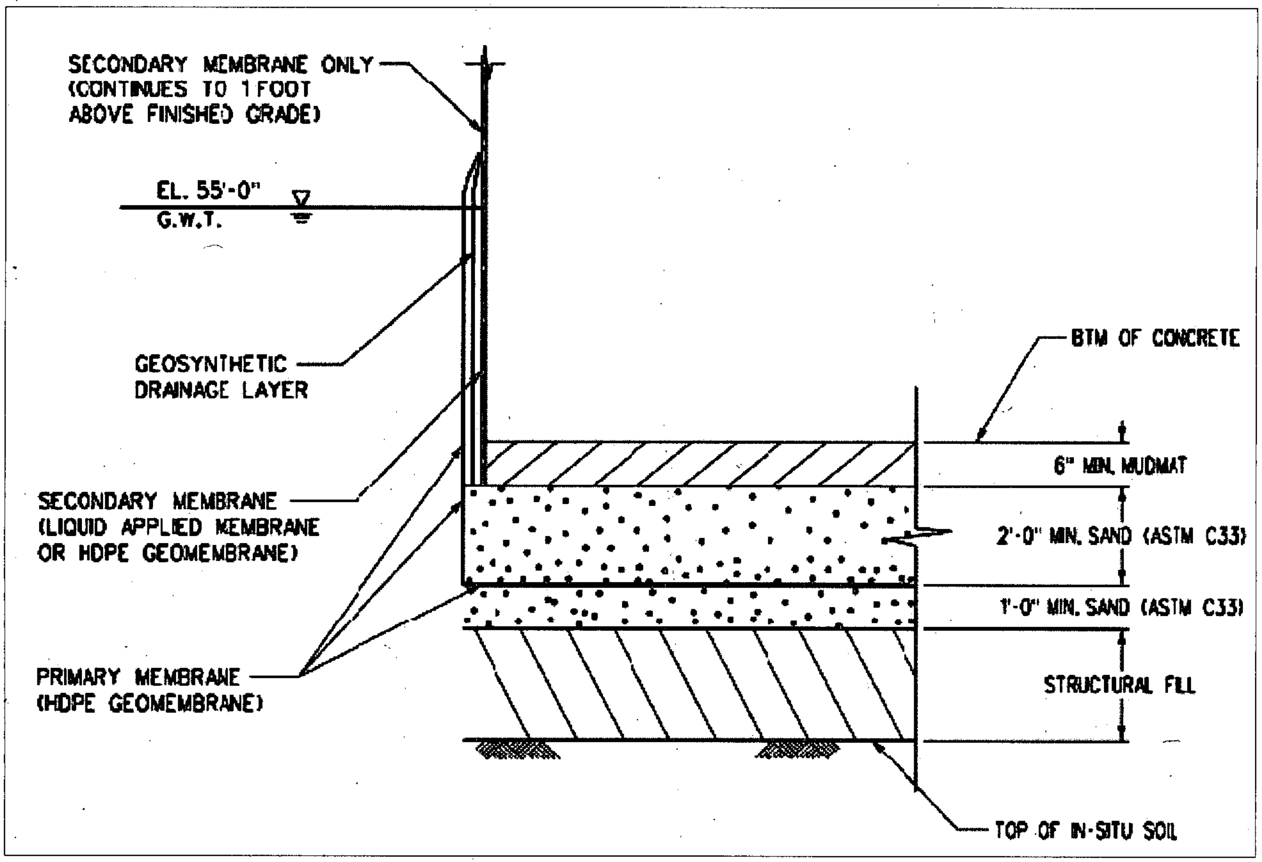

Figure 1 - Conceptual Configuration of Waterproofing Membrane

Part 2

As indicated in the response to RAI 144, Question 03.08.04-4[1], the waterproofing system for the nuclear island common basemat consists of two layers (Figure 1). The inner layer is a liquid-applied or high density polyethylene (HDPE) sheet waterproofing membrane layer applied to the embedded concrete walls from about one foot above the finished grade to the bottom of the wall. A vertical drainage geonet layer is then attached to the wall. The second layer, a HDPE geomembrane covers the drainage geonet and forms the primary waterproofing membrane layer.

This geomembrane is attached to the below-grade concrete walls at a level about two feet above the highest projected post-development groundwater level and extends over the entire immersed surfaces of the foundation walls. For the protection of the concrete foundations, a sheet of textured HDPE sandwiched within two sand layers is installed beneath the mud mat of the structure contiguous with the primary HDPE geomembrane on the buried walls discussed above.

As indicated in the response to Part 1 above, the mud mat, and therefore the primary HDPE geomembrane below the mud mat does not extend laterally beyond the outer perimeter of the foundations. Therefore the enveloping impermeable HDPE geomembrane will have no effect on the post-construction groundwater elevation, flow velocity, gradients, or flow direction, and it was not included as a feature in the post-construction groundwater flow analysis.

Part 3

Consistent with the response to RAI 144, Question 03.08.04-12[1], the following text is being added to FSAR Section 2.4.12.5 to reference the proposed groundwater monitoring system in the power block area:

> Below grade concrete that will be located beneath the groundwater table in the backfilled power block area may be exposed to the aggressive low pH groundwater of the Surficial aquifer, unless alternative design provisions are incorporated. Therefore, the facility design for such structures will include a waterproofing geomembrane envelope as described in Section 3.8.4.6.1.
>
> However, since it is possible for leakage to occur, a monitoring system (consisting of risers and drain sumps) will be installed inside the waterproofing geomembrane. The monitoring risers and drain sumps will be structure-specific and will be designed in parallel with the building foundations. Details regarding the groundwater monitoring systems are presented in Sections 3.8.4.7 and 3.8.5.7.

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1 G. Gibson (UniStar Nuclear Energy) to Document Control Desk ((NRC), "Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 144, Other Seismic Category I Structures, and RAI No. 145, Foundations," letter UN#10-193 dated July 23, 2010.

Part 4

The following text and the reference to the supporting data report (MACTEC 2009b) are being added to COLA FSAR Section 2.4.12.5 to support the values of hydraulic conductivity used for the structural fill material:

> Data from laboratory constant head permeability tests (ASTM Test Method D 2434-68 (2006)) were used as a starting point to develop estimates of hydraulic conductivity for the structural fill material. These tests yielded hydraulic conductivities of 2.7×10^{-2} cm/s (77 ft/day) and 2.9×10^{-2} cm/s (82 ft/day) for structural fill materials compacted to about 95% of the maximum dry density using modified Proctor (ASTM D1557-07).
>
> However, this type of laboratory test does not produce hydraulic conductivity values representative of those under field conditions. For each sample, the constant head permeability tests were performed under very high hydraulic gradients (0.3, 0.4 and 0.5) for which Darcy's Law does not typically apply. This is evidenced by the fact the three tests produced different values of permeability as the hydraulic gradient was varied. For example, the sample yielding an average hydraulic conductivity of 2.7×10^{-2} cm/s, yielded individual test results of 9.40×10^{-3} cm/s, 3.30×10^{-2} cm/s and 3.80×10^{-2} cm/s.
>
> The estimated horizontal hydraulic gradient in the fill material based on model runs for post-construction conditions is of the order of 0.02 (Bechtel, 2010). When hydraulic conductivity is plotted against the hydraulic gradient for the laboratory results, and the resulting curve is extrapolated to a hydraulic gradient of 0.02, the resulting hydraulic conductivity is of the order of 1×10^{-3} cm/s.
>
> Therefore, the lowest of the three measured values (9.4×10^{-3}, rounded to 1×10^{-2} cm/s) was conservatively selected as the upper bound for the hydraulic conductivity of the fill, and the extrapolated value of 1×10^{-3} cm/s, representing hydraulic conductivity under predicted field flow conditions, was selected as the lower bound for the hydraulic conductivity of the fill.

Part 5

The following information excerpted from the Groundwater Model Report, and the associated reference citations are being added to COLA FSAR Section 2.4.12.3.3:

> Effective porosity estimates for the water-bearing units are developed based on the grain size distribution of samples taken from the CCNPP site. Median grain size (d_{50}) values for samples collected in 2006 (Schnabel, 2007) and 2008 (MACTEC, 2009a) were sorted by stratigraphic unit. For each d_{50} value, an effective porosity value was estimated using Figure 2.17 in de Marsily (1986). The average value of effective porosity for each stratigraphic unit was calculated. However, Stephens et al. (1998) indicates that, based on the results of a field tracer test, effective porosities that are estimated from grain size data can over-estimate the actual effective porosity. The effective porosity estimated from the results of the field test was approximately 45% lower than that estimated based on the measured particle size. Therefore, in order to develop a more conservative estimate of the effective porosity, the estimates from the grain size data were reduced by 45%. The reduced effective porosities used for travel time calculations are: 0.139 for the

Surficial aquifer, 0.145 for the Upper Chesapeake unit, and 0.156 for the Lower Chesapeake Unit. Since data was not available for the Upper Chesapeake aquitard and the Lower Chesapeake aquitard, effective porosity was estimated to be 0.06 for these layers based on a mean value for clays (ANL, 1993). The effective porosity of the fill material was estimated using the same method as for the water-bearing units. The materials tested for use as structural fill are expected to have a maximum d_{50} of 8 mm (MACTEC, 2009b). The maximum value is used as it gives the smallest effective porosity, and is thus more conservative. Using Figure 2.17 in de Marsily (1986), a d_{50} of 8 mm corresponds to an effective porosity of 0.150; which when reduced by 45% gives an effective porosity of 0.082.

Part 6

The contaminant slug volumes for transport pathways through the Upper Chesapeake unit and the fill material in FSAR Section 2.4.13.1.4.10 are being corrected to 24,353 ft^3 (689.6 m^3) and 43,063 ft^3 (1219.4 m^3), respectively. Use of the correct effective porosity and contaminant slug volumes in the transport calculations has been verified.

COLA Impact

FSAR Section 2.4.12.3.3 is being updated as follows:

2.4.12.3.3 Ground Water Flow and Transport

The following sections present the most probable ground water flow direction and travel time from the CCNPP Unit 3 power block area to nearby surface water features. Based on the evaluation summarized in the above sections, only the shallow water bearing units (Surficial aquifer and the Upper Chesapeake and Lower Chesapeake water-bearing units) would be affected by construction and operation of the CCNPP Unit 3. Ground water use associated with CCNPP Unit 3 operations is discussed in Section 2.4.12.1.4. Accidental release parameters and pathways for liquid effluents in ground water and surface water are presented in Section 2.4.13.

The ground water seepage velocity is defined as distance over time and is calculated as follows:

Velocity = [(hydraulic gradient) x (hydraulic conductivity)] / (effective porosity)

Effective porosity estimates for the water-bearing units were developed based on the grain size distribution of samples taken from the CCNPP site. Median grain size (d_{50}) values for samples collected in 2006 (Schnabel 2007) and 2008 (MACTEC, 2009a) were sorted by stratigraphic unit. For each d_{50} value, an effective porosity value was estimated using Figure 2.17 in de Marsily (1986). The average value of effective porosity for each stratigraphic unit was calculated. However, Stephens et al. (1998) indicates that, based on the results of a field tracer test, effective porosities that are estimated from grain size data can over-estimate the actual effective porosity. The effective porosity estimated from the results of the field test was approximately 45% lower than that estimated based on the measured particle size. Therefore, in order to develop a more conservative estimate of the effective porosity, the estimates from the grain size data were reduced by 45%. The reduced effective porosities used for travel time calculations are: 0.139 for the Surficial aquifer, 0.145 for the Upper Chesapeake unit, and 0.156 for the Lower Chesapeake Unit. Since data was not available for the Upper Chesapeake aquitard and the Lower Chesapeake aquitard, effective porosity was estimated to be 0.06 for these layers based on a mean value for clays (ANL, 1993). The effective porosity of the fill material was estimated using the same method as for the water-bearing units. The materials tested for use as structural fill are expected to have a maximum d_{50} of 8 mm (MACTEC, 2009b). The maximum value is used as it gives the smallest effective porosity, and is thus more conservative. Using Figure 2.17 in de Marsily (1986), a d_{50} of 8 mm corresponds to an effective porosity of 0.150; which when reduced by 45% gives an effective porosity of 0.082.

. . .

FSAR Section 2.4.12.5 is being updated as follows (markup reflects the updated text previously provided in the follow-up response to RAI 101[2]):

2.4.12.5 Site Characteristics for Subsurface Hydrostatic Loading and Dewatering

. . .

The major conclusions from the post construction simulations are:

a. The water table in the power block area will be well below the site grade level. In all simulations, the water table in the power block area was more than 25 ft [7.6 m] below the site grade level of 85 ft [26 m] (NGVD 29).

b. The groundwater pathway for liquid effluent releases from the NAB depends on the hydraulic conductivity of the fill material. Data from laboratory constant head permeability tests (ASTM Test Method D 2434-68 (2006)) were used as a starting point to develop estimates of hydraulic conductivity for the structural fill material. These tests yielded hydraulic conductivities of $2.7x10^{-2}$ cm/s (77 ft/day) and $2.9x10^{-2}$ cm/s (82 ft/day) for structural fill materials compacted to about 95% of the maximum dry density using modified Proctor (ASTM D1557-07).

   However, this type of laboratory test does not produce hydraulic conductivity values representative of those under field conditions. For each sample, the constant head permeability tests were performed under very high hydraulic gradients (0.3, 0.4 and 0.5) for which Darcy's Law does not typically apply. This is evidenced by the fact the three tests produced different values of permeability as the hydraulic gradient was varied. For example, the sample yielding an average hydraulic conductivity of $2.7x10^{-2}$ cm/s, yielded individual test results of $9.40x10^{-3}$ cm/s , $3.30x10^{-2}$ cm/s and $3.80\ x10^{-2}$ cm/s.

   The estimated horizontal hydraulic gradient in the fill material based on model runs for post-construction conditions is of the order of 0.02 (Bechtel, 2010). When hydraulic conductivity is plotted against the hydraulic gradient for the laboratory results, and the resulting curve is extrapolated to a hydraulic gradient of 0.02, the resulting hydraulic conductivity is of the order of $1x10^{-3}$ cm/s.

   Therefore, the lowest of the three measured values ($9.4x10^{-3}$, rounded to $1x10^{-2}$ cm/s) was conservatively selected as the upper bound for the hydraulic conductivity of the fill, and the extrapolated value of $1x10^{-3}$ cm/s, representing hydraulic conductivity under predicted field flow conditions, was selected as the lower bound for the hydraulic conductivity of the fill.

   - If the hydraulic conductivity of the fill is equal to the lower end of the range of expected values ($1x10^{-3}$ cm/s [2.8 ft/day]), then releases from the bottom of the NAB will move first downwards to the Upper Chesapeake unit and then horizontally through this unit towards Chesapeake Bay where they will eventually discharge. Even with a conservative assumption of 0.145 for the effective porosity for the Upper Chesapeake unit, the estimated travel time from the release point to Chesapeake Bay is over 22 years.

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2 G. Gibson (UniStar Nuclear Energy) to Document Control Desk ((NRC), "Follow-up to Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No.101,Groundwater," letter UN#10-239, dated September 10, 2010.

. . .

Groundwater sampling and testing at the CCNPP Unit 3 site has been performed in eight separate sampling events. Samples were field tested for pH, and laboratory samples were tested for sulfate and chloride concentrations. Data from these sampling events were analyzed to determine the expected water quality of the groundwater in the excavations. For samples obtained from the Surficial aquifer, the mean pH was found to be 5.2, with a seasonal low mean of 4.9. Test results from the Surficial aquifer gave a pH range of 4.5 to 6.9. Mean sulfate and chloride concentrations in the Surficial aquifer were 14.9 and 13.2 mg/l, respectively. Seasonal high Surficial aquifer mean sulfate and chloride concentrations were 21.8 and 18.9 mg/l, respectively. In the Upper Chesapeake unit, the mean pH was found to be 7.4, with a seasonal low mean of 7.1. Test results from the Upper Chesapeake unit gave a pH range of 6.4 to 8.0. Mean sulfate and chloride concentrations in the Upper Chesapeake were 51.4 and 45.0 mg/l, respectively. In the Upper Chesapeake unit, seasonal high mean sulfate and chloride concentrations were 65.1 and 50.7 mg/l, respectively.

Below grade concrete that will be located beneath the groundwater table in the backfilled power block area may be exposed to the aggressive low pH groundwater of the Surficial aquifer, unless alternative design provisions are incorporated. Therefore, the facility design for such structures will include a waterproofing geomembrane envelope as described in Section 3.8.4.6.1.

However, since it is possible for leakage to occur, a monitoring system (consisting of risers and drain sumps) will be installed inside the waterproofing geomembrane. The monitoring risers and drain sumps will be structure-specific and will be designed in parallel with the building foundations. Details regarding the groundwater monitoring systems are presented in Sections 3.8.4.7 and 3.8.5.7.

FSAR Section 2.4.12.6 is being updated with the addition of the following references:

2.4.12.6 References

ANL, 1993. Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil. Environmental Assessment and Information Sciences Division Argonne National Laboratory, C. Yu, C. Loureiro, J.J Cheng, L.G. Jones, Y.Y. Wang, Y.P. Chia, and E. Faillace, 1993.

MACTEC, 2009a. Revised Laboratory Testing Results, Rev. 2, Calvert Cliffs Nuclear Power Plant Unit 3, Report by MACTEC Engineering and Consulting, March 11, 2009.

MACTEC, 2009b. Laboratory Data Report, Geotechnical Properties Testing Program for Structural Fill, Calvert Cliffs Nuclear Power Plant Unit 3, Rev. 1, Report by MACTEC Engineering and Consulting, June 17, 2009.

Schnabel, 2007. Geotechnical Subsurface Investigation Final Data Report, Calvert Cliffs Nuclear Power Plant, Binder 3 of 3, Rev. 001, Schnabel Engineering Inc, May 9, 2007.

FSAR Section 2.4.13.1.4.10 is being updated as follows (markup reflects the updated text previously provided in the response to RAI 104, Question 02.04.13-4[3]):

2.4.13.1.4.10 Transport Considering Advection, Radioactive Decay, Adsorption, and Dilution

For the purpose of evaluating the effects of the spill material on the surface water systems downstream of the discharge point, the average concentration and discharge of the highly diluted liquid effluent discharged from the aquifer were determined. The analysis presented below is based on the conservative assumption that there is no longitudinal or transverse dispersion of the liquid effluent in the groundwater.

Dimensions of the Contaminant Slug

The volume of the liquid release has been assumed to be 3,531.2 ft^3 (100 m^3), which represents 80 percent of the 4,414 ft3 (125 m^3) capacity of one Reactor Coolant Storage Tank [NUREG-0800, BTP 11-6 (NRC, 2007) recommends that 80 percent of the liquid volume be considered in this analysis]. The volume of the Upper Chesapeake unit that would be occupied by the release is estimated by dividing the release volume (3,531.2 ft^3 [100 m^3]) by the effective porosity of 0.145. This results in an estimated volume of ~~9,543.8 ft^3 (270.3 m^3)~~ 24,353 ft^3 (689.6 m^3). For the alternative pathway through the fill material, the contaminant slug would occupy a volume of ~~23,541 ft^3 (667 m^3)~~ 43,063 ft^3 (1219.4 m^3) due to the lower effective porosity of 0.082.

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3 G. Gibson (UniStar Nuclear Energy) to Document Control Desk ((NRC), "Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No.104,Question 02.04.13-4, Liquid Radioactive Release," letter UN#10-153, dated June 17, 2010.