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U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. NA3-11-048R
Docket No. 52-017
COL/MWH

DOMINION VIRGINIA POWER
NORTH ANNA UNIT 3 COMBINED LICENSE APPLICATION
SRP 03.07.01: RESPONSE TO RAI LETTER 81

On August 15, 2011, the NRC requested additional information to support the review of certain portions of the North Anna Unit 3 Combined License Application (COLA), which consisted of two questions. The responses to the following RAI questions are provided in Enclosures 1 and 2:

- RAI 5942 Question 03.07.01-5 — Shear Wave Velocity Profiles for Site-Specific Structures
- RAI 5959 Question 03.07.01-6 — Performance Based Surface Response Spectra for Site-Specific Structures

Please contact Regina Borsh at (804) 273-2247 (regina.borsh@dom.com) if you have questions.

Very truly yours,

Eugene S. Grecheck

cc: U. S. Nuclear Regulatory Commission, Region II
C. P. Patel, NRC
T. S. Dozier, NRC
G. J. Kolcum, NRC

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NRO

COMMONWEALTH OF VIRGINIA

COUNTY OF HENRICO

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Eugene S. Grecheck, who is Vice President-Nuclear Development of Virginia Electric and Power Company (Dominion Virginia Power). He has affirmed before me that he is duly authorized to execute and file the foregoing document on behalf of the Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 8th day of February, 2012
My registration number is 112536 and my
Commission expires: April 30, 2015

Jane D. Mack
Notary Public

Enclosures:

1. Response to NRC RAI Letter 81, RAI 5942 Question 03.07.01-5
2. Response to NRC RAI Letter 81, RAI 5959 Question 03.07.01-6

Commitments made by this letter:

None

ENCLOSURE 1

Response to NRC RAI Letter 81

RAI 5942 Question 03.07.01-5

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

North Anna Unit 3

Dominion

Docket No. 52-017

RAI NO.: 5942 (RAI LETTER 81)

SRP SECTION: 03.07.01 – SEISMIC DESIGN PARAMETERS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 8/15/2011

QUESTION NO.: 03.07.01-5

FSAR Section 2.5.4.7.1 describes creation of the eight S-wave velocity profiles for different structures used in Section 3.7.1 and Appendix 3OO. The FSAR states that those profiles are the result of a combination of different downhole velocity measurements. Except for the R/B velocity profile, the FSAR does not appear to explain how the profiles were "combined" (see FSAR section 2.5.4.7.1, pages 2-298 – 2.300). Please provide a description discussing how each of those profiles were developed.

Also, please describe the process for developing the profiles along the East side of the plant's footprint (e.g., the ESWP Tunnel and East PS/B) since there do not appear to be any P-S suspension logging measurements in this area. Finally, FSAR Section 2.5.4.7.1 (page 2-298) states that S-wave velocity values are averaged over 10-ft intervals (same for at least some of the other FIRS profiles) for the West PS/B and West PSFSV FIRS profiles. Since this approach is not standard practice for averaging S-wave velocities and since averaging over 10-ft interval will smooth impedance contrast gradients, please provide justification for the averaging approach.

Dominion Response

Response (a): Development of V_s Profiles

FSAR Section 2.5.4.7.1 indicates that there are five suspension P-S velocity logging boreholes (B-901, B-907, B-909, M-10, and M-30) used for the development of shear wave velocity (V_s) profiles for the seismic analysis of Unit 3 seismic Category I structures in FSAR Section 3.7.1 and Appendix 3OO. The measured V_s values from these five V_s borings are shown graphically on FSAR Figure 2.5-237. The V_s values from one, or a combination of two or three, V_s borings were used in conjunction with data from the rock/soil borings to develop the seven derived V_s profiles presented in FSAR Figures 2.5-241b through h. As described in FSAR Section

2.5.4.7.1, the derived V_s profile for the Reactor Building (R/B), the East Power Source Building (PS/B), and the East Power Source Fuel Storage Vault (PSFSV) structures was developed from V_s borings within the main power block area (B-901, B-907, and B-909). Further description of the development of this V_s profile is provided in the section, "Considerations in the Site Response Analysis," in the response to RAI 5693, Question 02.05.02-3, provided in Dominion Letter NA3-11-025R, dated August 25, 2011.

Two methods were used to develop the derived V_s profiles for the remaining seismic Category I structures. The method applied for each structure depended on:

- the proximity of the V_s boring(s) location to the structure location, and
- the subsurface characteristics in terms of thickness (top-to-bottom distance) and elevation (depth from plant grade) of each subsurface zone (subsurface zones are described in FSAR Sections 2.5.1.2.3 and 2.5.1.2.6) at the structure location relative to subsurface characteristics (zone thicknesses and elevation) at V_s boring locations.

Method (1)

For the cases where the V_s boring(s) is (are) in close proximity to the structure and the subsurface characteristics are similar at the V_s boring location and the structure location, the V_s boring data were used directly as the derived V_s profile for the structure, except that for subsurface material beneath the structure that will be excavated, the V_s data are replaced with the V_s values for concrete fill. For the cases where there are two V_s borings, an average of the V_s boring data from these two borings was used to create a single V_s profile. Method (1) was applied for the West PS/B, West PSFSV, and the Ultimate Heat Sink Related Structures (UHSRS). Additional descriptions of the development of the derived V_s profiles for these structures are provided later in this response.

Method (2)

For the cases where the subsurface characteristics at the nearest V_s boring locations and the structure location are not similar, a detailed evaluation of applicable V_s boring data and rock/soil boring data was performed to correlate the data and derive the V_s profile for the structure.

For each structure, applicable V_s borings were identified based on proximity to the structure, i.e., the nearest V_s borings were chosen as applicable. The V_s boring data were combined to form a single V_s profile by averaging the V_s data on a depth interval basis.

Downhole velocity measurement data obtained at each 1.64-ft depth increment within the boreholes were evaluated on a 'depth interval' basis to simplify the calculation of the derived V_s profiles. Depth intervals were defined for each subsurface zone in order to divide the total zone top-to-bottom distance (thickness) into smaller increments. Each zone was divided into several depth intervals of equal thickness. All of the V_s data within a depth interval were reviewed to determine the maximum, minimum, and average V_s value. These values were applied to represent the particular depth interval for the V_s profile.

For each structure, a subsurface profile was developed that represents the subsurface conditions beneath the structure, where the zone thicknesses and top of zone elevations are the average values determined from rock/soil boring data (boring logs and rock quality data

(RQD)) obtained from borings underlying or near the structure. Each zone was divided into the same number of depth intervals of equal thickness as was defined for the V_s profile above. The V_s values from the V_s profile depth intervals were applied to the corresponding subsurface profile depth intervals in order to derive the V_s profile used as input to the foundation input response spectra (FIRS) calculations for a structure.

This process resulted in a derived V_s profile for a structure that is representative of both measured V_s values nearest the structure and the actual average zone thicknesses found beneath the structure even though the V_s borings are not located beneath the structure location. Method (2) was applied for the UHSRS Pipe Chase and Essential Service Water Pipe Tunnels (ESWPTs). Additional descriptions of the development of the derived V_s profiles for these structures are provided later in this response.

West PS/B and West PSFSV

As described in FSAR Section 2.5.4.7.1.a, the derived V_s profile used for these structures was developed from V_s boring B-909 and is shown in FSAR Figure 2.5-241b. This derived V_s profile was used as input to the FIRS calculation for these structures because V_s boring B-909 is located in close proximity to these structures and has a similar subsurface profile to the average subsurface profile beneath and in the immediate vicinity of these structures. In addition, V_s boring B-909 data show a subsurface zone thickness similar to each subsurface zone near the structures. These subsurface conditions are shown by the data in FSAR Table 2.5-208 and the top-of-rock contours in FSAR Figures 2.5-209, -210, and -211 in the vicinity of boring B-909. These same contours are present beneath the West PS/B and West PSFSV, which indicates that the subsurface zone thicknesses determined by boring B-909 data are relatively constant when passing under these structures. This is confirmed by the compilation of information from the boring logs and from the RQD data (described in FSAR Sections 2.5.1 and 2.5.4) gathered from the seven borings beneath or close to these structures (B-903, B-915, B-921, M-17, M-20, W-6, and W-7).

For the West PS/B and West PSFSV, the derived V_s profile was developed by averaging measured V_s values from the B-909 boring over 10-ft vertical depth intervals for Zones III-IV and IV. Measured V_s values were recorded at 1.64-ft vertical intervals for the V_s boring. The minimum V_s value for each 10-ft interval of Zone III-IV and Zone IV layer, as shown in Figure 2.5-241b, is the lowest measured V_s value that was recorded in the respective interval. Similarly, the maximum V_s value is the highest measured V_s value that was recorded in the respective interval. The material above the top elevation of Zone III-IV, as determined by V_s boring B-909, will be replaced with concrete fill as described in FSAR Section 2.5.1.2.6. The concrete fill has an average V_s of 7,000 ft/sec, and minimum and maximum values of 6,000 ft/sec and 8,000 ft/sec, respectively, as depicted in FSAR Figure 2.5-241b.

UHSRS A and B

As described in FSAR Section 2.5.4.7.1.a, the derived V_s profile used for these structures was developed from V_s boring M-30 and is shown in FSAR Figure 2.5-241c. This derived V_s profile was used as input to the FIRS calculations for UHSRS A and B because V_s boring M-30 is in close proximity to both structures (M-30 is located beneath the Plant East edge of UHSRS A) and has a similar subsurface zone profile to the average subsurface zone profiles beneath

UHSRS A and B. The subsurface zones defined by boring M-30 data have similar thicknesses to the corresponding zones beneath these structures except that the top of Zone IV is deeper at the southwest corner of UHSRS B (as indicated in FSAR Table 2.5-208 by the depth to the top of Zone IV for boring M-28) resulting in a greater thickness of the overlying Zone III-IV at that location. These subsurface conditions are shown by the data in FSAR Table 2.5-208 and the top-of-rock contours in FSAR Figures 2.5-209, -210, and -211 in the vicinity of borings M-28 and M-30 and under UHSRS A and B. The contours shown in these figures beneath UHSRS A and B indicate that the subsurface zones found at the location of boring M-30 are relatively constant in thickness when passing under these structures (except at the southwest corner of UHSRS B). This is confirmed by the data from the borings beneath or near UHSRS A (M-1, M-12, M-29, M-30, and M-31) and the borings beneath or near UHSRS B (B-948, M-1, M-2, M-12, and M-28).

For UHSRS A and B, the derived V_s profile was developed by averaging measured V_s values from the M-30 boring over 10-ft vertical depth intervals. Measured V_s values were recorded at 1.64-ft vertical intervals for the V_s boring. The area of the site around this boring has experienced less weathering than other areas examined during the subsurface investigations supporting Unit 3, and therefore Zones III and III-IV are thinner in this area. There is approximately 10 ft of material between the bottom of the UHSRS A basin foundation elevation and the top of Zone IV elevation as determined by V_s boring M-30. Because a minimum of 3 ft of concrete fill will be placed immediately beneath each UHSRS foundation following excavation, as described in FSAR Section 2.5.4.7.1, there will be 7 ft of Zone III and Zone III-IV material remaining in this 10-ft interval. This material was addressed as a single layer with a V_s of 3,465 ft/sec in the UHSRS A and B analysis based on the measured V_s values for this range of depth. The minimum V_s value for each 10-ft interval of Zone IV and for the 7-ft combined Zone III and Zone III-IV layer, as shown in Figure 2.5-241c, is the lowest measured V_s value that was recorded in the respective interval. Similarly, the maximum V_s value is the highest measured V_s value that was recorded in the respective interval. The concrete fill has an average V_s of 7,000 ft/sec, and minimum and maximum values of 6,000 ft/sec and 8,000 ft/sec, respectively.

UHSRS C

As described in FSAR Section 2.5.4.7.1.a, the derived V_s profile used for this structure was developed from V_s boring B-907 and is shown in FSAR Figure 2.5-241d. This derived V_s profile was used as input to the FIRS calculations for UHSRS C because V_s boring B-907 is located nearest the structure and has a similar subsurface profile to the average profile beneath UHSRS C. The subsurface zones defined by boring B-907 data have similar thicknesses to the corresponding zones beneath the structure except that the top of Zone III-IV under UHSRS C is at a higher elevation than the top of the Zone III-IV layer at the boring B-907 location resulting in a smaller thickness of the Zone III beneath UHSRS C than at the boring B-907 location. These subsurface conditions are shown by the data in FSAR Table 2.5-208 and the top-of-rock contours in FSAR Figures 2.5-209, -210, and -211 in the vicinity of B-907 and under UHSRS C. The contours present beneath UHSRS C indicate that the subsurface zones found at the location of boring B-907 are relatively constant in thickness when passing under this structure except for the smaller thickness of Zone III material. This is confirmed by the data from five borings beneath or near UHSRS C (B-919, M-3, M-4, M-6, and M-7). The data (boring logs and RQD) from these five borings were used to determine the average thickness, the top elevation, and the thickness range of each subsurface zone.

For UHSRS C, the derived V_s profile was developed by averaging measured V_s values from the B-907 boring over 10-ft vertical depth intervals. Measured V_s values were recorded at 1.64-ft vertical intervals within the V_s boring B-907. The minimum V_s value for each 10-ft interval shown in Figure 2.5-241d, is the lowest measured V_s value that was recorded in the respective interval. Similarly, the maximum V_s value is the highest measured V_s value that was recorded in the respective interval. Three feet of concrete fill will be placed immediately beneath the structure's foundation following excavation, as described in FSAR Section 2.5.4.7.1. The concrete fill has an average V_s of 7,000 ft/sec, and minimum and maximum values of 6,000 ft/sec and 8,000 ft/sec, respectively.

UHSRS D

As described in FSAR Section 2.5.4.7.1.a, the derived V_s profile used for this structure was developed from V_s borings B-907 and M-10 and is shown in FSAR Figure 2.5-241e. This derived V_s profile was used as input to the FIRS calculations for UHSRS D because V_s borings B-907 and M-10 are located nearest to UHSRS D and, when averaged, have a relatively similar subsurface profile to the average profile beneath UHSRS D. The subsurface zones defined by V_s boring B-907 data are representative of subsurface zones under the southeast portion of the structure, while the subsurface zones defined by boring M-10 data are representative of zones under the northwest portion of the structure. These subsurface conditions are confirmed by the data from five borings beneath or near UHSRS D (B-930, M-6, M-7, M-8, and M-27). The data (boring logs and RQD) from these five borings were used to determine the average thickness, the top elevation, and the thickness range of each subsurface zone. The top elevation of Zone IV and the thickness of Zone III-IV layers are similar between borings B-907 and M-10. These subsurface conditions as determined by the rock/soil borings beneath or near UHSRS D are consistent with each measured zone thickness and the range of thickness for each zone as determined from borings B-907 and M-10 data. Therefore, it is reasonable to combine the measured V_s values from these two V_s borings and use this resulting profile as the derived V_s profile for the UHSRS D.

For UHSRS D, the derived V_s profile was developed by averaging the measured V_s values from borings B-907 and M-10 over 10-ft vertical depth intervals. Measured V_s values were recorded at 1.64-ft vertical intervals for both V_s borings. Thus, within a 10-ft depth interval, there were six V_s readings from B-907 and six V_s readings from M-10. The average V_s value used for an interval was the average of these 12 values, the minimum was the smallest of the 12 values, and the maximum was the largest of the 12 values. The average thickness of Zone IIB beneath the foundation is 20 ft as determined by the average of the five rock/soil borings beneath or near UHSRS D. However, as described in FSAR Section 2.5.4.5.3, this material will be excavated and replaced with concrete fill, and thus the V_s value of concrete fill was used for this top 20-ft layer in developing the derived V_s profile. The concrete fill has an average V_s of 7,000 ft/sec, and minimum and maximum values of 6,000 ft/sec and 8,000 ft/sec, respectively.

UHSRS Pipe Chase

As described in FSAR Section 2.5.4.7.1, the UHSRS Pipe Chase is a relatively short section that runs between UHSRS B and UHSRS C. The pipe chase foundation bottom is only 4 ft below final grade and 20 ft wide. Because of this shallow embedment depth and relatively narrow foundation width, the seismic response analysis conservatively used the free-field profile from the top of Zone III to Plant Grade, Elevation 290 ft. This accounts for the small thickness of *in situ* soil surrounding the pipe chase as depicted in FSAR Figure 2.5-241f. Four rock/soil borings are within 100 ft of the structure (M-28 is beneath the structure and B-919, B-906 and M-3 are nearby) and the zone thicknesses are similar among these borings. The data (boring logs and RQD) from these four borings were used to determine the average thickness, the top elevation, and the thickness range of each subsurface zone.

As further described in FSAR Section 2.5.4.7.1, the derived V_s profile used for this structure was developed from V_s borings B-901, B-907, and M-30 and is shown in FSAR Figure 2.5-241f. Method (2), described earlier, was used to develop the derived V_s profile (in Zones III, III-IV, and IV) from these nearest V_s borings because the average zone thicknesses and locations (depth below grade) beneath the pipe chase are not similar to the thicknesses and locations of the zones at the three selected V_s boring locations. Figure 2.5-241f identifies the number and length of the depth intervals for each zone used in the development of the derived V_s profile.

East ESWPT

As shown in FSAR Figure 2.5-241g, the bottom of the East ESWPT foundation is at Elevation 259 ft. The average top of Zone III material beneath the East ESWPT is at Elevation 245 ft resulting in an average of 14 ft of concrete fill between the bottom of the foundation and the top of Zone III rock. There are three rock/soil borings directly beneath the East ESWPT (B-934, M-16, and M-19) and five more that are within 100 ft of the structure (B-926, B-927, B-933, B-948, and M-12). From these eight borings, the average thicknesses of Zone III and Zone III-IV were determined.

As described in FSAR Section 2.5.4.7.1, the derived V_s profile used for this structure was developed from V_s borings B-901, B-907, and M-30 and is shown in FSAR Figure 2.5-241g. This derived V_s profile was used as input to the FIRS calculations for the East ESWPT (except that the concrete fill is explicitly included in the soil-structure interaction (SSI) analysis models rather than the site response analysis models) because the average zone thicknesses and locations (depth below grade) beneath the tunnel are not similar to the thicknesses and locations of the zones at the three selected V_s boring locations. Therefore, Method (2) was used to develop the derived V_s profile from these nearest V_s borings. Figure 2.5-241g identifies the number and length of the depth intervals for each zone used in the development of the derived V_s profile.

West ESWPT

As shown in FSAR Figure 2.5-241h, the bottom of the West ESWPT foundation is at Elevation 259 ft. The average top of Zone III material beneath the West ESWPT is at Elevation 244 ft, resulting in an average of 15 ft of concrete fill between the bottom of the foundation and the top of Zone III rock. There are no V_s borings that are relatively close to the West ESWPT. Borings B-907 and B-909 are nearest the structure and were used as the basis for developing a combined V_s profile beneath the West ESWPT. Boring M-10 is as close to the Plant North end of the West ESWPT as B-907. However, it is remote from the remainder of the structure and therefore was not included.

There are three borings directly beneath the West ESWPT (M-17, M-18, and M-27) and five more that are within 100 ft of the structure (B-921, M-11, M-13, M-21, and W-8). (Borings M-14 and M-15 are also directly under the pipe tunnel; however, they only extend to Zone IIB, which will be removed, and therefore were not used.) From the eight borings, the thicknesses of Zone III and Zone III-IV were determined.

As described in FSAR Section 2.5.4.7.1, the derived V_s profile used for this structure was developed from V_s borings B-907 and B-909 and is shown in FSAR Figure 2.5-241h. This derived V_s profile was used as input to the FIRS calculations for the West ESWPT (except that the concrete fill is explicitly included in the SSI analysis models rather than the site response analysis models) because the average zone thicknesses and locations (depth below grade) beneath the tunnel are not similar to the thicknesses and locations of the zones at the two selected V_s boring locations. Therefore, Method (2) was used to develop the derived V_s profile from these nearest V_s borings. Figure 2.5-241h identifies the number and length of the depth intervals for each zone used in the development of the derived V_s profile.

Response (b): V_s Profiles along the East Side of the Plant Footprint

The V_s profiles for structures on the East side of the plant footprint were developed as described for the East PS/B, East PSFSV, and East ESWPT in Response (a) above.

Response (c): Justification for V_s Data Averaging Approach

The V_s profile from boring B-909 was considered representative of the profile beneath the West PS/B and West PSFSV structures as described in Response (a) above. The profile, in this case, was divided into discrete 10-ft vertical depth intervals within each zone and these vertical intervals did not cross zone boundaries. Therefore, the larger changes in V_s that can occur at the zone boundaries (e.g., between Zone III and Zone III-IV) were not lost, and the contrast of V_s between different zones was not diminished or smoothed, by the averaging process. Note that V_s data for SHAKE analysis need to be input in a series of depth intervals within each zone, rather than as the actual measured values at each 1.64 ft depth. A 10-ft depth interval typically provides 6 measured values from which average, minimum and maximum values can be computed. The selected depth interval was increased or decreased from 10 ft for different profiles depending on the zone thickness and the variation of the measured V_s data.

In FSAR Figure 2.5-241b, the average 28-ft depth of Zone III material below the PS/B mat is to be replaced with concrete fill and is shown in the figure with an average V_s of 7,000 ft/sec, and minimum and maximum V_s values of 6,000 ft/sec and 8,000 ft/sec, respectively. For boring B-909, there is only moderate variation of V_s below about Elevation 225 ft in the Zone III-IV and Zone IV material (FSAR Figure 2.5-237). This variation is accounted for by establishing the maximum and minimum V_s values for each 10-ft vertical interval equal to the maximum and minimum, respectively, of the measured values within the 10-ft vertical depth interval. Therefore, an isolated significant deviation in V_s, either maximum or minimum, is represented as occurring over the entire 10-ft interval. Although averaging the V_s values over 10-ft intervals may tend to smooth the data within each zone, the range of variation of V_s values, based on the minimum and maximum V_s within the interval, is represented in the site-specific simulated (randomized) soil profiles as described in FSAR Section 3OO.1.1 and the impedance contrast between different zones includes those minimum and maximum V_s values, which offsets any smoothing within each zone.

Proposed COLA Revision

None

ENCLOSURE 2

Response to NRC RAI Letter 81

RAI 5959 Question 03.07.01-6

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

North Anna Unit 3

Dominion

Docket No. 52-017

RAI NO.: 5942 (RAI LETTER 81)

SRP SECTION: 03.07.01 – SEISMIC DESIGN PARAMETERS

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

DATE OF RAI ISSUE: 8/15/2011

QUESTION NO.: 03.07.01-6

FSAR Section (Appendix) 3OO.1.3 states that multiple performance-based surface response spectra (PBSRS) were calculated as 5% damped response spectra at finished grade. Figures 3OO-233 and 3OO-234 show horizontal and vertical PBSRS for the eight different structures. Please provide a description discussing how each of those profiles were developed.

Also, please describe the process for developing the profiles along the East side of the plant's footprints (e.g., ESWP Tunnel and East PS/B) since there are no P-S suspension logging measurements in this area.

Dominion Response

The horizontal and vertical performance-based surface response spectra (PBSRS) provided in Figures 3OO-233 and 3OO-234 are obtained using individual soil profiles developed for the Reactor Building (R/B) Complex, East and West Power Source Buildings (PS/Bs), East and West Essential Service Water Pipe Tunnel (ESWPT), the Ultimate Heat Sink Related Structures (UHSRS) A through D, and the UHSRS Pipe Chase. Note that the development of horizontal and vertical PBSRS follows the same methodology and uses the same soil profiles as the full column outcrop foundation input response spectra (FIRS) described in FSAR Appendix 3OO, Section 3OO.1.3. The development of the shear-wave velocity (V_s) profiles, the maximum and minimum V_s values defining the range of variation of V_s, and the maximum and minimum thicknesses for each rock zone is described in the response to RAI 5942, Question 03.07.01-5. This information is used as input to the soil profile simulation (SPS) program which generates 60 simulated soil profiles for each of the aforementioned structures consistent with the observed V_s and thickness data reported for each structure as described in FSAR Section 3OO.1.1.

The development of profiles along the east side of the plant's footprint is described in the response to RAI 5942 Question 03.07.01-5.

Proposed COLA Revision

None