PMTurkeyCOLPEm Resource

From: Franzone, Steve <Steve.Franzone@fpl.com>
Sent: Monday, August 01, 2016 8:01 AM
To: Comar, Manny
Cc: TurkeyCOL Resource; Maher, William; Burski, Raymond; Orthen, Richard
Subject: [External_Sender] Response to RAI 02.05.04-26 (eRAI 7811) and FSAR Subsection 2.5.4 Grout Test Program Description
Attachments: FSAR_Changes_from_L-2015-209 Signed 10-29-2015 Combined RAI 2.5.4-26 Revised Response and Grout Test Program.pdf

Manny
I have attached the FSAR changes associated with our revised response to RAI 2.5.4 – 26 issued Oct 29, 2015. This response added our voluntary grout test program submittal and our associated ITAAC to the original response to 2.5.4-26.
The FSAR changes were associated with the addition of the ITAAC. I have attached the associated FSAR changes for your convenience. This changes will be incorporated into the upcoming Rev. 8 of the COLA.

Thanks
Steve Franzone
NNP Licensing Manager - COLA
“Nobody can go back and start a new beginning, but anyone can start today and make a new ending.” ~ Maria Robinson
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REFERENCES:

1. FPL Letter L-2015-047 to NRC dated February 19, 2015, FSAR Subsection 2.5.4 Grout Test Program Description
2. FPL Letter L-2015-199 to NRC dated July 15, 2015, Response and Revised Response to NRC Request for Additional Information Letter No. 082 (eRAI 7811) SRP Section 02.05.04 – Stability of Subsurface Materials and Foundations
3. American Concrete Institute, *Guide to Durable Concrete* (ACI 201.2R-08), 2008
4. Lombardi, G., *Grouting of Rock Masses*, 3rd International Conference on Grouting and Grout Treatment, March 2003.
5. U.S. Army Corps of Engineers, *Engineer Manual 1110-2-3506, Grouting Technology*, January 1984**.**
6. Bowles, J., *Foundation Analysis and Design*, 5th ed., McGraw-Hill Companies, Inc., New York, 1997.
7. McCormac, J., Nelson, J., *Design of Reinforced Concrete*, Seventh Edition, John Wiley & Sons, Inc., 2006.
8. American Concrete Institute, *Building Code Requirements for Structural Concrete and Commentary*, ACI 318-11, 2011.
9. Brinkgreve, R.B.J. and Swolfs, W.M., *PLAXIS 3D Foundation Version 2 Part 2: Reference Manual*, PLAXIS bv, 2007.
10. American Concrete Institute, Guide to Mass Concrete, ACI 207.1R-05, Farmington Hills, Michigan, 2006.

ASSOCIATED COLA REVISIONS:

FSAR Subsection 2.5.4.4.5.5 will be revised in a future COLA revision as follows:

2.5.4.4.5.5 Summary and Commitment

Based on geophysical site characterization data (References 286 and 320), and drilling observations as outlined in Subsection 2.5.4.1.2.1, there is no apparent indication that sinkhole hazards exist at the site. There is also no apparent evidence for the presence of underground openings within the survey area that could result in surface collapse. Large low gravity anomalies with magnitudes less than –30 μGals are only detected outside the power block areas, primarily in areas associated with surface depressions containing vegetation. Once the effects of variations in muck thickness are removed from the residual gravity data, all the remaining low gravity anomalies can be explained by density variations within the Miami Limestone. The results of the drilling program and borehole geophysical data (Subsections 2.5.1.2.4 and 2.5.4.1.2.1) indicate the existence of two preferential secondary porosity flow zones. The extent of rod drops integrated with the field geophysical data supports the interpretation that large voids are absent beneath the footprints of the Units 6 & 7 nuclear islands.

However, considering the uncertainties related to resolution in the geophysical data at depth and away from survey lines, the subsurface grouting program ~~will be~~**is** considered in the determination of constrained void sizes. The zone between El. –35 feet and El. –60 feet within the diaphragm walls **(the Grouted Zone)** ~~will be~~**is** grouted according to the **grout** closure criteria **(for individual grout stages and for completed areas of the Grouted and Extended Grouted Zones)** that ~~will be~~**are** developed as part of the grout test program (determined from the results of water pressure tests, evaluation of available boring data, and the target residual permeability of the ~~grouted zone~~**Grouted Zone**). This grouting ~~will~~ **results in any remaining voids having an insignificant impact on the stability of Category I structure foundations (or are structurally insignificant)**~~ensure that potential voids in this zone are filled~~. **The void size defined as structurally insignificant is determined in the grout test program.** In addition, for the zone between El. –60 feet and El. –110 feet within the diaphragm walls **(the Extended Grouted Zone)**, grouting ~~will be~~**is** performed in every primary grout borehole. Primary grout holes ~~will be~~**are** spaced less than or equal to 20 feet on center (Figure 2CC-239). This configuration ~~is expected to constrain~~**constrains** the maximum undetected void size to approximately 20 feet. **The ITAAC set of actions and criteria established for this foundation construction (grouting) activity are necessary and sufficient to provide reasonable assurance that, when met, the stability of Category I structure foundations is in conformance with the combined license. Specifically, successful grouting ITAAC execution results in any remaining voids in the Grouted Zone being structurally insignificant, and any remaining voids in the Extended Grouted Zone having a maximum equivalent spherical diameter of equal to or less than 20 feet. The grouting ITAAC are provided in Part 10 of the COL Application in Appendix B Table 3.8-6 and are discussed in Subsection 14.3.3.6.**

The third and fourth paragraphs of FSAR Subsection 2.5.4.5.1.2 will be revised in a future COLA revision as follows:`

2.5.4.5.1.2 Power Block and Site Grade Raising

Structural fill consisting of excavated fill material is placed around but not below any nuclear island structure. Replacement material below the nuclear islands consists of concrete fill **and**~~. The selection of concrete fill mix design is made at project detailed design. A~~ **a** mix is selected that achieves the mechanical properties used for the design analyses. The compressive strength of 1.5 ksi is ~~estimated~~**chosen** for concrete fill. To ensure that the compressive strength is equal to or greater than this value, concrete test cylinders are made in the field and tested according to ACI 311.5 (Reference 324). The selection of the mix considers the strength requirements as well as the durability requirements to prevent potential sulfate attack. **The ITAAC set of actions and criteria established for this foundation construction (concrete fill compressive strength and methods to control thermal cracking) activity are necessary and sufficient to provide reasonable assurance that, when met, the stability of Category I structure foundations is in conformance with the combined license. Specifically, successful concrete fill ITAAC execution ensures that the concrete fill placed**

underneath Seismic Category I structures meets the specifications in ACI 207.1R-05. The concrete fill ITAAC are provided in Part 10 of the COL Application in Appendix B Table 3.8-5 and are discussed in Subsection 14.3.3.5.

The concrete fill exposure to sulfate attack from groundwater is classified as Class 2 exposure according to Reference 323. Recommendations for improving sulfate resistance are provided in the ACI Guide to Durable Concrete, ACI 201.2R-08 (Reference 323). For the first lift of concrete (bottom lift), the requirements in Table 6.3 of Reference 323 for water-cementitious material ratio and type of cementitious materials are followed in order to provide resistance to sulfate attack. The minimum thickness of the first lift of concrete fill is 2.5 feet. The concrete mix for the first lift contains a maximum water-cementitious material ratio by mass of 0.45, and a sulfate resisting Type V cement or equivalent as defined in Sections 6.2.5, 6.2.7, and 6.2.9 of the ACI Guide to Durable Concrete, ACI 201.2R-08 (Reference 323). In addition, Type V cement or equivalent according to ACI 201.2R-08 (Reference 323) is used for all the lifts for additional protection. Delivery tickets are prepared according to ACI 311.5 (Reference 324) and inspected to ensure that the water-cementitious material ratio and the type of cementitious materials for the first lift meet durability requirements in Reference 323 for Class 2 sulfate exposure. **The ITAAC set of actions and criteria established for this foundation construction (concrete fill sulfate attack resistance) activity are necessary and sufficient to provide reasonable assurance that, when met, the stability of Category I structure foundations is in conformance with the combined license. Specifically, successful concrete fill ITAAC execution ensures that the first lift of concrete fill placed underneath Seismic Category I structures meets the ACI 201.2R-08 durability requirements. The concrete fill ITAAC are provided in Part 10 of the COL Application in Appendix B Table 3.8-5 and are discussed in Subsection 14.3.3.5.**

FSAR Subsection 2.5.4.6.2 will be revised in a future COLA revision as follows:

2.5.4.6.2 Construction Dewatering

The excavation for each new unit will be surrounded by a reinforced concrete diaphragm wall that will act as a cut-off for horizontal groundwater flow into the excavation. Conceptual plans indicate each excavation will have dimensions of approximately 210 feet by 310 feet. The planned bottom of the wall is at El. –60 feet, i.e., just below a layer of limestone situated between the Key Largo Limestone (Subsection 2.5.4.2.1.3) and the Fort Thompson Formation (Subsection 2.5.4.2.1.2.4) that is considerably less permeable than either of these strata. This is referred to as the Freshwater Limestone in Appendix 2BB and Appendix 2CC. The layer has a lower permeability and thus reduces the amount of vertical inflow into the bottom of the excavation during dewatering.

The existing groundwater elevation in the power block areas is dependent on tidal variations, but averages close to El. 0 feet. The base of the excavation for the nuclear island is approximately El. –35 feet. Thus, temporary construction dewatering is needed down to at least El. –35 feet. The pumping test program described in Subsection 2.4.12.1.4 resulted in the development of estimates of the hydraulic conductivity of the

Freshwater Limestone and the underlying Fort Thompson Formation. Freshwater Limestone used in the groundwater model described in Appendix 2CC is assumed to have a vertical hydraulic conductivity of approximately 2.3E-06 cm/sec, compared to approximately 1.7E-01 cm/sec for the Fort Thompson Formation. In the groundwater model, the Freshwater Limestone is assumed to be absent if the available information (from borings, etc.) indicates a thickness of less than 1.5 feet.

Various geologic features can provide potential pathways for water flow such as: zones of secondary porosity, fractures, bedding planes, and voids. As discussed in Appendix 2.5AA, zones of secondary porosity contain vugs on the order of centimeter scale. Fracturing and jointing at the site is widely spaced except under the vegetated depressions and drainages, where the Miami Limestone, Key Largo Limestone, and Fort Thompson formations are slightly to moderately fractured as observed within the inclined borings of the supplemental investigation (Reference 290). **Based on the field data described above, a void size is defined as equal to or greater than 0.5 feet.**

Within the slightly to moderately fractured zones, openness of discontinuities varies from tight (no visible separation) to moderately wide (0.03 to 0.1 feet), averaging slightly open (less than 0.003 feet). As discussed in Subsection 2.5.4.1.2.1, the largest potential voids or sediment infills that were found are limited in size and extent. As discussed in Subsection 2.5.4.4.5.5, **Part 10 of the COL Application in Appendix B Table 3.8-6 provides an ITAAC that when successfully executed will result in** ~~potential~~**any remaining** voids ~~in the grouted zone~~**between El. –35 feet and El. –60 feet** ~~will be~~ **being structurally insignificant**~~grouted~~ and **any remaining** ~~the maximum equivalent spherical diameter of potential~~ voids between El. –60 feet and El. –110 feet **having a maximum equivalent spherical diameter of equal to or less than** ~~will be constrained to~~ 20 feet**, which is accomplished** by the grout program. **The elevation range from El. –35 feet to El. –60 feet is called the “Grouted Zone.”** The elevation range from El. –60 feet to El. –110 feet is called “the ~~extended zone~~**Extended Grouted Zone**.” ~~Based on the field data described above, a void size is defined as equal to or greater than 0.5 feet.~~

For construction-related groundwater control, a grouted zone or “plug” will be constructed via grout injections into the rock mass between the bottom of the excavation at approximately El. –35 feet and the bottom of the diaphragm wall at approximately El. –60 feet. In general, **for the Grouted Zone,** grouting will be performed in a series of split spaced borings starting with primary order grout boreholes, and continuing through secondary order grout boreholes at a minimum. **The term “grout borehole” refers to holes drilled for grouting operations and does not necessarily mean that physical samples will be obtained and geologically described. The term “verification boring” refers to holes drilled and water pressure tested where physical samples are obtained to physically and visually assess the suitability of grouting parameters as well as geologically describing the cores. Verification borings not meeting the residual hydraulic conductivity criteria will be pressure grouted. Verification borings meeting the residual hydraulic conductivity criteria will be backfilled with grout. For** ~~In the~~ primary grout boreholes **in the Grouted Zone**, individual grout stages will ~~initially~~ be grouted to **grout**

stage ~~"absolute refusal"~~ closure criteria. **The grout stage closure criteria will be developed based on results of the grout test program.** ~~Absolute refusal will be defined as zero (no measureable) flow of grout into the rock formation while the injection pressure is maintained equal to the target pressure for the stage for a duration of five minutes.~~

~~After enough (not more than eight adjacent) of the primary grout boreholes have been grouted using these criteria, the closure criteria may be adjusted based on grout takes, the results of water pressure tests, evaluation of available boring data, and the target residual permeability of the grouted zone.~~ Upon completion of the grout stages in the primary grout boreholes, secondary grout boreholes will be drilled and grouted to the ~~adjusted~~**grout stage** closure criteria. The water pressure test results **from verification borings** and grout takes from the primary and secondary grout boreholes will be evaluated to determine the need for tertiary and higher order grout boreholes. Tertiary grout boreholes are likely to be required in some areas. ~~Quarternary~~**Quaternary** grout boreholes are anticipated to be minimal but may be needed at some locations where excessive grout take occurs in higher order grout boreholes. Grouting parameters will be measured in real-time including injection pressures, rate of injection, ~~Apparent Lugeon value (hydraulic conductivity),~~ and total volume of grout. When the grout takes have been reduced, the residual hydraulic conductivity of the grout mass will be determined via water pressure tests performed in cored verification borings in the area.

An area of the ~~grouted zone~~**Grouted Zone** will be accepted as complete when the results of verification borings indicate that the residual hydraulic conductivity of the rock mass is equal to or below the target residual hydraulic conductivity.

As discussed in Subsection 2.5.4.4.5.5, primary grout boreholes will be extended to El. –110 feet (i.e., just above the interface between the Fort Thompson and Upper Tamiami formations) in order to constrain the maximum undetected spherical void size to approximately 20 feet. **The water pressure test results from verification borings and grout takes from the primary grout boreholes will be evaluated to determine the need for secondary grout boreholes. An area of the Extended Grouted Zone will be accepted as complete when the results of verification borings indicate that the residual hydraulic conductivity of the rock mass is equal to or below the target residual hydraulic conductivity. The Extended Grouted Zone will have a different residual hydraulic conductivity requirement than the Grouted Zone, as the purpose of grouting the Extended Grouted Zone is to constrain maximum undetected void size, not to reduce the hydraulic conductivity of the rock mass.**

The groundwater model simulation (Appendix 2CC) assumes hydraulic conductivity of the grout plug is 1.0E-04 cm/sec. The corresponding predicted groundwater extraction rate is 96 gpm per unit. In addition to using this value of hydraulic conductivity, a series of sensitivity analyses using a range of hydraulic conductivities (1.0E-03, 1.0E-05 and 1.0E-06 cm/sec) is conducted to determine the feasible range of dewatering discharge rates, which range from approximately 1000 to 1 gpm per unit. These values demonstrate that grouting can significantly reduce the quantity of discharge water generated during excavation dewatering activities.

FSAR Subsection 2.5.4.6.2.1 will be revised in a future COLA revision as follows:

2.5.4.6.2.1 Grout Test Program

A grout test program will be performed to validate the grout design and grouting techniques, ~~and~~to determine the approximate grout takes for the Key Largo Limestone and Fort Thompson formations**, and to determine the grout closure criteria for individual grout stages and for completed areas of the Grouted and Extended Grouted Zones**.

Grouting will be performed to facilitate construction dewatering and is not classified as safety-related. Mix design, material control, laboratory testing, grout placement, and field testing will be performed under a quality program.

The layout for the grout test program will be selected to resemble the planned construction grouting configuration. Grout borehole spacing will be set with regard to the spacing of the dominant geologic features and the construction grouting configuration. Grout borehole orientations and inclinations will be selected to promote intersections with the dominant fractures and bedding features in the area of the work. Since the fractures in the Key Largo Limestone and Fort Thompson formations range from vertical and subvertical to around 40 degree dip, it is anticipated that the inclination of the grout boreholes will be adjusted to best intercept the dominant features in the treatment area.

It is anticipated that on the order of ten primary grout boreholes will be drilled for the grout test program, with a spacing of approximately 20 feet. It is anticipated that on the order of five secondary grout boreholes will be drilled for the grout test program, and will be offset from primary grout boreholes such that a secondary grout borehole is at the center of the square formed by four adjacent primary grout boreholes. Verification borings will be drilled at various locations within the grouted area to measure residual hydraulic conductivity of the rock mass and to physically and visually assess the suitability of grouting parameters. It is anticipated that five verification borings will be drilled for the grout test program.

The grout test program will be used to optimize and finalize the grouting and dewatering specifications, including:

- Spacing for primary and secondary grout boreholes. Primary grout boreholes will be spaced less than or equal to 20 feet on center. Spacing of primary and secondary grout boreholes may be reduced based on results from the grout test program.
- Suitability of the formation for grouting via downstages, upstages, or a combination of upstages and downstages. Upstage grouting is a method whereby packers or expansion plugs block off preselected portions of the grout boreholes in ascending stages while those portions are being grouted. In this method, grout boreholes are drilled to their full depth, pressure tested, and grouted in successive stages from the bottom up. Alternatively, downstage grouting is the grouting of progressively deeper zones in stages, with the deeper zones accessed by drilling through previously injected grout. Effectiveness of the staging method will be determined by **grout** borehole conditions during drilling including **grout** borehole instability during or after

drilling, loss of circulation of drill fluid, difficulties setting packers in **grout** boreholes during ~~water pressure testing and~~ grouting, and by the level of improvement of **grout** borehole conditions after grouting has been performed in an area.

- Inclination of grout boreholes (vertical or inclined). As described above, **grout borehole** ~~boring~~ orientations and inclinations will be selected to promote intersections with the dominant fractures and bedding features in the area of the work. It is anticipated that the inclination of the grout boreholes will be adjusted during the grout test program to best intercept the dominant features.

- Effective grout mixes using locally available materials and water sources. Multiple grout mixes will be identified for high and low mobility grout. Grout mixes will be tested to assess their mobility, stability, and durability. Different grout mixes will be considered for the ~~grouted zone~~**Grouted Zone** and the ~~extended zone~~**Extended Grouted Zone**. As shown in Table 2.4.12-211, the sulfate values measured from 24 water samples range from 2280 ppm to 4400 ppm, resulting in a median value of about 3800 ppm, or close to 0.4 percent by weight. **This classifies the concrete exposure to sulfate attack as Class 2 exposure according to ACI 201.2R-08 (Reference 323).** The **amount of** grout **pumped into** ~~within~~ potential voids is **expected to be minimal (no physical evidence indicating large voids), and variable across the site.**~~not expected to be a uniform material in terms of strength-stiffness properties. Therefore, potential cracking within the grout material due to sulfate attack will not significantly alter the mechanical response of the grout-rock mass. In addition, stability~~ **Stability** analyses do not consider any increase in strength or stiffness due to the presence of the grout.

- Drilling and flushing of grout boreholes. The grout boreholes will be advanced using water flushed, rotary, or rotary percussive drilling. The primary grout boreholes in an area will be drilled~~, water pressure tested,~~ and grouted before the drilling proceeds on the secondary grout boreholes. ~~Primary and secondary grout~~**Grout** borehole rock drilling will be monitored for penetration rate, down thrust pressure, rod torque, drilling fluid pressure and flow. Rock mass data will be collected using a drilling parameter recorder.

- Injection rates and pressure. Grouting pressures will be selected using **the grouting intensity method pressure-volume curves from Lombardi (Reference 328)** ~~a~~**in** combination ~~of best practices~~**with more traditional industry practice** (e.g., Reference 327 uses 0.5 psi per foot of overburden and 1.0 psi per foot of rock)~~ and experience from similar projects~~. Injection rates will be dictated by the ability to reach and maintain the target pressure. Injection volume limits will be optimized in the test program by **use of the pressure-volume curves and** evaluating the grout travel distance. Additionally, **target pressures will be evaluated from the perspective of a potential hydraulic fracture in the grouted rock and** ~~a rock pressure capacity test can be performed to determine~~ the peak allowable grouting pressure **will be established** for the site.

- Grouting conditions will be evaluated by using computer controlled real time monitoring of grout injected volumes, injection pressures, injection flow rates, ~~Apparent Lugeon values,~~grout mix changes and automatic recording of data.

- **For primary grout boreholes in the Grouted Zone, initially**~~Initially, closure criteria for~~ individual grout stages will be **grouted to "absolute refusal" grout stage closure criteria. Absolute** ~~based on absolute~~ refusal **for the stage will be defined as zero (no measureable) flow of grout into the rock formation with the injection pressure**~~, or a time interval (approximately 5 minutes) where the grout is~~ maintained at the target pressure **for the target duration of time**~~and no measurable flow is occurring~~. **After enough (not more than eight adjacent) of the primary grout boreholes have been grouted using these criteria, the grout stage closure** ~~Closure~~criteria **may be adjusted based on grout takes, the results of water pressure tests from verification borings, evaluation of available boring data, and the target residual permeability.**~~ will be modified for efficiency as the grout test program progresses.~~ If the grout take for a stage is significant, closure will be achieved by using progressively thicker mixes that have reduced mobility. If necessary to reach closure, grouting may be stopped temporarily to allow grout to set and then resumed.

- Verification borings will be drilled and cored for the performance of water pressure tests to measure the residual hydraulic conductivity of the rock mass and to physically and visually assess the suitability of grout borehole spacing and inclination. Acceptance criteria for a completed area of the ~~grouted zone~~**Grouted Zone** will be based on water pressure testing performed in verification **borings**~~boreholes~~. **For example, a**~~A~~ target area residual hydraulic conductivity of 10 Lugeons or less is **generally** reasonable. The acceptance criteria will be confirmed to be adequate for the site based on the results from the grout test program. The ~~extended zone~~**Extended Grouted Zone** will ~~not~~ have a **different** residual hydraulic conductivity requirement, as the purpose of grouting this zone is to constrain maximum undetected void size.

The second paragraph of FSAR Subsection 2.5.4.10.8 will be revised in a future COLA revision as follows:

2.5.4.10.8 Stability of Category I Structures Considering Postulated Voids in Subsurface

As discussed in Subsection 2.5.4.4.5.5, the grouting program ~~will be~~ **is** utilized to constrain void sizes. The zone between El. –35 feet and El. –60 feet within the diaphragm walls **(the Grouted Zone)** ~~will be~~ **is** grouted using a multi-stage grouting program; this ~~will~~ **results in any remaining voids in this zone being structurally insignificant**~~ensure that potential voids in this zone are grouted~~. For the zone between El. –60 feet and El.–110 feet within the diaphragm walls **(the Extended Grouted Zone)**, grouting ~~will be~~ **is** conducted in every primary grout borehole, constraining the maximum undetected void size to approximately 20 feet.

FSAR Subsection 2.5.4.12 will be revised in a future COLA revision as follows

2.5.4.12 Techniques to Improve Subsurface Conditions

~~Given the depths of structure foundations and the subsurface conditions that occur at those depths, as shown in part on Figures 2.5.4-221 and 2.5.4-222, special ground improvement measures are not warranted.~~ Ground treatment is limited to over-excavation of unsuitable materials, such as zones of less competent materials occurring at foundation subgrades, and their replacement with lean concrete fill. Groundwater control **(accomplished by grouting)** is required as part of this over-excavation as described in Subsections 2.5.4.5 and 2.5.4.6. **Additionally, grouting is used to constrain the size of potential voids, as described in Subsection 2.5.4.4.5.5.**

Over-excavation of approximately 21 feet at the reactor/auxiliary building is designed to replace soils and weak rock that are not adequate to directly support the high foundation loads of these structures, with the required FOS. For all affected structures, compacted limerock fill and lean concrete fill are placed according to engineering specifications and quality control/quality assurance testing procedures established during detailed design phase.

According to ACI 207 (Reference 281), the lean concrete fill under the nuclear island is defined as mass concrete. A thermal control plan considering the geometry of the fill concrete, the proposed 1,500 psi strength, total volume of fill concrete placement, and rate of concrete production, ~~will be~~**is** prepared to minimize thermal cracking in accordance with ACI 207 guidelines.

As described in Subsection 2.5.4.4.5.5, the zone between El. –35 feet and El. –60 feet (the Grouted Zone) is grouted according to the grout closure criteria that are developed as part of the grout test program, therefore resulting in any remaining voids in this zone being structurally insignificant. In addition, for the zone between El. –60 feet and El. –110 feet (the Extended Grouted Zone), grouting is performed in every primary grout borehole. Primary grout boreholes are spaced less than or equal to 20 feet on center, therefore constraining the maximum undetected void size to approximately 20 feet.

Across the entire plant area, the muck of Stratum 1 is removed and replaced with compacted limerock fill as described in Subsection 2.5.4.5.1.1.

The following reference will be added to Subsection 2.5.4.13 in a future revision of the COLA:

328. Lombardi, G., *Grouting of Rock Masses*, 3rd International Conference on Grouting and Grout Treatment, March 2003.

FSAR Subsection 14.3.3.5 will be revised in a future COLA revision as follows:

14.3.3.5 Concrete Fill ITAAC

The ITAAC set of actions and criteria established for this foundation construction (concrete fill) activity are necessary and sufficient to provide reasonable assurance that, when met, the stability of Category I structure foundations is in conformance with the combined license. Subsection 2.5.4.5 discusses, in part, the excavations, backfill (including cementitious construction material) and earthwork analyses for Seismic Category I structures. The objective of this concrete fill ITAAC is to ensure reliable performance of the foundation bearing material over the life of the plant. Specifically, ~~proper~~**successful concrete fill** ITAAC **execution ensures that**~~are specified to ensure~~ the first lift of concrete fill material is resistant to sulfate attack. By verifying water-cementitious material ratio and cement type, this ITAAC provides a method to confirm that sulfate-resistant properties of the fill material are achieved.

~~Additionally, the~~**Successful concrete fill** ITAAC **execution also ensures**~~have been developed to ensure~~ that the static and dynamic properties of the material ~~will be~~**are** the same as, or better than the design parameters. In general, by testing the mean 28-day compressive strength of cementitious construction material, this ITAAC provides a method to confirm that the properties (static and dynamic) of said material are met prior to the construction of the Seismic Category I structure.

FSAR Subsection 14.3.3.6 will be added in a future COLA revision as follows:

14.3.3.6 ITAAC for Category I Structure Foundation Grouting

The ITAAC set of actions and criteria established for this foundation construction (grouting) activity are necessary and sufficient to provide reasonable assurance that, when met, the stability of Category I structure foundations is in conformance with the combined license. This ITAAC ensures that the zone between El. –35 feet and El. –60 feet within the diaphragm walls (the Grouted Zone) is grouted according to the grout closure criteria that are developed as part of the grout test program. Specifically, successful grouting ITAAC execution results in any remaining voids in the Grouted Zone being structurally insignificant. The void size defined as structurally insignificant is determined in the grout test program. In addition, for the zone between El. –60 feet and –110 feet within the diaphragm walls (the Extended Grouted Zone), grouting is performed in every primary grout borehole. Primary grout boreholes are spaced less than or equal to 20 feet on center. Specifically, successful grouting ITAAC execution results in any remaining voids in the Extended Grouted Zone having a maximum equivalent spherical diameter of equal to or less than 20 feet. By verifying that the grout closure criteria of each zone are met and the as-built locations of the grout boreholes, this ITAAC provides a method to confirm that any remaining voids in the Grouted Zone are structurally insignificant and that the maximum equivalent spherical diameter of remaining voids in the Extended Grouted Zone is equal to or less than 20 feet.

Table 3.8-6 (Sheet 1 of 2)
Seismic Category I Structure Foundation Grouting [(1)]

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
Inside the region defined by the diaphragm walls, drilling and pressure grouting is performed. The grout closure criteria, when used in conjunction with the specified grout borehole spacing: • Will result in any remaining voids between El. –35 ± 2 feet and El. –60 ± 2 feet (the Grouted Zone) being structurally insignificant, which is accomplished through drilling and pressure grouting of primary and secondary grout boreholes, and, if necessary, as indicated by site data, tertiary and quaternary grout boreholes; and	i. Testing and analysis will be performed through a grout test program to define grout closure criteria for both the Grouted Zone and Extended Grouted Zone, as follows: • For both the Grouted Zone and Extended Grouted Zone, the grout test program will identify and define grout closure criteria for grout consistency to ensure the grout flows into and fills potential voids in the vicinity of each grout borehole, and • For the Grouted Zone, the grout test program will identify and define grout closure criteria for identifying when each grout borehole has been filled and pressurized with grout and filling may cease or tertiary or quaternary grout boreholes are necessary, and	i. The grout closure criteria, when used in conjunction with the specified borehole spacing, will ensure that any voids remaining in the Grouted Zone are structurally insignificant and ensure that any voids remaining in the Extended Grouted Zone are equal to or less than 20 feet ii. Grout closure criteria as established in the grout test program are met inside the region defined by the diaphragm walls and the grout boreholes meet the following requirements: • For the Grouted and Extended Grouted Zones, primary grout boreholes are drilled throughout the entire interior region defined by the diaphragm walls and with spacing of less than or equal to 20 feet on center at the ground surface,

Table 3.8-6 (Sheet 2 of 2)
Seismic Category I Structure Foundation Grouting [(1)]

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
• Will result in any remaining voids between El. –60 ± 2 feet and El. –110 ± 2 feet (the Extended Grouted Zone) having a maximum equivalent spherical diameter of equal to or less than 20 feet, which is accomplished through drilling and pressure grouting of primary grout boreholes and, if necessary, as indicated by site data, secondary grout boreholes.	• For the Extended Grouted zone, the grout test program will identify and define grout closure criteria for identifying when each grout borehole has been filled and pressurized with grout and filling may cease or secondary grout boreholes are necessary. ii. Inspections and analysis will be performed of the as-built locations, depth and spacing of all grout boreholes, both with respect to the Grouted Zone and the Extended Grouted Zone, and the grout data associated with each grout borehole and zone.	• For the Grouted Zone, secondary grout boreholes are drilled throughout the entire interior region defined by the diaphragm walls and are offset from primary grout boreholes such that a secondary grout borehole is at the center of the square formed by four adjacent primary grout boreholes at the ground surface, and • Each additional grout borehole (tertiary or quaternary) drilled to meet grout closure criteria for the Grouted Zone is located based on a documented engineering evaluation consistent with the grout closure criteria • Each additional grout borehole (secondary) drilled to meet grout closure criteria for the Extended Grouted Zone is located based on a documented engineering evaluation consistent with the grout closure criteria.

Note:
[(1)] **All elevations are presented in the North American Vertical Datum of 1988 (NAVD88)**

ENCLOSURES:

None