**Ronald B. Clary**
General Manager
New Nuclear Deployment

SCE&G®
A SCANA COMPANY

April 29, 2009
NND-09-0101

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

ATTN: Document Control Desk

Subject: Virgil C. Summer Nuclear Station (VCSNS) Units 2 and 3 Combined License Application (COLA) - Docket Numbers 52-027 and 52-028 Supplemental Response No. 1 to NRC Request for Additional Information (RAI) Letter No. 030

References:
1. Letter from Ravindra G. Joshi (NRC) to Alfred M. Paglia (SCE&G), Request for Additional Information Letter No. 030 Related to SRP Section 2.5.2 for the Virgil C. Summer Nuclear Station Units 2 and 3 Combined License Application, dated February 10, 2009.
2. Letter from Ronald B. Clary (SCE&G) to Document Control Desk, Response to NRC Request for Additional Information (RAI) Letter No. 030, dated March 12, 2009.

The enclosure to this letter provides the South Carolina Electric & Gas Company (SCE&G) supplemental response to the RAI items included in the NRC letter referenced above. This letter supplements the initial response to the NRC provided by SCE&G and provides responses to NRC RAI Numbers 02.05.02-6, 02.05.02-15, 02.05.02-18 and 02.05.02-19. The enclosure also identifies any associated changes that will be incorporated in a future revision of the VCSNS Units 2 and 3 COLA.

Also attached to this letter is a CD that contains electronic data that was requested by the NRC in RAI 02.05.02-19. The supplemental information contained in the files on the CD is provided to support the NRC's review of the VCSNS COLA Section 2.5.2, but does not comply with the requirements for electronic submissions as stated in NRC Guidance Document, "Guidance for Electronic Submissions to the NRC," dated October 29, 2008. The NRC staff requested that these files be provided in their native formats. Formatting the data to comply with the guidance on electronic submissions would not serve the request to provide these files in their native formats.

Should you have any questions, please contact Mr. Al Paglia by telephone at (803) 345-4191, or by email at apaglia@scana.com.

D083
NRO

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

Executed on this 29th day of April, 2009.

Sincerely,

Ronald B. Clary
General Manager
New Nuclear Deployment

AMM/RBC/am

Enclosure

c (without enclosure):
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**NRC RAI Letter No. 030 Dated February 10, 2009**

**SRP Section: 2.5.2 – Vibratory Ground Motion**

Question from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

**NRC RAI Number: 02.05.02-6**

Page 2.5.2-3 of the FSAR states that the magnitudes in the updated seismicity catalog were converted to EPRI best-estimate values of mb based on FSAR Equations 2.5.2-1 and 2.5.2-2. Please justify the use of these formulas, which are based on magnitude data acquired more than 20 years ago. If these formulas were not adequate, please explain any inadequacy. Please also explain why newer data was not used to compute these formulas. Also, in FSAR Equation 2.5.2-3 (page 2.5.2-3), you use b=1.0. Is this b-value supported by the regional seismicity data?

**VCSNS RESPONSE:**

In the development of the EPRI (FSAR Reference 235) methodology and database, an effort was made to develop a uniform characterization of body-wave magnitude [$m_b$] for each earthquake in the EPRI seismicity catalog in order to develop a robust database from which rigorous assessments of magnitude-frequency recurrence and maximum magnitudes could be made for subsequent input to probabilistic seismic hazard analyses [PSHA]. Reference 235 discusses the statistical analyses that were applied to the EPRI seismicity catalog to develop the magnitude conversion relations, referenced in the FSAR as Equations 2.5.2-1 and 2.5.2-2. The earthquake database from which these relationships were derived – including the assessments of various magnitude and intensity measures for each earthquake serving as input to the regressions for magnitude conversion relationships – was developed under an equivalent SSHAC [Senior Seismic Hazards Analysis Committee] Level 4 process (Reference 270). The EPRI seismicity catalog and the magnitude conversion relations developed from that database are still considered to be an adequate characterization of seismicity in the central and eastern U.S. through 1984.

There are relatively few data occurring after 1984 with which to supplement the rigorous statistical analysis done by EPRI (Reference 235). In Table 2.5.2-202 there are only 10 events with both Emb values determined from $M_d$ using Equation 2.5.2-1 and an alternate and independent $m_b$ value. The trend of these values – although too small in number to confidently determine an alternate conversion relation – suggests a slightly lower Emb value than assigned using Equation 2.5.2-1. All of the Emb values determined from $M_L$ and Equation 2.5.2-2 are obtained from the ANSS catalog, which presents only a single magnitude field, precluding investigation of an Emb($M_L$) trend considering these data. The Emb values adopted for the EPRI catalog update of the FSAR are believed to be reasonable for their purpose: to investigate whether the

recurrence parameters or maximum magnitudes used in the EPRI study need to be modified on the basis of more recent seismicity.

In Reference 235 a b-value of 1.0 was used to determine $m_b$* in the EPRI seismicity catalog. Again for consistency in methodology, b=1.0 was used in the FSAR for the updated seismicity when using Equation 2.5.2-3. Figures 2.5.2-220, -221, and -222 show that b=1.0 is a reasonable global b-value for the purposes of evaluating $m_b$* and is consistent with b-values of about 0.95 to 1.1 found for regional seismicity for both the EPRI and updated EPRI catalogs as measured from these figures. In addition, although Emb values for earthquakes in the updated portion of the catalog are derived from several directly reported magnitude scales, all have been assumed to have uncertainties represented by standard deviations between 0.1 and 0.41. For $\sigma$ values in this range, and for b-values between 0.95 and 1.1 the correction to Emb from Equation 2.5.2-3 of the FSAR is 0.02 or less indicating that the use of a b-value of 1.0 is not critical.

**References for the Response (from VCSNS FSAR):**

Reference 235 EPRI, *Seismic Hazard Methodology for the Central and Eastern United States*, Volume 1, Part 2: Methodology (Revision 1). EPRI Report NP-4726-A, Rev. 1, Palo Alto, California, November 1988.

Reference 270 Senior Seismic Hazards Analysis Committee, *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts*, Prepared by Senior Seismic Hazard Analysis Committee (SSHAC), NUREG/CR-6372, 1997.

This response is PLANT SPECIFIC.

**ASSOCIATED VCSNS COLA REVISIONS:**

No COLA changes have been identified as a result of this response.

**ASSOCIATED ATTACHMENTS:**

None

**NRC RAI Letter No. 030 Dated February 10, 2009**

**SRP Section: 2.5.2 – Vibratory Ground Motion**

Question from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

**NRC RAI Number: 02.05.02-15**

In FSAR Section 2.5.2.4.5 (page 2.5.2-40), the applicant stated that it used the cumulative absolute velocity (CAV) model of Hardy et al. (2006) to model the damageability of small-magnitude earthquakes to engineered facilities. Please provide details of how the CAV filter was implemented and describe how the seismic hazard curves and the UHRS would change if CAV filtering had not been applied. In addition, please describe how the local sources and the high frequency (5-10 Hz) controlling earthquake was affected by the CAV filter.

**VCSNS RESPONSE:**

The cumulative absolute velocity (CAV) model is applied using the procedure described in Hardy et al. (2006). The CAV model accounts for the non-damageability of earthquake ground motions from small magnitude, short duration earthquakes. A CAV amplitude of 0.16 g-sec is used as a conservative threshold below which ground motions will not cause damage to engineered facilities. The relevant equation for calculating the probability of CAV>0.16 g-sec is given in Equations 2-2, 2-4, 2-7, and 2-8 of Hardy et al. (2006). Equation 2-7 of Hardy et al. (2006) is plotted in Figure RAI-2.5.2-15.1 below, which is taken from Figure 2-34 of Hardy et al. (2006). CAV depends on the magnitude of the earthquake, on the peak ground acceleration (PGA) level, on the site conditions as represented by the average shear wave velocity in the top 30 m ($V_{S30}$), and on duration of the ground motion, which is estimated from the magnitude. As Figure RAI-2.5.2-15.1 shows, as the magnitude increases and/or the PGA level increases, the probability of CAV>0.16 g-sec increases to unity.

The CAV model was implemented in the seismic hazard calculations by calculating the probability that CAV>0.16 g-sec, and by modifying the frequency of exceedence of ground motions within the hazard calculations to only include damaging ground motions, i.e. by multiplying by the probability that CAV>0.16 g-sec. This calculation depends on the magnitude of the earthquake, on the peak ground acceleration (PGA) level, on the site conditions as represented by the average shear wave velocity in the top 30 m ($V_{S30}$), and on duration of the ground motion, which is estimated from the magnitude. Seismic hazard calculations for spectral accelerations other than 100 Hz (which is equivalent to PGA) are discussed in the response to RAI 02.05.02-16 (See letter from Ronald B. Clary (SCE&G) to Document Control Desk, Response to NRC Request for Additional Information (RAI) Letter No. 030, dated March 12, 2009).

The effect of the CAV filter on seismic hazard curves is to limit the hazard at low amplitudes to an asymptotic value, which is the frequency of occurrence of damaging ground motions from earthquakes in the region. At high amplitudes, there is little effect of the CAV filter. If the CAV filter had not been applied, the hazard curves would not roll over to the horizontal asymptote but would be higher at small amplitudes. At high amplitudes there would be little to no difference in the seismic hazard curves.

Within the seismic hazard calculations, the local seismic sources themselves are not affected by the CAV filter; the CAV filter affects the calculation of the frequency of damaging ground motions at the site and depends, among other parameters, on $V_{S30}$ at the site. Regarding the high-frequency controlling earthquake ground motions, inasmuch as the CAV model filters out short-duration, non-damaging ground motions from small magnitude earthquakes, and these ground motions tend to occur during earthquakes close to the site, non-use of the CAV filter would include these ground motions in the hazard calculations and would result in a smaller-magnitude, closer-distance controlling earthquake.

**References for the Response:**

Hardy, G, K. Merz, N. A. Abrahamson, and J. Watson-Lamprey (2006). *Program on Technology Innovation: Use of Cumulative Absolute Velocity (CAV) in Determining Effects of Small Magnitude Earthquakes on Seismic Hazard Analyses*, Elec. Power Res. Inst., Palo Alto, CA, Rept. 1014099, August.

This response is PLANT SPECIFIC.

**ASSOCIATED VCSNS COLA REVISIONS:**

No COLA changes have been identified as a result of this response.

**ASSOCIATED ATTACHMENTS:**

Figure 2.5.2-15.1.

**Attachment to RAI 02.05.02-15**

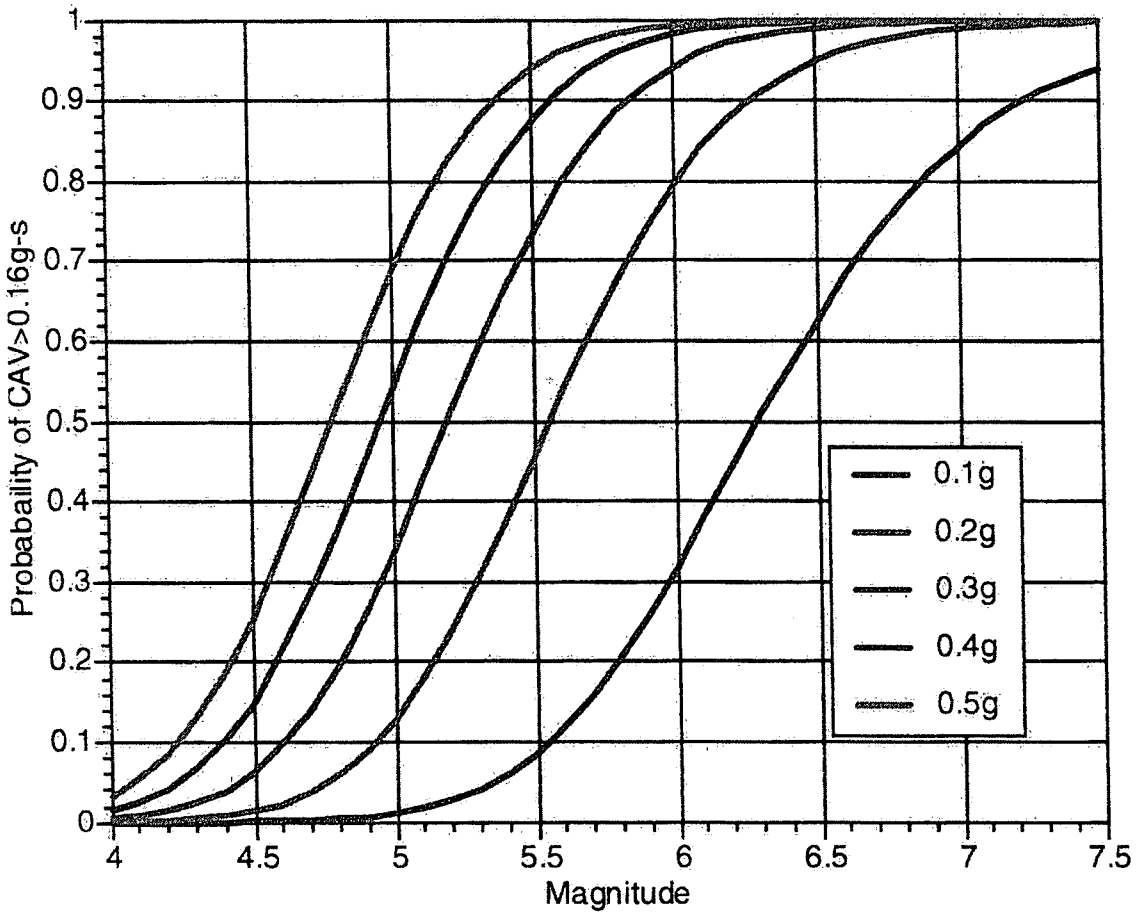



**Figure 2.5.2-15.1. Probability of CAV>0.16 g-sec as a function of earthquake magnitude and PGA level (taken from Figure 2-34 of Hardy et al. (2006), for a site with $V_{S30}$=1000 m/s. For a given magnitude, the probability of CAV>0.16 g-sec increases with increasing PGA level.**

**NRC RAI Letter No. 030 Dated February 10, 2009**

**SRP Section: 2.5.2 – Vibratory Ground Motion**

Question from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

**NRC RAI Number: 02.05.02-18**

FSAR Section 2.5.2.5 states that the site is underlain by weathered and unweathered bedrock with a high shear velocity (greater than 8,500 fps) and, therefore, a site response analysis was not performed to develop the GMRS because the S-wave velocity is consistent (i.e. within the uncertainty) with the ground motion model used in the PSHA (S-wave velocity greater than 9,200 fps). While FSAR Figure 2.5.4-226, "Shear Wave Velocity of Layer V with 5-Foot Vertical Distance Averaging" shows the mean S-wave velocity to be greater than 8,500 fps, the profile exhibits a large standard deviation particularly below Unit 2 in the 310 to 355 ft elevation range. FSAR Section 2.5.4.7.3 presents the results of site response calculations but does not discuss the impact of the site response on the GMRS.

Please provide additional justification for not performing a site response calculation as part of the development of the GMRS, in light of the significant S-wave velocity variability beneath the site and the observed S-wave velocity values that are significantly less than 8,500 fps.

**VCSNS RESPONSE:**

The response to RAI 02.05.02-18 is divided into (a) a geologic/seismic component and (b) a sensitivity study to examine the effects of variation of rock shear wave velocity on the GMRS that is quantified by performing the site response analysis for both Units 2 and 3.

The site response discussed in FSAR Section 2.5.4.7.3 was performed to evaluate liquefaction potential in the native saprolitic soils occurring at the site, not as part of the development of the GMRS. As noted in the FSAR, these saprolitic soils and underlying moderately to partially weathered rock will be removed during construction. Calculation of GMRS in FSAR Section 2.5.2.4 follows RG 1.208 and ASCE 43-05 and is performed for a rock horizon with shear wave velocity of 9200 ft/sec without any further amplification of motion.

(a) The high $V_s$ values measured below about El. 330 ft at Unit 2 and from the top of hard rock at about El. 355 at Unit 3, as well as high rock quality designation (RQD) values logged in boreholes across the site (COLA Part 11), indicate that the VCSNS Units 2 and 3 site, underlain by a plutonic complex, is a hard rock site (once the native saprolitic soils and weathered rock have been removed) that does not require a site response for structures founded on the hard rock or on concrete fill overlying the rock.

Therefore, a site response calculation is not required as part of the development of the GMRS.

The subhorizontal fracture zones that appear related to the decrease in $V_s$ values noted in the RAI are restricted in both a vertical and lateral extent to limited zones across the site. The shear wave velocity ($V_s$) data shown in FSAR Figure 2.5.4-226 are from the four Unit 2 boreholes in which $V_s$ was measured, i.e., B-201 and B-206 within the nuclear island, and B-207 and B-211 outside the nuclear island footprint. As these data indicate, the average $V_s$ below about El. 330 ft is 9,200 fps or more. Ground motion attenuation relations used to conduct probabilistic seismic hazard analysis are generally assumed by the developers of these relations to be directly applicable to hard rock with a shear wave velocity of 9,200 fps. Therefore, for structures founded on hard rock there is no need to consider further site-specific amplification of strong earthquake ground motion. Thus, amplification does not need to be considered for the rock below El. 330 ft. From about El. 330 ft to El. 355 ft , which is the top of sound rock , the average $V_s$ is about 8,000 fps. The 25 ft thickness of rock with a $V_s$ value about 13% less than 9,200 fps would be expected to have minimal amplification effects and only for very high frequencies.

The data and analyses presented in the FSAR incorporate a geologic conceptual model of the site based on the geologic mapping described in FSAR Subsections 2.5.1.1 and 2.5.1.2, on the borehole lithologic and geophysical data presented in COLA Part 11 and on geotechnical data discussed in FSAR Subsection 2.5.4. As stated in the FSAR (Subsection 2.5.1.2.3), the VCSNS Units 2 and 3 site is located within the Winnsboro plutonic complex. This felsic plutonic complex consists of several phases that include granodiorite, quartz diorite, migmatite, and pegmatite dikes. This coarse- to medium-grained intrusive complex is dated by Rb-Sr and K-Ar methods at about 300 MA (FSAR Reference 2.5.1-240). Both field mapping and core samples indicate that the Winnsboro plutonic complex intruded amphibolite-grade metamorphic country rock composed primarily of complexly interlayered and folded biotite and hornblende gneiss and amphibolite schist. Based on the lithologies and its areal extent (FSAR Figures 2.5.1-220 and 224), the pluton is a deeply rooted, large rock mass within the continental crust. The decrease in shear wave velocity seen in Borings B-201 and B-206 is correlated with a zone of subhorizontal, slightly weathered fractures observed in the rock core and noted on the boring logs as a decrease in RQD values. RAI Figure 02.05.02-18.1 is a boring location map showing the locations of the geologic profiles contained in RAI figures 02.05.02-18.2 through 02.05.02-18.5. These profiles show the various phases of the plutonic complex, rock core recovery and RQD values. The geologic profiles graphically demonstrate that the subhorizontal fractures are confined to relatively thin zones that are not demonstrably continuous across the site. Geologic subsurface Profile A-A' (RAI Figure 02.05.02-18.2) shows the intervals of relatively lower RQD; interpreted as subhorizontal fracture zones in borings B-201, B-202, B-205 and B-206. The fracture zone in granodiorite in Boring B-201 between approximate elevations 338 and 325 ft, correlated with the lower shear wave velocities cited in SCE&G RAI 02.05.02-18, cannot be traced to the granodiorite in Boring B-202 located

approximately 55 ft to the northeast or to Boring B-203, approximately 49 ft to the southwest. A correlation between the fracture zone at approximate elevation 338 in both borings B-201 and B-202 is equivocal because the zone at B-202 is thinner than the zone in Boring B-201 and connectivity cannot be demonstrated with available data. Boring B-206 shows high rock core recovery and high RQD for the quartz diorite and migmatite at the same elevation.

Geologic subsurface profile B-B' (RAI Figure 02.05.02-18.3) is generally oriented northeast-southwest. The subhorizontal fracture zone in indicated by lower RQD values and lower shear wave velocities in Boring B-201 cannot be traced to either Boring B-203 or Boring B-204.

Geologic subsurface profile C-C' (RAI Figure 02.05.02-18.4) extends from the nuclear island to north of the turbine building in a generally west-east orientation.

Geologic subsurface profile D-D' (RAI Figure 02.05.02-18.5) extends from the turbine building to Boring B-211, south of the reactor containment. Intervals of granodiorite/migmatite with lower RQD values are not observed in Boring B-216 approximately 70 ft to the south of Boring B-217.

Attached Table RAI 02.05.02-18.1 presents RQD and Recovery data for boreholes near Unit 2. Scanning across these data also indicates that the fracture zones are relatively thin rock mass discontinuities that do not comprise a continuous zone across the Unit 2 site.

The subhorizontal fractures at Unit 2 are not observed at Unit 3 and appear to represent local rock mass discontinuities. The high rock core recovery and RQD values across the site indicate that fractures occur to only a very limited extent across the site. Recovery versus elevation for Unit 2 is shown on RAI Figure 02.05.02-18.6 (attached, and also included in the response to RAI 02.05.04-10) and RQD versus elevation is shown on FSAR Figure 2.5.4-211 for both Units 2 and 3. The response to RAI 02.05.04-13 shows the correlation of RQD and $V_s$ in each borehole. Since the discontinuities at Unit 2 are thin and discontinuous (2 borings out of 8), the rock above El. 330 ft does not require a site response. However, a site response analysis, conducted as a sensitivity study, is discussed below.

(b) The measured shear wave velocity data and the boring designation for each Unit are shown in Figure RAI 02.05.02-18.7. In this Figure the scatter in the data particularly for Unit 2 at the elevation of the GMRS horizon (El. 355 ft) are depicted. Figure RAI 02.05.02-18.8 shows the mean plus/minus one standard deviation of the shear wave velocity data showing the larger variation for Unit 2. The velocity of 9200 ft/sec considered in the PSHA computation of GMRS is also marked in this figure. Clearly, except for a limited thickness of fractured, weathered rock at about El 355 ft, the rock velocity well exceeds the 9200 ft/sec indicating very sound rock foundation for the plant site. To capture the variability of the data and using the mean damping value of 1%,

both the velocity profiles and the damping profiles are randomized resulting in a set of 60 randomized profiles for each Unit. The resulting randomized profiles are shown in Figures RAI 02.05.02-18.9 and 18.10 for Units 2 and 3, respectively.

The randomized profiles were used in site responses analyses maintaining linear rock properties. The input motion is the high frequency (HF) and low frequency (LF) response spectra corresponding to 1E-4 and 1E-5 levels. The mean and median of the spectral amplifications are shown in Figures RAI 02.05.02-18.11a and 18.11b for Units 2 and 3, respectively. As shown the amplification is very small and is limited to the high frequency range. Following RG 1.208 and the ASCE 43-05, the design response spectra (DRS) were computed. Figure RAI 02.05.02-18.12 compares the GMRS with the DRS as well as the AP1000 CSDRS and the hard rock high frequency spectrum (HRHFS). As shown the difference between GMRS and DRS is very small with HRHFS effectively enveloping the DRS spectra.

Due to limited thickness and areal extent of the weathered rock beneath Unit 2 and its generally high shear wave velocity, the overall amplification is very small and its impact on the GMRS is negligible.

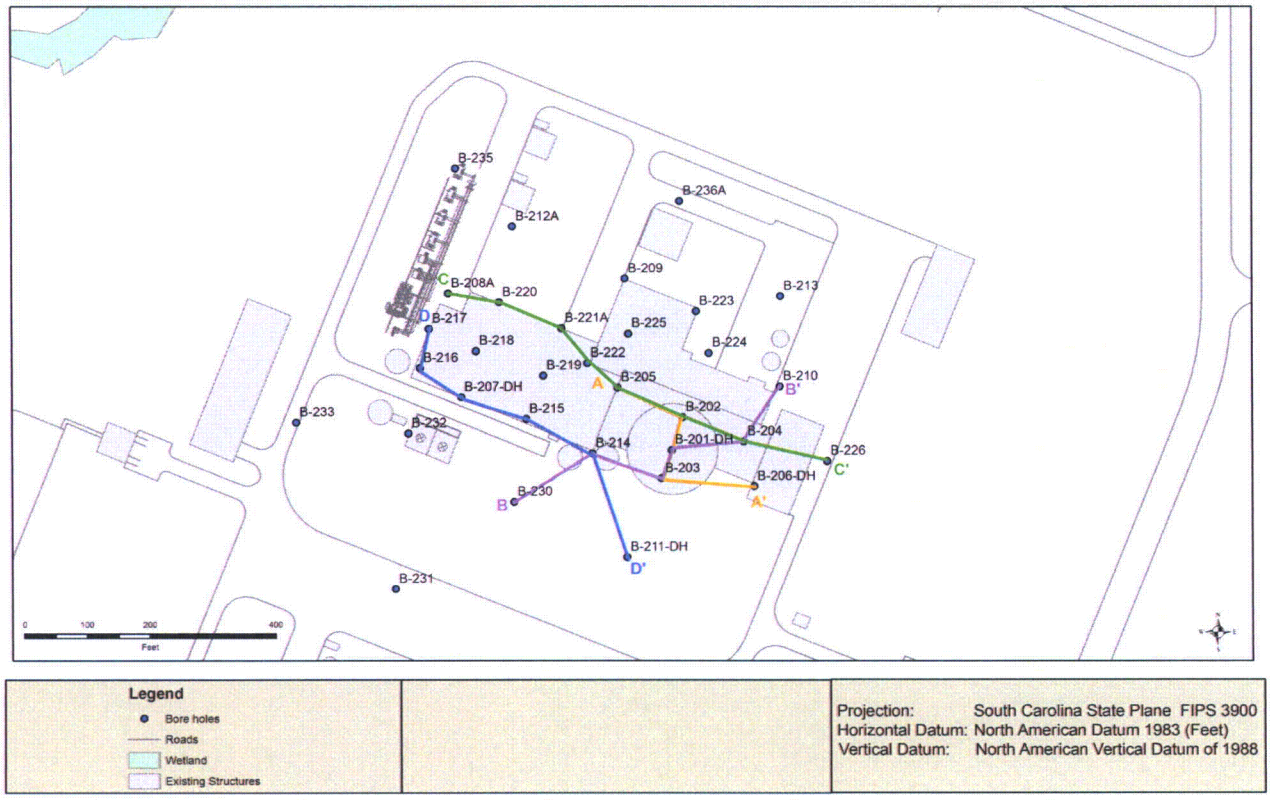
This response is PLANT SPECIFIC.

**ASSOCIATED VCSNS COLA REVISIONS:**

No COLA changes have been identified as a result of this response.

**ASSOCIATED ATTACHMENTS:**

Figures 2.5.2-18.1 through 2.5.2-18.12;
Table RAI 02.05.02-18.1




**Legend**

- Bore holes
- Roads
- Wetland
- Existing Structures

Projection: South Carolina State Plane FIPS 3900
Horizontal Datum: North American Datum 1983 (Feet)
Vertical Datum: North American Vertical Datum of 1988

**Figure 02.05.02-18.1 Boring and Geologic Subsurface Profile Locations within Unit 2**

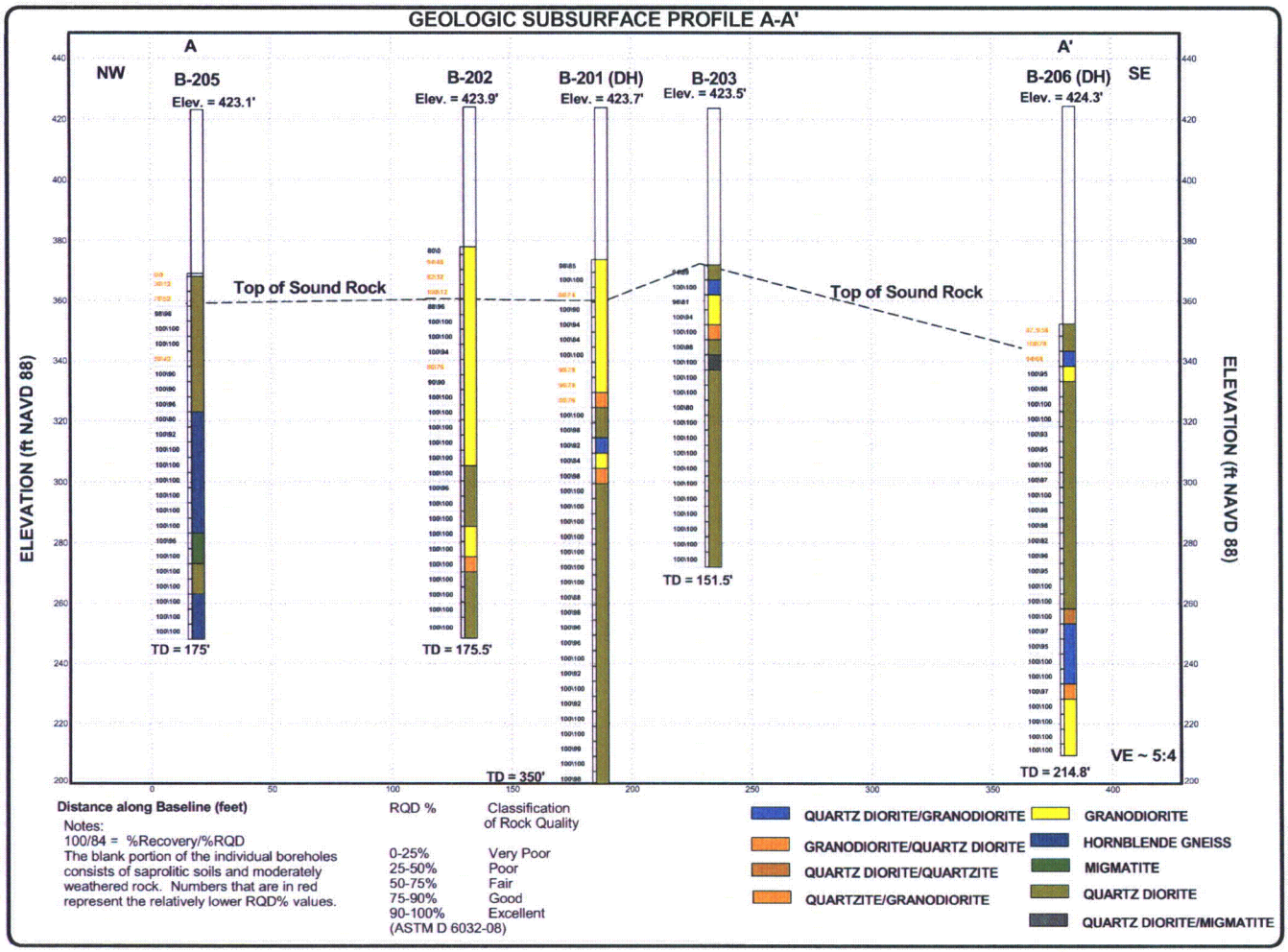



**Figure 02.05.02-18.2 Geologic Subsurface Profile A-A'**

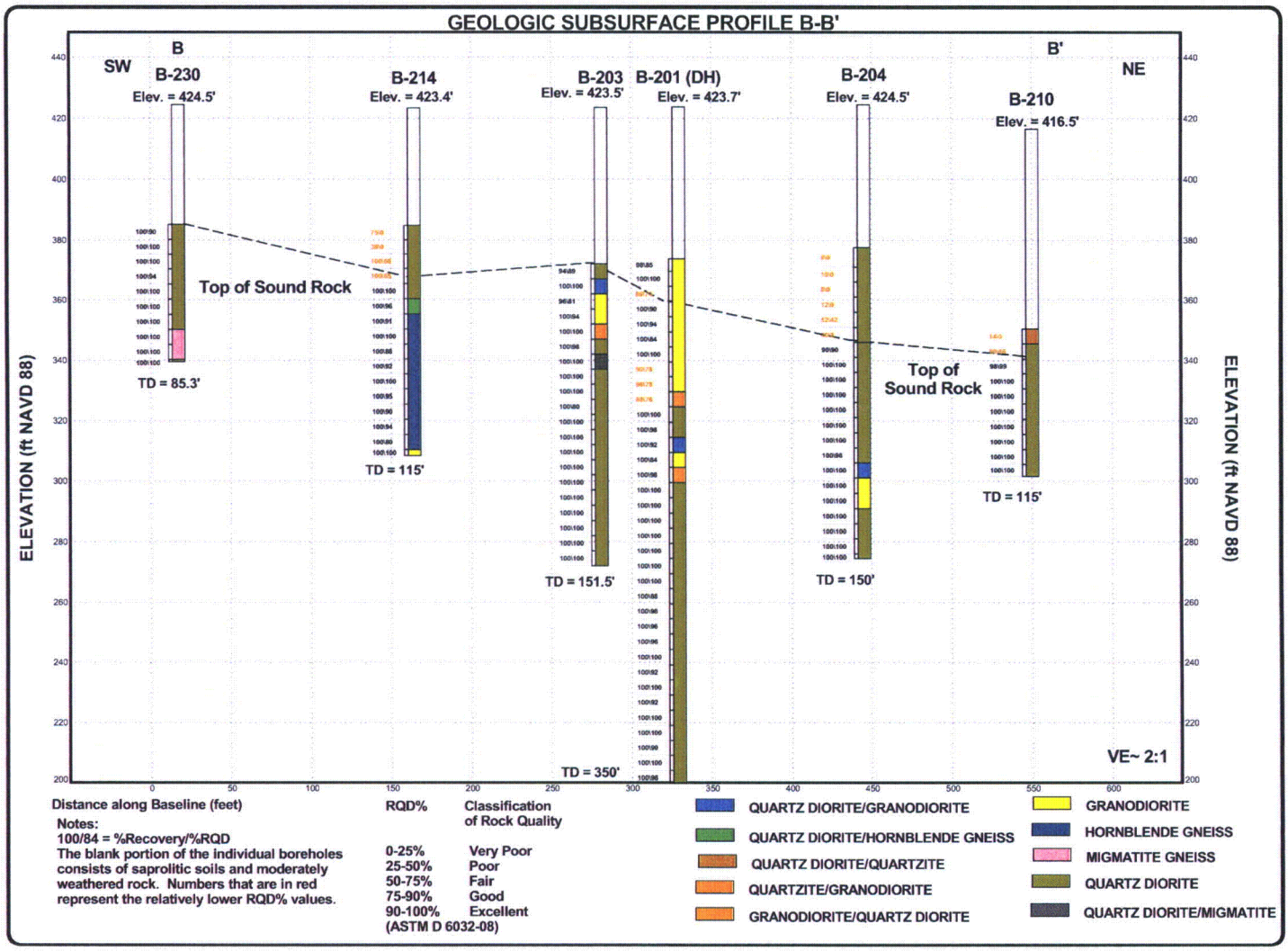



**Figure 02.05.02-18.3 Geologic Subsurface Profile B-B'**

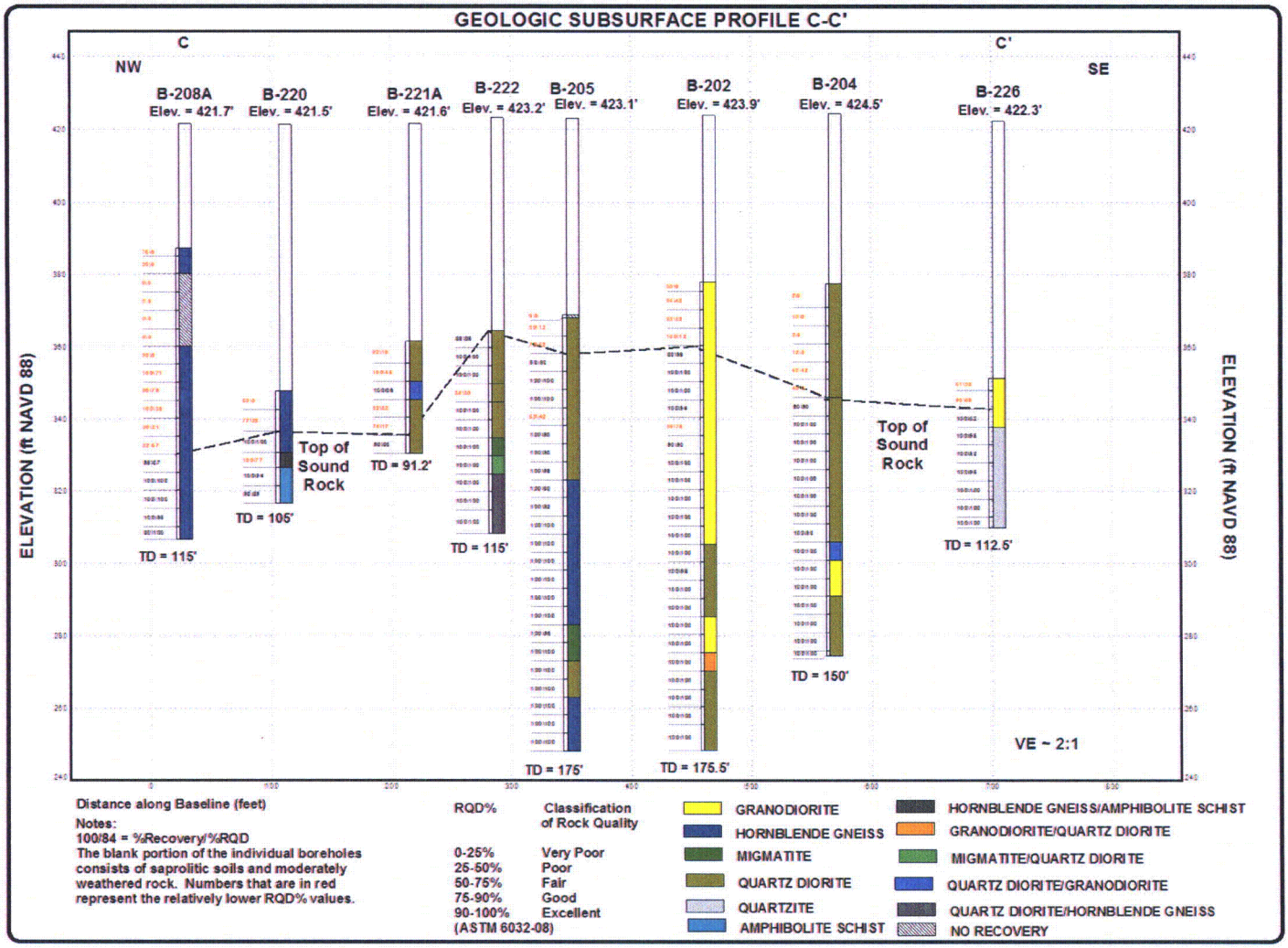



**Figure 02.05.02-18.4 Geologic Subsurface Profile C-C'**

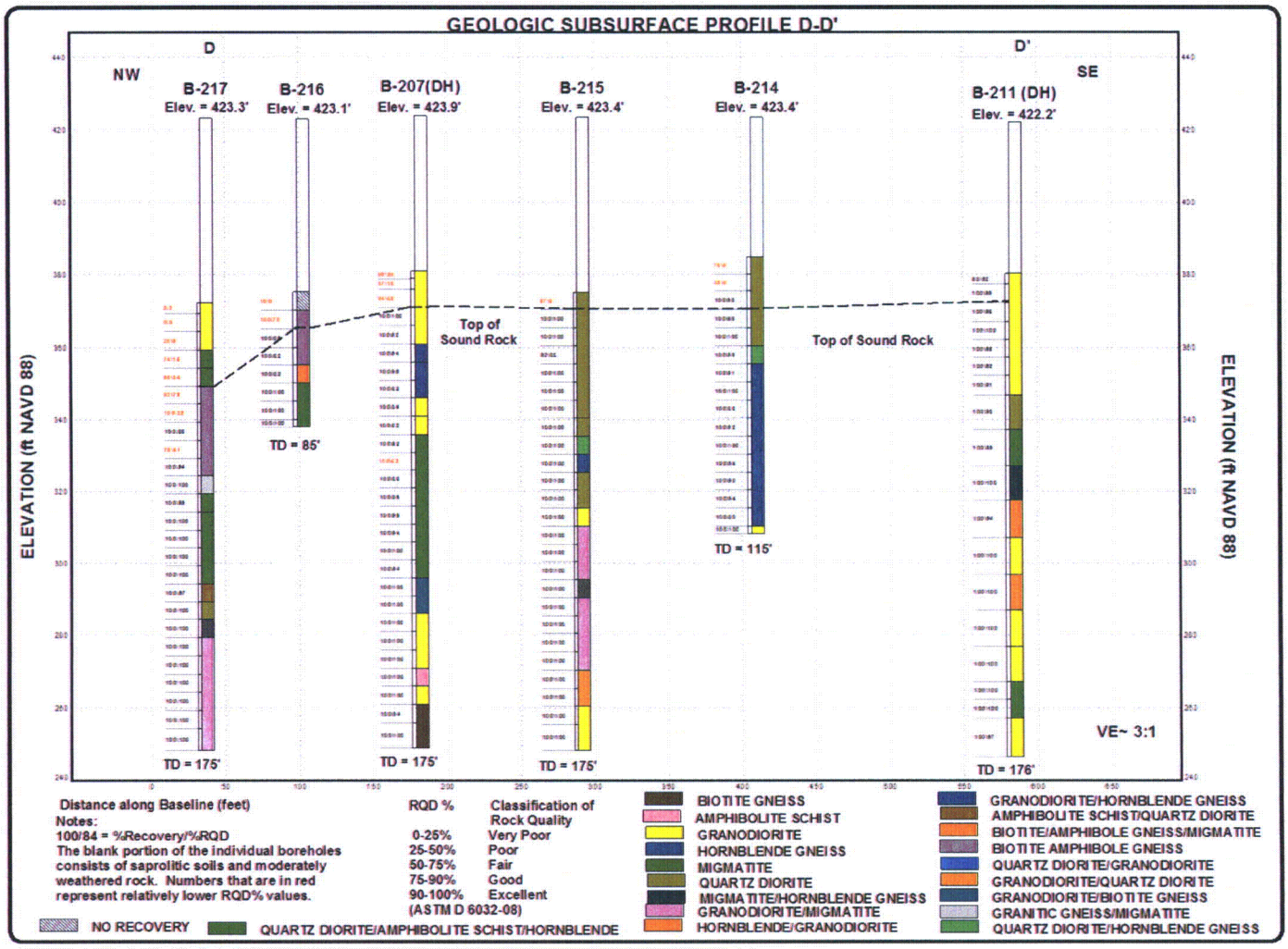



**Figure 02.05.02-18.5 Geologic Subsurface Profile D-D'**

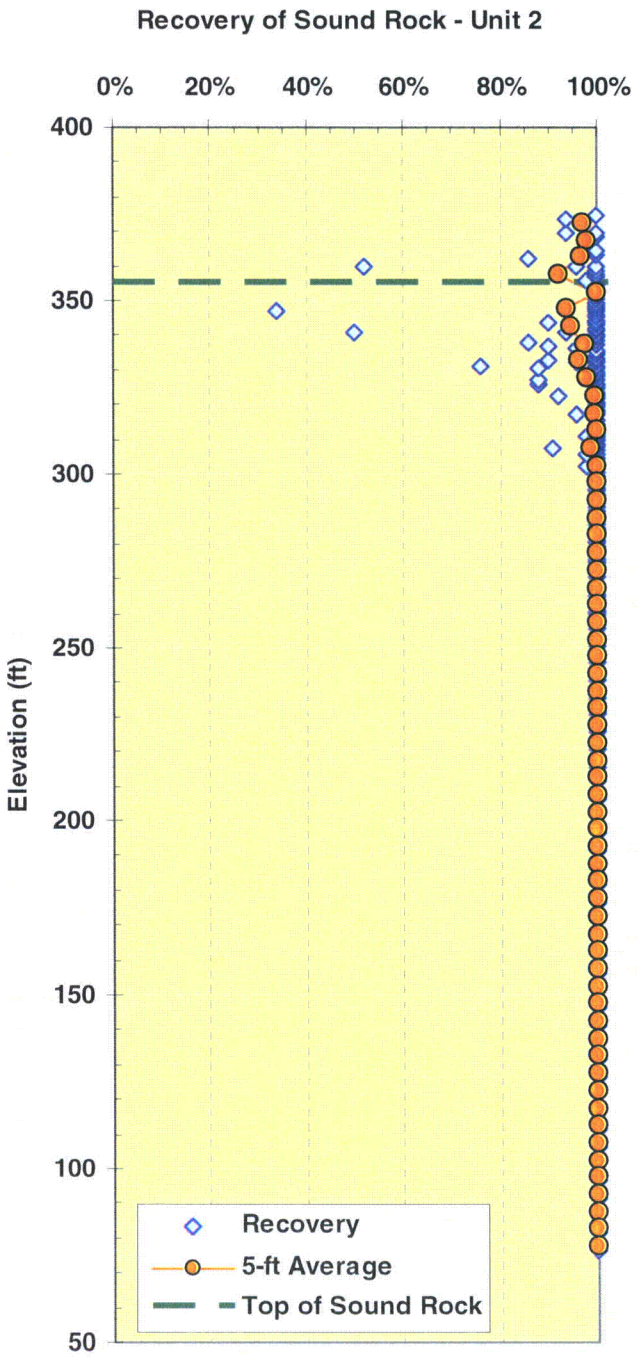



Figure 02.05.02-18.6 Recovery of Sound Rock-Unit 2

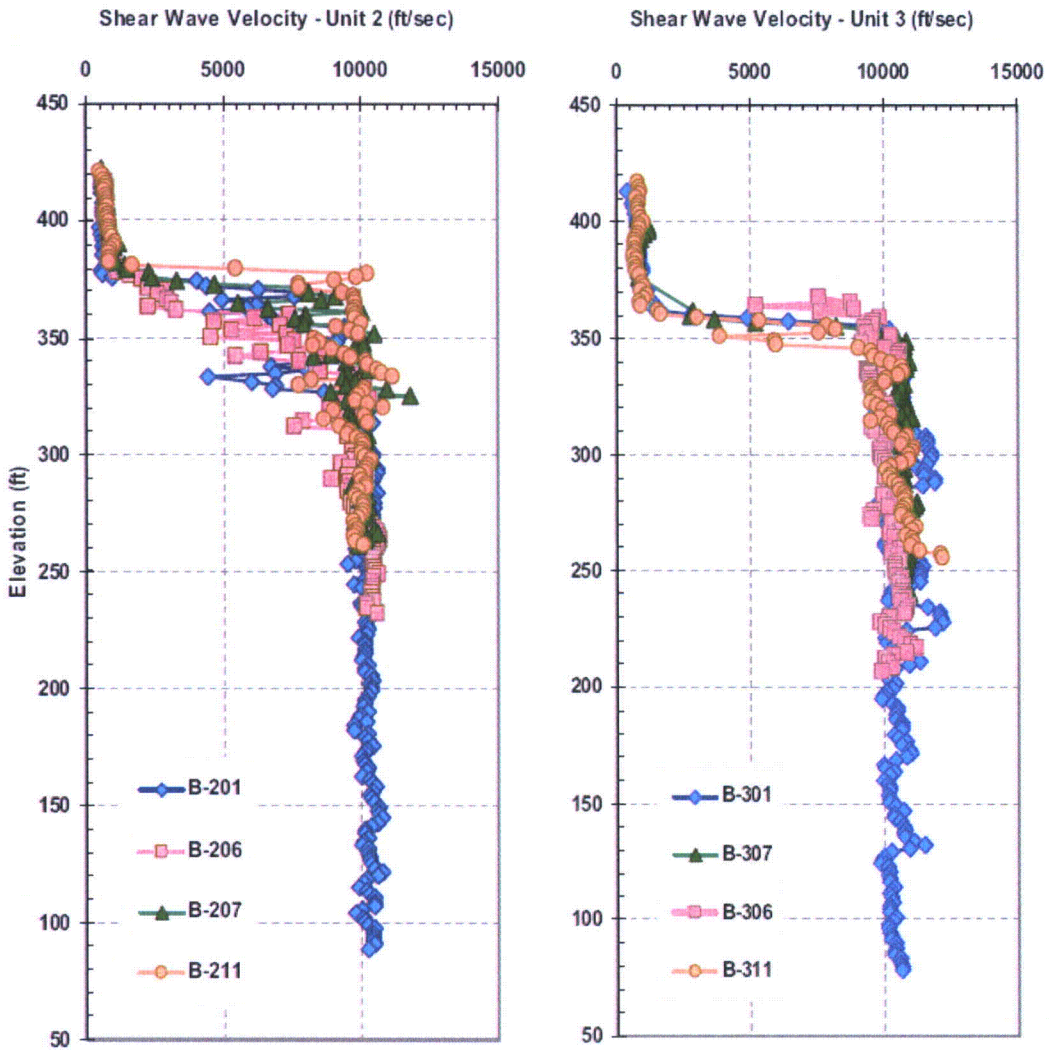



**Figure 02.05.02-18.7 Measured Shear Wave Velocity Data for Units 2 and 3**

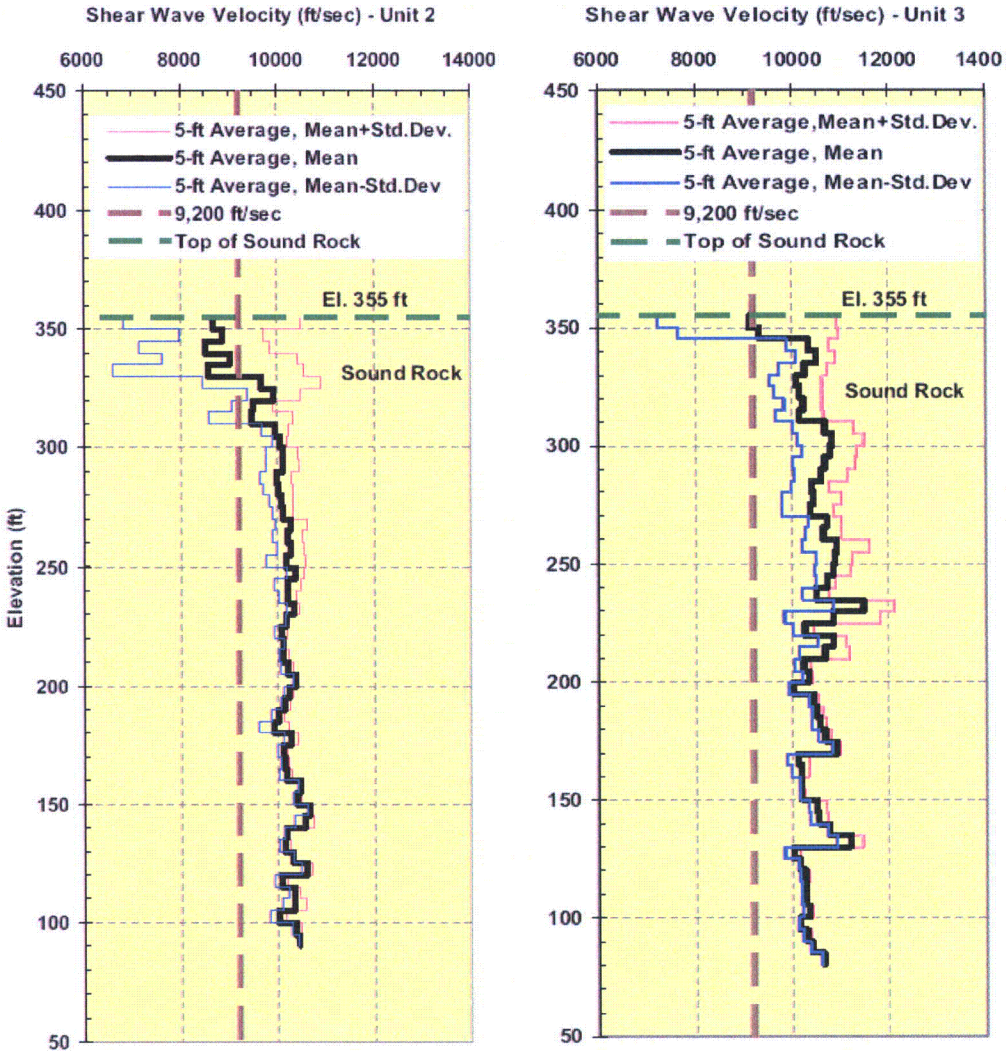



**Figure 02.05.02-18.8 The Mean plus/minus one Standard Deviation of Shear Wave Velocity Profiles for Units 2 and 3**

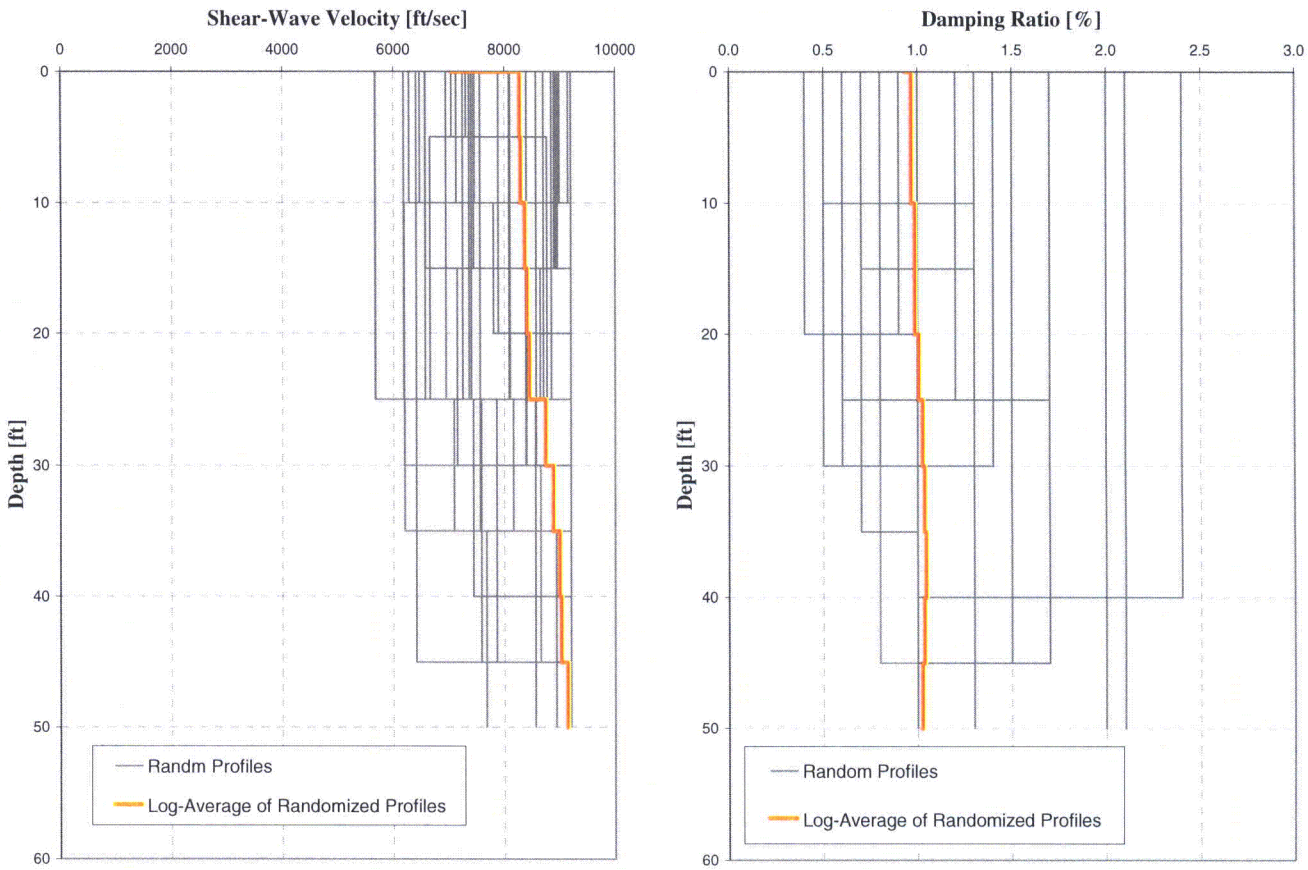



**Figure 02.05.02-18.9 Randomized Velocity and Damping Profiles for Unit 2**

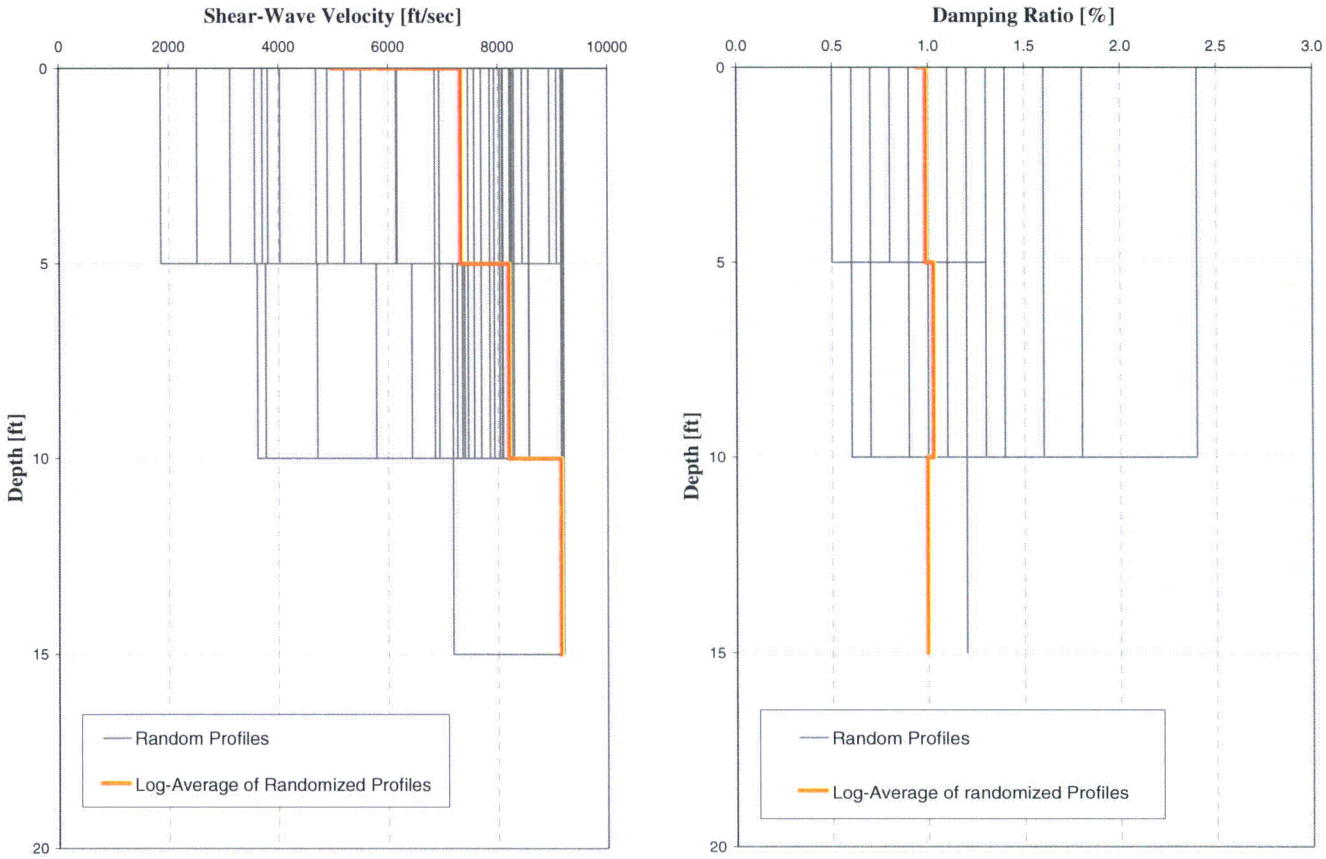
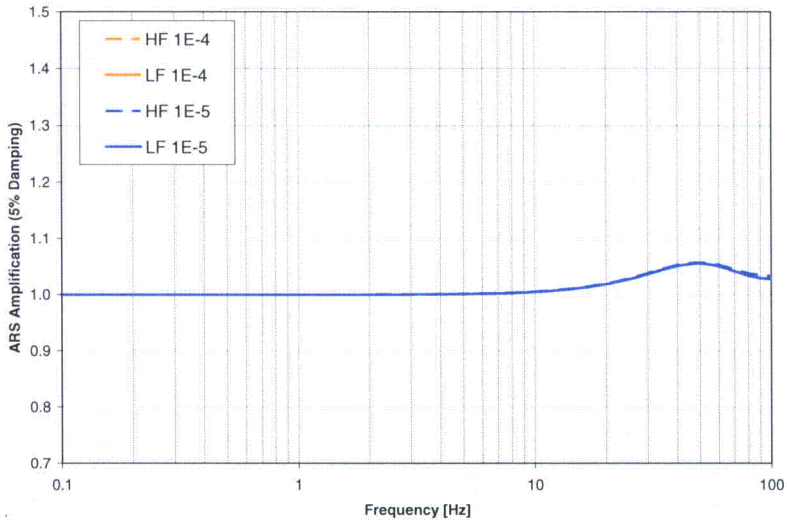
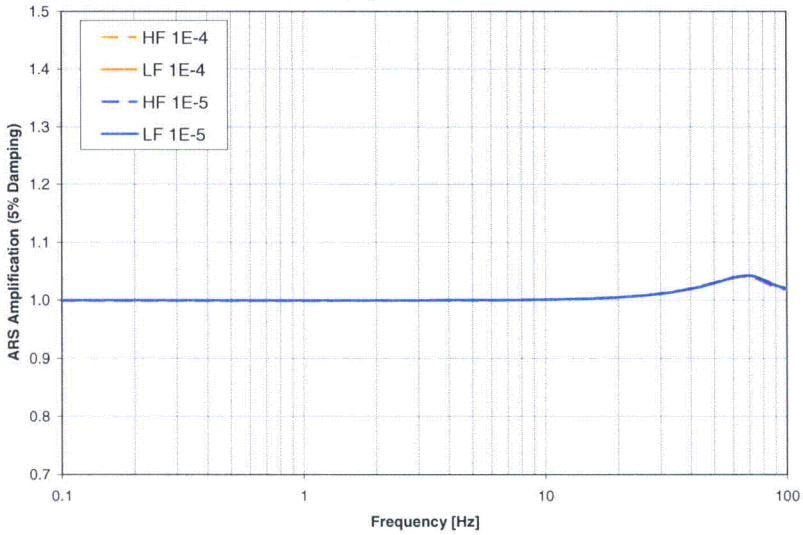



**Figure 02.05.02-18.10 Randomized Velocity and Damping Profiles for Unit 3**




(a) Unit 2




(b) Unit 3

**Figure 02.05.02-18.11 Median and Mean Spectral Amplification Factors for 1E-4 and 1E10-5 HF and LF Input Motions**

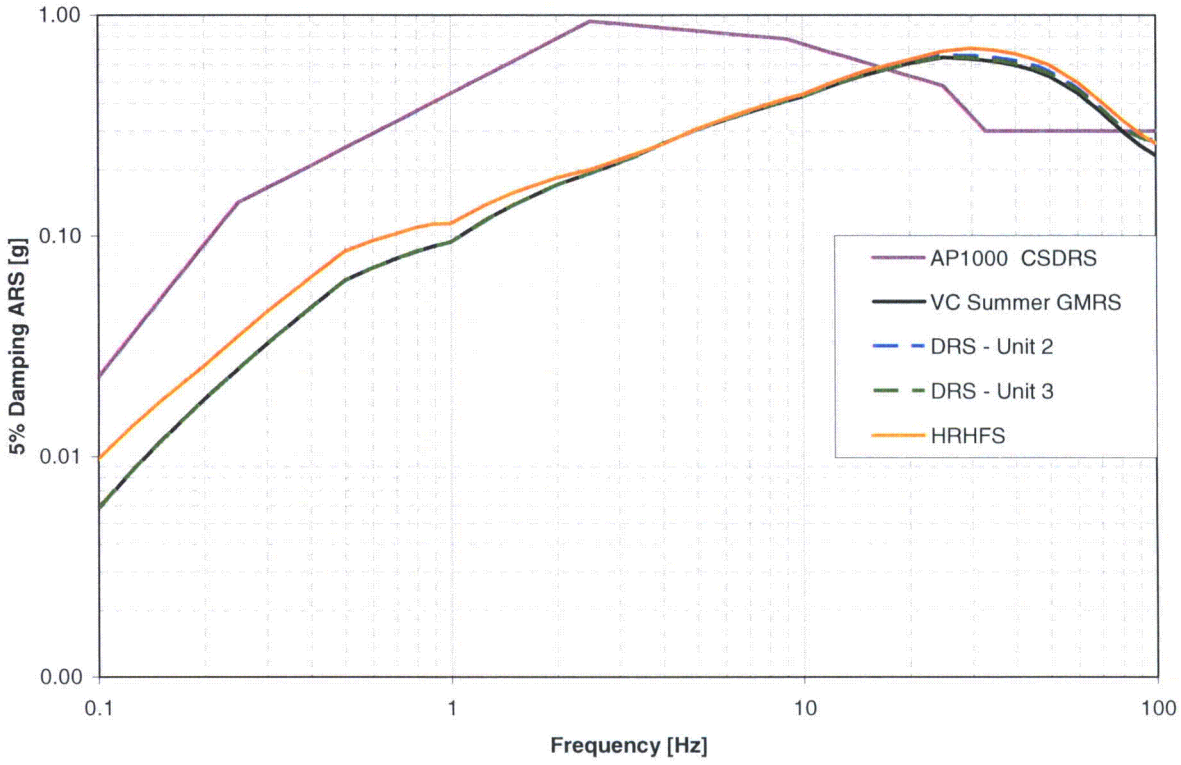



**Figure 02.05.02-18.12 Comparison of GMRS with DRS and AP1000 CSDRS and HRHFS**

# Table RAI 02.05.02-18.1 (Sheet 1 of 2)

B-201 GS = 403.7 ft. Sound Rock = 362 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 372 | 98% | 88% |
| 367 | 100% | 100% |
| 362 | 90% | 76% |
| 357 | 100% | 90% |
| 352 | 100% | 94% |
| 347 | 100% | 84% |
| 342 | 100% | 100% |
| 337 | 92% | 72% |
| 332 | 94% | 75% |
| 327 | 88% | 71% |
| 322 | 100% | 100% |
| 317 | 100% | 98% |
| 312 | 100% | 92% |
| 307 | 100% | 84% |
| 302 | 100% | 98% |
| 297 | 100% | 100% |
| 292 | 100% | 100% |
| 287 | 100% | 100% |
| 282 | 100% | 100% |
| 277 | 100% | 100% |
| 272 | 100% | 100% |
| 267 | 100% | 100% |
| 262 | 100% | 88% |
| 257 | 100% | 98% |
| 252 | 100% | 96% |
| 247 | 100% | 98% |
| 242 | 100% | 100% |
| 237 | 100% | 92% |
| 232 | 100% | 100% |
| 227 | 100% | 92% |
| 222 | 100% | 100% |
| 217 | 100% | 100% |
| 212 | 100% | 98% |
| 207 | 100% | 100% |
| 202 | 100% | 98% |
| 197 | 100% | 98% |
| 192 | 100% | 98% |
| 187 | 100% | 94% |
| 182 | 100% | 100% |
| 177 | 100% | 98% |
| 172 | 100% | 100% |
| 167 | 100% | 96% |
| 162 | 100% | 94% |
| 157 | 100% | 94% |
| 152 | 100% | 100% |
| 147 | 100% | 100% |
| 142 | 100% | 100% |
| 137 | 100% | 100% |
| 132 | 100% | 94% |
| 127 | 100% | 100% |
| 122 | 100% | 100% |
| 117 | 100% | 98% |
| 112 | 100% | 100% |
| 107 | 100% | 94% |
| 102 | 100% | 100% |
| 97 | 100% | 100% |
| 92 | 100% | 94% |
| 87 | 100% | 92% |
| 81 | 100% | 100% |
| 76 | 100% | 96% |

B-202 GS = 423.9 ft. Sound Rock = 360 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 377 | 80% | 0% |
| 372 | 94% | 48% |
| 368 | 82% | 32% |
| 363 | 100% | 12% |
| 358 | 98% | 96% |
| 353 | 100% | 100% |
| 348 | 100% | 100% |
| 343 | 100% | 94% |
| 338 | 98% | 78% |
| 333 | 90% | 90% |
| 328 | 100% | 100% |
| 323 | 100% | 100% |
| 318 | 100% | 100% |
| 313 | 100% | 100% |
| 308 | 100% | 100% |
| 303 | 100% | 100% |
| 298 | 100% | 98% |
| 293 | 100% | 100% |
| 288 | 100% | 100% |
| 283 | 100% | 100% |
| 278 | 100% | 100% |
| 273 | 100% | 100% |
| 268 | 100% | 100% |
| 263 | 100% | 100% |
| 258 | 100% | 100% |
| 252 | 100% | 100% |

B-203 GS = 423.5 ft. Sound Rock = 372 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 370 | 94% | 89% |
| 365 | 100% | 100% |
| 360 | 96% | 51% |
| 355 | 100% | 94% |
| 350 | 100% | 100% |
| 345 | 100% | 98% |
| 340 | 100% | 100% |
| 335 | 100% | 100% |
| 330 | 100% | 100% |
| 325 | 100% | 80% |
| 320 | 100% | 100% |
| 315 | 100% | 100% |
| 310 | 100% | 100% |
| 305 | 100% | 100% |
| 300 | 100% | 100% |
| 295 | 100% | 100% |
| 290 | 100% | 100% |
| 285 | 100% | 100% |
| 280 | 100% | 100% |
| 275 | 100% | 100% |

B-204 GS = 424.5 ft. Sound Rock = 346 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 372 | 0% | 0% |
| 369 | 12% | 0% |
| 364 | 0% | 0% |
| 359 | 12% | 0% |
| 354 | 62% | 42% |
| 349 | 60% | 8% |
| 344 | 90% | 90% |
| 339 | 100% | 100% |
| 334 | 100% | 100% |
| 329 | 100% | 100% |
| 324 | 100% | 100% |
| 319 | 100% | 100% |
| 314 | 100% | 100% |
| 309 | 100% | 96% |
| 304 | 100% | 100% |
| 299 | 100% | 100% |
| 294 | 100% | 100% |
| 289 | 100% | 100% |
| 284 | 100% | 100% |
| 279 | 100% | 100% |
| 275 | 100% | 100% |

B-205 GS = 423.1 ft. Sound Rock = 358 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 369 | 0% | 0% |
| 364 | 30% | 12% |
| 361 | 76% | 62% |
| 356 | 98% | 98% |
| 351 | 100% | 100% |
| 346 | 100% | 100% |
| 341 | 92% | 42% |
| 336 | 100% | 98% |
| 331 | 100% | 92% |
| 326 | 100% | 96% |
| 321 | 100% | 80% |
| 316 | 100% | 92% |
| 311 | 100% | 100% |
| 306 | 100% | 100% |
| 301 | 100% | 100% |
| 296 | 100% | 100% |
| 291 | 100% | 100% |
| 286 | 100% | 100% |
| 281 | 100% | 96% |
| 276 | 100% | 100% |
| 271 | 100% | 100% |
| 266 | 100% | 100% |
| 261 | 100% | 100% |
| 256 | 100% | 100% |
| 251 | 100% | 100% |

B-206 GS = 424.3 ft. Sound Rock = 348 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 360 | 88% | 58% |
| 355 | 100% | 78% |
| 350 | 94% | 68% |
| 336 | 100% | 98% |
| 331 | 100% | 98% |
| 326 | 100% | 100% |
| 321 | 100% | 100% |
| 316 | 100% | 93% |
| 311 | 100% | 98% |
| 306 | 100% | 100% |
| 301 | 100% | 97% |
| 296 | 100% | 100% |
| 291 | 100% | 98% |
| 286 | 100% | 98% |
| 281 | 100% | 92% |
| 276 | 100% | 98% |
| 271 | 100% | 98% |
| 266 | 100% | 100% |
| 261 | 100% | 100% |
| 256 | 100% | 100% |
| 251 | 100% | 97% |
| 246 | 100% | 95% |
| 241 | 100% | 100% |
| 236 | 100% | 100% |
| 231 | 100% | 97% |
| 226 | 100% | 100% |
| 221 | 100% | 100% |
| 216 | 100% | 100% |
| 211 | 100% | 100% |

Sound Rock = 374 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 380 | 92% | 20% |
| 375 | 97% | 13% |
| 371 | 94% | 56% |
| 368 | 100% | 100% |
| 363 | 100% | 92% |
| 358 | 100% | 94% |
| 353 | 100% | 96% |
| 348 | 100% | 82% |
| 343 | 100% | 84% |
| 338 | 100% | 82% |
| 333 | 100% | 52% |
| 328 | 100% | 52% |
| 323 | 100% | 98% |
| 318 | 100% | 86% |
| 313 | 100% | 96% |
| 308 | 100% | 94% |
| 303 | 100% | 100% |
| 298 | 100% | 94% |
| 293 | 100% | 100% |
| 288 | 100% | 100% |
| 283 | 100% | 100% |
| 278 | 100% | 100% |
| 273 | 100% | 100% |
| 268 | 100% | 100% |
| 263 | 100% | 100% |
| 258 | 100% | 94% |
| 252 | 100% | 100% |

B-209 GS = 407.9 ft. Sound Rock = 328 ft

| Elevation | Recovery % |
|---|---|
| 352 | 80% |
| 347 | 70% |
| 342 | 24% |
| 337 | 76% |
| 332 | 92% |
| 327 | 38% |
| 322 | 92% |
| 317 | 96% |
| 312 | 100% |
| 307 | 91% |
| 302 | 98% |
| 297 | 100% |
| 292 | 100% |
| 287 | 100% |
| 282 | 100% |
| 277 | 100% |
| 272 | 100% |
| 267 | 100% |
| 262 | 100% |
| 259 | 100% |

Notes
Numbers in red in represent the "relatively low" RQD % values.

| RQD (Rock Quality Designation) | Classification of Rock Quality |
|---|---|
| 0-25% | Very Poor |
| 25-50% | Poor |
| 50-75% | Fair |
| 75-90% | Good |
| 90-100% | Excellent |

ASTM D 6032-08 Standard "Test Method for Determining Rock Quality Designation (RQD) of Rock Core

The core recovery and RQD values in gray are not considered geotechnically sound rock.

These elevations represent the top of the core run

Relative elevation at which the borings are "centered."

# Table RAI 02.05.02-18.1 (Sheet 2 of 2)

| RQD% |
|---|
| 0% |
| 28% |
| 16% |
| 32% |
| 47% |
| 43% |
| 91% |
| 88% |
| 100% |
| 56% |
| 100% |
| 100% |
| 100% |
| 100% |
| 100% |
| 98% |
| 100% |
| 100% |
| 100% |
| 100% |

B-210 GS = 416.5 ft
Sound Rock = 341 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 348 | 14% | 0% |
| 346 | 80% | 80% |
| 338 | 98% | 96% |
| 333 | 100% | 100% |
| 328 | 100% | 100% |
| 323 | 100% | 100% |
| 318 | 100% | 100% |
| 313 | 100% | 100% |
| 308 | 100% | 100% |
| 304 | 100% | 100% |

B-211 GS = 422.2 ft
Sound Rock = 377 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 379 | 99% | 92% |
| 375 | 100% | 99% |
| 370 | 100% | 95% |
| 365 | 100% | 100% |
| 360 | 100% | 95% |
| 356 | 100% | 92% |
| 350 | 100% | 91% |
| 342 | 100% | 96% |
| 332 | 100% | 99% |
| 322 | 100% | 100% |
| 312 | 100% | 94% |
| 302 | 100% | 100% |
| 292 | 100% | 100% |
| 282 | 100% | 100% |
| 272 | 100% | 100% |
| 266 | 100% | 100% |
| 260 | 100% | 100% |
| 252 | 100% | 97% |

B-222 GS = 429.2 ft
Sound Rock = 364 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 362 | 86% | 86% |
| 357 | 100% | 100% |
| 352 | 100% | 100% |
| 347 | 34% | 32% |
| 342 | 100% | 100% |
| 337 | 100% | 100% |
| 332 | 100% | 100% |
| 327 | 100% | 100% |
| 322 | 100% | 100% |
| 317 | 100% | 100% |
| 311 | 100% | 100% |

B-223 GS = 410.5 ft
Sound Rock = 344 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 360 | 42% | 0% |
| 355 | 48% | 0% |
| 351 | 20% | 0% |
| 350 | 52% | 14% |
| 355 | 48% | 14% |
| 346 | 80% | 0% |
| 341 | 100% | 83% |
| 336 | 98% | 80% |
| 331 | 78% | 48% |
| 327 | 100% | 68% |

B-224 GS = 419.2 ft
Sound Rock = 360 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 349 | 100% | 100% |
| 346 | 100% | 96% |
| 341 | 94% | 74% |
| 336 | 98% | 86% |
| 331 | 88% | 12% |
| 326 | 88% | 61% |
| 321 | 100% | 96% |
| 316 | 100% | 96% |
| 311 | 98% | 97% |
| 306 | 98% | 98% |

| Elevation | Recovery % | RQD% |
|---|---|---|
| 360 | 0% | 0% |
| 355 | 4% | 0% |
| 350 | 8% | 0% |
| 345 | 0% | 0% |
| 340 | 0% | 0% |
| 335 | 0% | 0% |
| 330 | 32% | 38% |
| 355 | 100% | 84% |
| 350 | 100% | 96% |
| 344 | 100% | 90% |

B-226 GS = 422.3 ft
Sound Rock = 345 ft

| Elevation | Recovery % | RQD% |
|---|---|---|
| 350 | 51% | 38% |
| 345 | 60% | 60% |
| 340 | 100% | 82% |
| 335 | 100% | 95% |
| 330 | 100% | 92% |
| 325 | 100% | 95% |
| 320 | 100% | 100% |
| 315 | 100% | 100% |
| 311 | 100% | 100% |

**NRC RAI Letter No. 030 Dated February 10, 2009**

**SRP Section: 2.5.2 – Vibratory Ground Motion**

Question from Geosciences and Geotechnical Engineering Branch 2 (RGS2)

**NRC RAI Number: 02.05.02-19**

Please provide the following information related to the site response calculations presented in FSAR Section 2.5.4.7.3:

1) Please provide electronic versions of the S-wave velocity data and profiles shown in FSAR Figure 2.5.4-226 and FSAR Figure 2.5.4-224.

2) Please provide electronic versions of shear modulus reduction and damping data and curves shown in FSAR Figures 2.5.4-240 (Sheets 1 to 3).

3) Please provide electronic versions of input data to the site response calculations described in FSAR Section 2.5.4.7.3 (i.e. randomized S-wave velocity profiles, input time histories, randomized shear modulus reduction and damping curves).

**VCSNS RESPONSE:**

1) The electronic versions of the S-wave velocity data and profiles shown in FSAR Figure 2.5.4-226 and FSAR Figure 2.5.4-224 are provided on the enclosed CD.

2) The electronic versions of shear modulus reduction and damping data and curves shown in FSAR Figures 2.5.4-240 (Sheets 1 to 3) are provided on the enclosed CD.

3) The electronic versions of input data to the site response calculations described in FSAR Section 2.5.4.7.3 are provided on the enclosed CD. The readme.txt file includes the relevant information on the input data. Note that since PSHAKE is used, no acceleration time histories are used and only acceleration response spectra (ARS) are used as input motions.

This response is PLANT SPECIFIC.

**ASSOCIATED VCSNS COLA REVISIONS:**

No COLA changes have been identified as a result of this response.

**ASSOCIATED ATTACHMENTS:**

Enclosed CD containing data files as noted above.