Ronald B. Clary
Vice President
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SCE&G®
A SCANA COMPANY

June 24, 2010
NND-10-0231

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 to NRC Request for Additional Information (RAI) Letter No. 056 Related to SRP Section 2.5.4

Reference: 1. Letter from Chandu P. Patel (NRC) to Alfred M. Paglia (SCE&G), Request for Additional Information Letter No. 056 Related to SRP Section 2.5.4 for the Virgil C. Summer Nuclear Station Units 2 and 3 Combined License Application, dated July 9, 2009.

2. Letter from Ronald B. Clary (SCE&G) to Document Control Desk (NRC), Response to NRC Request for Additional Information (RAI) Letter No. 056, dated August 7, 2009.

In Reference Letter 2 above, a response to NRC RAI 02.05.04-36 was provided by SCE&G. Based on subsequent discussions with the NRC staff, a revision to RAI 02.05.04-36 is provided in Enclosure 1 to this submittal. Changes from the previous response are noted with red lined strike through text for deletions, and green underlined text for additions. In this submittal only RAI 02.05.04-36 is being revised. This submittal is intended to supersede the previous response to RAI 02.05.04-36 provided by letter dated August 7, 2009 (Reference 2). The enclosure also identifies associated changes that will be incorporated in a future revision of the VCSNS Units 2 and 3 COLA.

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 24th day of June, 2010.

Sincerely,

Ronald B Clary

Ronald B. Clary
Vice President
New Nuclear Deployment

AMM/RBC/am

Enclosure

c:

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NRC RAI Letter No. 056 Dated July 9, 2009

SRP Section: 2.5.4 – Stability of Subsurface Materials and Foundations

QUESTIONS for Geosciences and Geotechnical Engineering Branch 2 (RGS2)

NRC RAI Number: 02.05.04-36

We noted that (1) In your response to RAI 02.05.04-3, you stated that some portions of sound (nonrippable) rock left above foundation base level after excavation "will be removed down to foundation base level using controlled blasting." But in response to RAI 02.05.04-14, you stated that "[h]owever, this [controlled blasting] would not be practical since the thickness of rock to be removed would not be known. In addition, even controlled blasting would have some impact, such as minor fracturing, on the immediately underlying rock, which would be less desirable than letting the thin transition zone remain in place." Those two statements are inconsistent. (2) In your response to RAI 02.05.04-3, you stated that "where needed, the concrete placed between the top of sound rock and the base of the nuclear island will have a strength of about 5,000 psi. One reason for selecting this strength is that, according to Boone (2005), concrete with this strength has a shear wave velocity of around 9,000 fps [2,743 m/s], i.e., close to that of the in-situ rock." Based on our confirmatory calculations, in accordance with ACI 318-08, for unreinforced concrete with strength of 34,483 kPa (5,000 psi), the corresponding shear wave velocity is about 2,225 m/s (7,300 fps) – far less than that estimated by you. (3) In your response to RAI 02.05.04-4, you indicated that the concrete fill will have maximum thickness of 1.52 to 5.18 m (5 to 17 ft) underneath the nuclear island. For unreinforced concrete fill with such thickness, cracking will be a serious distress to be concerned about.

In order for us to fully evaluate the adequacy of the foundation, please explain (a) how the foundation base level will be reached to meet the "sound rock" criterion; (b) how you ensure that the proposed concrete fill will have properties to sound rock to meet the uniformity requirement; and (c) how the proposed concrete fill will be designed to reduce cracking distress and to ensure long term strength and stability.

VCSNS RESPONSE:

(1) If above foundation level the rock is non-rippable, then by definition the only way to reach foundation level is by controlled blasting, with every precaution being taken not to impact the underlying rock. If below foundation level the rock is non-rippable, then there is a choice of leaving this in-situ rock in place or removing it by blasting and replacing it with concrete. The response to RAI 02.05.04-14 argues that it is preferable to leave the thin layer of non-rippable rock below the foundation level in place rather than blast it out and replace it with concrete, particularly since the exact thickness of the rock is not known. Whether the in-situ rock is kept in place or replaced with concrete, it will consist of a few feet of

high strength material (10,000 psi rock or 5,000 psi concrete) that will have a shear wave velocity at or relatively close to that of sound rock (9,200 ft/sec). This thin layer would not impact the response analysis to any significant extent.

(2) The relationship between the strength of concrete and its shear wave velocity is empirical. The Boone (2005) equation is derived from actual measurements on concrete specimens. The relationship in ACI 318-08 is between strength and elastic modulus, and the elastic modulus can then be converted to shear wave velocity. Both equations demonstrate that the shear wave velocity for a certain strength of concrete is typically higher than the shear wave velocity of bedrock with the same strength. Since concrete itself consists of different proportions of different coarse and fine aggregates, cement and water (and sometimes flyash as noted in (3)), then it is to be expected that there will be different empirical relationships between strength and shear wave velocity in the literature. Since concrete strength continues to increase with age, the shear wave velocity will also increase with age. Thus, whether a shear wave velocity of 8,990 ft/sec (Boone), 7,300 ft/sec (ACI) or 8,145 ft/sec (average) for 5,000 psi concrete is used, this value will increase during the lifetime of the plant.

The maximum thickness of the concrete will be below Unit 2. Boring logs indicate this maximum thickness will be about 17 ft. Based on the response to RAI 02.05.02-18, this concrete would not significantly impact the seismic response. The response to RAI 02.05.02-18 looked primarily at the impact on the seismic response of a limited thickness of fractured rock beneath the Nuclear Island. For Unit 2, the upper 25 ft of rock ranged in shear wave velocity from about 6,500 ft/sec to 10,500 ft/sec, with an average of about 8,800 ft/sec. Since the concrete has a shear wave velocity range similar to the weathered rock, but is thinner, the effect on the seismic response will be less. The response to RAI 02.05.02-18 showed that for the Unit 2 case, there was zero amplification up to 10 Hz; the amplification then increased to a maximum of about 5% at 50 Hz, and fell to about 3% at 100 Hz. The response concluded that the overall amplification is very small and its impact on the GMRS is negligible. The same would be true for the concrete.

(3) To establish the foundation bearing level for the Nuclear Island (NI), fill concrete will be used beneath the footprint of the NI basemat, and extending a few feet outward. The excavation around the NI and beneath other major power block structures will be backfilled with compacted granular structural fill. The relative concrete and structural fill locations are shown on revised FSAR Figures 2.5.4-220 through 2.5.4-223. The NI fill concrete will extend a several feet (5 or 6 feet), beyond the footprint of the Nuclear Island. Concrete fill will be used between the bottom of the Nuclear Island foundation and the finish grade on sound rock. Based on the top of Layer V (Sound Rock) contours (FSAR Figure 2.5.4-202), the top of sound rock occurs generally at El. 360 +/- 5 ft beneath the NI at Units 2 and 3, but it is approximately 17 ft lower (EL 343 ft) at the northeast corner of

the Unit 2 Nuclear Island and approximately 12 ft higher (EL 372 ft) beneath the southern part of the Unit 2 NI. The NI areas will be excavated in sound rock to approximately EL 357 ft, where required, to allow a minimum 3 ft thickness of fill concrete and mud mat beneath the NI basemats. The fill concrete will be approximately 17 ft thick beneath the northeastern corner of the Unit 2 basemat.

American Concrete Institute (ACI) defines mass concrete as "any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking." The definition is intentionally vague because many factors, including the concrete mix design, the dimensions, the type of the placement, and the curing methods, affect whether or not cracking will occur. ACI 207~~.1R-96~~, "Mass Concrete," prepared by ACI Committee 207, governs the design and construction of mass concrete. Typically, there are two common concerns associated with thermal cracks in mass concrete. They are: (1) the maximum temperature inside a concrete pour and (2) the maximum temperature difference between the hottest spot and the surface of a concrete pour. Specifications of mass concrete typically limit the maximum temperature to 155^{0}F and the maximum temperature difference between the interior and the surface to 36^{0}F, so that early-age thermal cracks in mass concrete will be minimized. It is a common practice to limit the least dimension of each concrete pour so that the temperature and temperature difference of the pour can stay within their respective limits.

According to the ACI mass concrete definition, the fill concrete under the Nuclear Island of V. C. Summer Unit 2 is a mass concrete. A thermal control plan considering the geometry of Unit 2 fill concrete, the proposed 5,000 psi strength, total volume of fill concrete placement, and rate of concrete production, will be prepared to make sure that the rule-of-thumb temperature limits will not be exceeded. The thermal control plan, based on the ACI 207 series guidelines for preventing thermal cracking in concrete, will have the following elements:

- Use well-graded aggregate and Type I and/or II cement in the concrete mix.
- Because of its relatively high strength specification, the fill concrete will likely have a high content of Portland cement substitutes, such as Class F flyash and/or slag, to minimize the heat of hydration.
- In anticipation of variations in elevation in sound rock surface, the minimum thickness of fill concrete will be set at 3 feet, which includes the 6-inch layer of mud mat.
- Even with the heat of hydration in the design mix minimized, it may still require the concrete to be placed in relatively thin lifts to avoid cracking.

Thus, the maximum thickness of each concrete lift will be set at about ~~5~~five feet.

- Concrete will be placed using a step technique to minimize the live face of concrete, thus minimizing the chance for cold joints.
- Exposed surfaces of each concrete lift will be insulated, if required.
- When another lift is required on top of an existing lift, the top lift will be poured only after the bottom lift has enough time to properly cool down.
- Concrete placing temperature will be controlled as necessary by use of ice, chilled water, shading aggregate piles, spraying coarse aggregate for evaporative cooling, and scheduling placements (such as at night) to take advantage of coolest temperatures.
- Planned vertical joints in each concrete lift will be properly treated.
- Planned horizontal joint between two concrete lifts will be properly treated.

This response is PLANT SPECIFIC.

ASSOCIATED VCSNS COLA REVISIONS:

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

Add the following information to the last paragraph of FSAR Subsection 2.5.4.12 to read as follows:

> To establish the foundation bearing level for the Nuclear Island (NI), fill concrete will be used beneath the footprint of the NI basemat, and extending a few feet outward. The excavation around the NI and beneath other major power block structures will be backfilled with compacted granular structural fill. The relative concrete and structural fill locations are shown on FSAR Figures 2.5.4-220 through 2.5.4-223. The NI fill concrete will extend several feet (5 or 6 feet), beyond the footprint of the NI. Concrete fill will be used between the bottom of the NI foundation and the finish grade on sound rock. Based on the top of Layer V (Sound Rock) contours (FSAR Figure 2.5.4-202), the top of sound rock occurs generally at El. 360 +/- 5 ft beneath the NI at Units 2 and 3, but it is approximately 17 ft lower (EL 343 ft) at the northeast corner of the Unit 2 NI and approximately 12 ft higher (EL 372 ft) beneath the southern part of the Unit 2 NI. The NI areas will be excavated in sound rock to approximately EL 357 ft, where required, to allow a minimum 3 ft thickness of fill concrete and mud mat beneath the NI basemats. The fill concrete will be approximately 17 ft thick beneath the northeastern corner of the Unit 2 basemat.

American Concrete Institute (ACI) defines mass concrete as "any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking." The definition is intentionally vague because many factors, including the concrete mix design, the dimensions, the type of the placement, and the curing methods, affect whether or not cracking will occur. ACI 207, "Mass Concrete," prepared by ACI Committee 207, governs the design and construction of mass concrete. Typically, there are two common concerns associated with thermal cracks in mass concrete. They are: (1) the maximum temperature inside a concrete pour and (2) the maximum temperature difference between the hottest spot and the surface of a concrete pour. Specifications of mass concrete typically limit the maximum temperature to 155^{0}F and the maximum temperature difference between the interior and the surface to 36^{0}F, so that early-age thermal cracks in mass concrete will be minimized. It is a common practice to limit the least dimension of each concrete pour so that the temperature and temperature difference of the pour can stay within their respective limits.

Since the northeastern corner under the Unit 2 basemat is expected to require approximately 17 feet of fill concrete, according to the definition of mass concrete in ACI 207, "Mass Concrete", the fill concrete under the NI of Unit 2 is a mass concrete. A thermal control plan considering the geometry of Unit 2 fill concrete, the proposed 5,000 psi strength, total volume of fill concrete placement, and rate of concrete production, will be prepared to help ensure that the rule-of-thumb temperature limits will not be exceeded. The thermal control plan, based on the ACI 207 guidelines for preventing thermal cracking in concrete, will have the following elements:

- Use well-graded aggregate and Type I and/or II cement in the concrete mix.

- Because of its relatively high strength specification, the fill concrete will likely have a high content of Portland cement substitutes, such as Class F flyash and/or slag, to minimize the heat of hydration.

- In anticipation of variations in elevation in sound rock surface, the minimum thickness of fill concrete will be set at 3 feet, which includes the 6-inch layer of mud mat.

- Even with the heat of hydration in the design mix minimized, it may still require the concrete to be placed in relatively thin lifts to avoid cracking. Thus, the maximum thickness of each concrete lift will be set at about five feet.

- Concrete will be placed using a step technique to minimize the live face of concrete, thus minimizing the chance for cold joints.

- Exposed surfaces of each concrete lift will be insulated, if required.

- When another lift is required on top of an existing lift, the top lift will be poured only after the bottom lift has enough time to properly cool down.

- Concrete placing temperature will be controlled as necessary by use of ice, chilled water, shading aggregate piles, spraying coarse aggregate for evaporative cooling, and scheduling placements (such as at night) to take advantage of coolest temperatures.

- Planned vertical joints in each concrete lift will be properly treated.

- Planned horizontal joints between two concrete lifts will be properly treated.

ASSOCIATED ATTACHMENTS:

None