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SOUTHERN COMPANY

March 6, 2014

Docket Nos.: 50-424
50-425

NL-14-0317

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555-0001

Vogtle Electric Generating Plant – Units 1 and 2
Response to NRC Request for Additional Information
Associated with Flooding Re-evaluation

Reference:

1. NRC Letter, *Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f) Regarding Recommendations 2.1, 2.3, and 9.3, of the Near-Term Task Force Review of Insights from the Fukushima Daiichi Accident*, dated March 12, 2012.

2. Southern Nuclear Operating Company Letter, *Flooding Recommendation 2.1 Hazard Reevaluation Report for Vogtle Electric Generating Plant Requested by 10 CFR 50.54(f)*, dated March 5, 2013.

3. Southern Nuclear Operating Company Letter *Supplemental Letter to Flooding Hazard Reevaluation Report for Vogtle Electric Generating Plant* dated May 24, 2013.

4. NRC Letter, *Vogtle Electric Generating Plant, Units 1 and 2 – Request For Additional Information (TAC MF1117 and MF1118)*, dated February 7, 2014.

Ladies and Gentlemen:

On March 12, 2012, the Nuclear Regulatory Commission (NRC) issued Reference 1 to all power reactor licensees and holders of construction permits in active or deferred status. Enclosure 1 of Reference 1 requested each addressee perform and submit a Flood Hazard Reevaluation Report (FHRR).

By letter dated March 5, 2013, as clarified by letter dated May 24, 2013, Southern Nuclear Operating Company (SNC) submitted the Vogtle Electric Generating Plant (VEGP) flooding hazard reevaluation report (References 2 and 3). On February 7, 2014, SNC received a request for additional information on the VEGP FHRR (Reference 4). SNC provides the Enclosure to this letter as the response to the request.

As discussed with NRC staff on February 20, 2014, the Enclosure does not include the responses to questions number 5, 6, 8, and 9. In order to prepare

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a response to these questions, it is necessary to re-run the HEC-HMS and HEC-RAS models, and develop additional computer modelling and additional detailed analysis. The response to these questions will be provided by May 30, 2014 as agreed to by the NRC staff.

This letter contains no new NRC commitments. If you have any questions, please contact John Giddens at 205.992.7924.

Mr. C. R. Pierce states he is the Regulatory Affairs Director of Southern Nuclear Operating Company, is authorized to execute this oath on behalf of Southern Nuclear Operating Company and, to the best of his knowledge and belief, the facts set forth in this letter are true.

Respectfully submitted,

C R Pierce

C. R. Pierce
Regulatory Affairs Director

CRP/JMG/RCW

Sworn to and subscribed before me this 6 *day of* March, *2014.*

Laura L. Crugto
Notary Public

My commission expires: 10/8/2017

Enclosures: 1. RAI Responses for VEGP FHRR
2. RAI Attachments - DVD (Electronic Files: sent to NRC Document Control Desk and Senior Project Manager, only)

cc: Southern Nuclear Operating Company
Mr. S. E. Kuczynski, Chairman, President & CEO
Mr. D. G. Bost, Executive Vice President & Chief Nuclear Officer
Ms. T. E. Tynan, Vice President – Vogtle
Mr. D. R. Madison, Vice President – Fleet Operation
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U. S. Nuclear Regulatory Commission
Mr. V. M. McCree, Regional Administrator
Mr. R. E. Martin, NRR Senior Project Manager – Vogtle
Mr. L. M. Cain, Senior Resident Inspector – Vogtle

Alabama Department of Public Health
Mr. J. H. Turner, Environmental Director Protection Division

Vogtle Electric Generating Plant – Units 1 and 2
Response to NRC Request for Additional Information
<u>Associated with Flooding Reevaluation</u>

Enclosure

RAI Responses for the Vogtle Electric Generating Plant – Units 1 and 2

RAI Responses for the Vogtle Electric Generating Plant – Units 1 and 2

NRC RAI 1 **Local Intense Precipitation Flooding - electronic files**

The licensee is requested to provide electronic versions of the input files used for HEC-HMS and HEC-RAS models in Section 2.1 of the Flood Hazard Reevaluation Report (FHRR) related to the local intense precipitation flood analyses.

SNC Response to RAI 1

The electronic versions of the input files used in HEC-HMS and HEC-RAS computer modeling are provided on the attached electronic storage media. A description of the contents of each subfolder is as follows:

1. HEC-HMS and HEC-RAS Files (subfolder name containing all HEC files)

    1.1 U12 HEC-HMS (Units 1&2 runoff analysis)

    1.2 U34 Unsteady Flow Modeling With Side Weir (subfolder containing Units 3&4 HEC files)

        1.2.1 Unsteady U34HEC-HMS (Units 3&4 runoff analysis)
        1.2.2 Unsteady U34HEC-RAS (Units 3&4 unsteady flood routing analysis)

The numerical modeling using HEC-HMS and HEC-RAS programs should be performed in the following order:

a. Perform VEGP Units 3&4 watershed hydrologic runoff analysis using the HEC-HMS files shown under Item 1.2.1 above.

b. Under Item 1.2.2 of the above, perform VEGP Units 3&4 unsteady flood routing and backwater flow analysis for the construction phase of the main ditch using the hydrographs obtained under Item 1.2.1 above. The purpose of this analysis is to determine the overflow hydrograph from VEGP Units 3&4 power block area over the vehicle barrier system (VBS) and into the VEGP Units 1&2 power block area.

c. Perform the VEGP Units 1&2 hydrologic runoff analysis using HEC-HMS files under Item 1.1 above and using the VEGP Units 3&4 overflow hydrograph over the VBS and into the VEGP Units 1&2 power block area as determined under above Item (b).

NRC RAI 2 Local Intense Precipitation Flooding – drainage ditch

The licensee is requested to provide detailed descriptions of the Units 3 and 4 drainage ditch during construction and post-construction phases so that the staff can review the licensee's assumption that the local intense precipitation flood analyses is more conservatively analyzed using the construction-phase configuration of the Units 3 and 4 drainage ditch.

SNC Response to RAI 2

A plan view of the VEGP Units 3 and 4 drainage ditch during the construction phase for VEGP Units 3 and 4 is provided on Sheet 1 of Attachment RAI 2-1 contained on the electronic storage media in the file named "Attachment RAI 2-1.pdf". The construction phase drainage ditch consists of two distinct reaches: the upstream reach and the downstream reach. The upstream reach is a segment of the main ditch which existed prior to VEGP Units 3 and 4 construction phase activities. There are two construction phase culvert crossings located very close to each other in this segment of the main ditch. In the HEC-RAS model these two culverts were conservatively considered blocked and modeled as a single inline weir spanning the length of both culvert crossings. The downstream reach is a temporary replacement ditch for the main ditch for use during the VEGP Units 3 & 4 construction phase.

The drainage ditch during construction phase is a trapezoidal earth lined ditch with a 10-foot wide bottom with depth ranging from about 5 feet in the upstream reach (i.e. upstream of the culvert crossing) to about 15 feet in the downstream reach. Four sample ditch cross sections at River Stations 5071, 4861, 4200, and 3000 are shown on Sheets 2 through 5 in Attachment RAI 2-1. River Station 5071 is located upstream of the culvert crossing in the upstream reach; River Station 4861 is located on the upstream side of the culvert crossing. River Stations 4200 and 3000 are located at the upstream and downstream ends of the temporary replacement ditch, respectively.

Plan views of the VEGP Units 3 and 4 post-construction permanent main ditch are shown on sheets 6 and 7 of Attachment RAI 2-1. The main ditch, once construction is complete, is planned to consist of a concrete lined ditch that has a sloping wall on the left side (looking downstream) and a vertical wall on the right side of the ditch. The width of the main ditch ranges from 14 to 17 feet, getting wider as the ditch progresses downstream. The depth of the ditch ranges from 8 to 12 feet along the length of the ditch. There are no culvert crossings in the post-construction ditch configuration. Sample cross sections for the post-construction ditch are show on Sheets 8 through 10 of Attachment RAI 2-1. The cross sections are shown at Stations 2411.71, 1419.09, and 100.0 representing the upstream, center, and downstream portions of the post-construction main ditch, respectively.

NRC RAI 3 Local Intense Precipitation Flooding - map

The licensee is requested to provide electronic versions of the Units 1 and 2 plant layout and elevation map presented in the Attachment 1, Sheet 1-of-1 in Calculation Package No. X2CA77 so that the staff can understand the pattern of the onsite drainage related to the local intense precipitation flood analyses. The licensee is also requested to provide descriptions of the sources of the elevation data, the methods used to incorporate (interpolate) elevation measurements into local intense precipitation flood analysis, and the likely magnitude of the errors in the local intense precipitation flood analyses associated with these elevation errors.

SNC Response to RAI 3

The electronic version of the VEGP Units 1 and 2 power block layout and ground elevation map presented in the calculation package is provided in the attached electronic storage media under the file name: Attachment RAI 3-1.pdf.

The elevation data used for the Local Intense Precipitation (LIP) Flooding Analysis came from two surveys, one performed for the ground surface and the second for the double row vehicle barrier system (VBS). The typical tolerance requirements for ground surveys, based on typical National Map Standards pertaining to contour mapping, is that ninety percent (90%) of all spot elevations should accurately be plotted to within one fourth the contour interval (±0.5 ft for a two-foot contour interval), and the remaining ten percent (10%) shall not be in error by more than one half the contour interval (±1 ft for a two-foot contour interval). The survey tolerance level of the power block ground elevations does not impact flood level estimates due to level pool routing method with initial pre-storm water level of 217 ft across the power block area. The VBS elevations control the peak flood overflow discharges from the power block area since the storage area inside the VBS has been filled by the rising limb of the inflow hydrograph.

The VBS itself is over 6,600 feet long along four sides of the power block area with many elevation measurements; therefore, level interpolation was not necessary and not used in the analysis. The data regarding the tolerance level of the VBS crest elevation survey cannot be located. However, the uncertainty due to survey tolerances at each VBS weir crest is independent and not cumulative and consequently flow over each VBS segment is independent and is only related to its own crest elevation. Thus, the PMP flood flows from power block area occur at multiple locations along the VBS and the resulting maximum flood level is not expected to change.

The LIP analyses were performed using the conservative assumptions that i) all storm drains are clogged; ii) all pedestrian openings are blocked; and iii) the power plant vehicle accesses through the VBS are all closed. These conservative assumptions compensate for the survey tolerances uncertainties in the elevation data and the applied modeling methodology.

NRC RAI 4 Local Intense Precipitation Flooding - site features

The licensee is requested to provide (1) a discussion of roof drainage features (e.g., scuppers, gutter outlets, etc.) for plant buildings, and how runoff from these drainage features are incorporated into the local intense precipitation flood analyses; (2) a detailed description of the methods and site data used to develop and apply the Vehicle Barrier System (VBS) stage-volume relationship, the VBS broad-crested weir equations, and the VBS rating curves related to the local intense precipitation flood analysis; and (3) an electronic versions of the spreadsheet used to construct the VBS rating curves described in Calculation Package No. X2CA77.

SNC Response to NRC RAI 4

(1) The runoff from all roofs within the VEGP Units 1 and 2 power block area is added to the runoff from the yard area instantaneously without accounting for any time delay or storage. This has been achieved by including the roof areas as part of the entire power block drainage area. Theoretically, the roofs, scuppers, and gutters store a portion of the rain and delay the runoff. However, it was conservatively assumed this effect to be negligible and was not included in the runoff modelling. In addition, the volume of buildings has been subtracted from the power block area stage-storage relationship development while their surface area is included in the total watershed area.

(2) a. The stage-volume relation was developed using a Micro Station fill routine applied to the areas bounded within the contours shown on topographic mapping of the site, augmented by spot elevations obtained by field survey. On the southern boundary of the VBS, a small storage area located outside the VBS has been excluded from stage-storage data, as shown in the Attachment RAI 3-1, although it is connected to the power block area via a culvert. This area outside the VBS is approximately 4.1% of the total area, and runoff from this area is conservatively and instantaneously added to the VEGP Units 1&2 power block area.

b. The elevation of the VBS is not constant around the perimeter of the power block area. To determine the stage-discharge relationship, the VBS is divided into many segments of constant elevation. Additionally, there are two rows of the VBS referred to as inside and outside rows. Discharge over the VBS is treated as a case of broad-crested weir discharge, as discussed in the IAHR Hydraulic Structures Design Manual (Reference 1). Discharge per unit length of a broad-crested weir is given in the reference manual as:

$$q = C_d\sqrt{2g}H^{3/2} = C_w H^{3/2} \text{ with } C_w = \sqrt{2g} * C_d$$

Where H is the energy head on the weir (i.e. elevation plus velocity head), and C_d is a discharge coefficient determined empirically as a function of head and L representing the flow length over the weir crest, (see Figure 1), according to the following empirical relation (Reference 1):

$$C_d = 0.42\left[1 - \frac{2}{9(1+(H/L)^4)}\right]$$

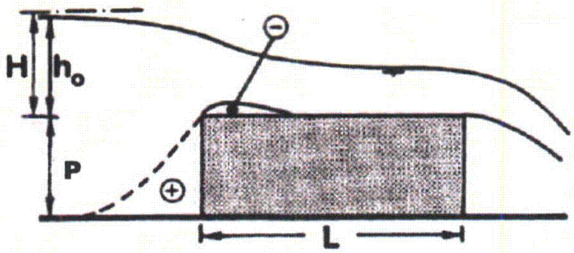

Figure 1 – Definition sketch for broad-crested weir equation (Reference 1)

For each VBS segment, the crest flow length over the weir, L, is either 24 inches or 60 inches varying along the perimeter. As an example, the 60 inch VBS length at some locations may be a part of the inside row and some other locations it may be a part of the outside row. Figure 2 shows a plot of the coefficient for the two weir crest flow lengths, indicating that there is small variation in the discharge coefficient over the expected range of heads.

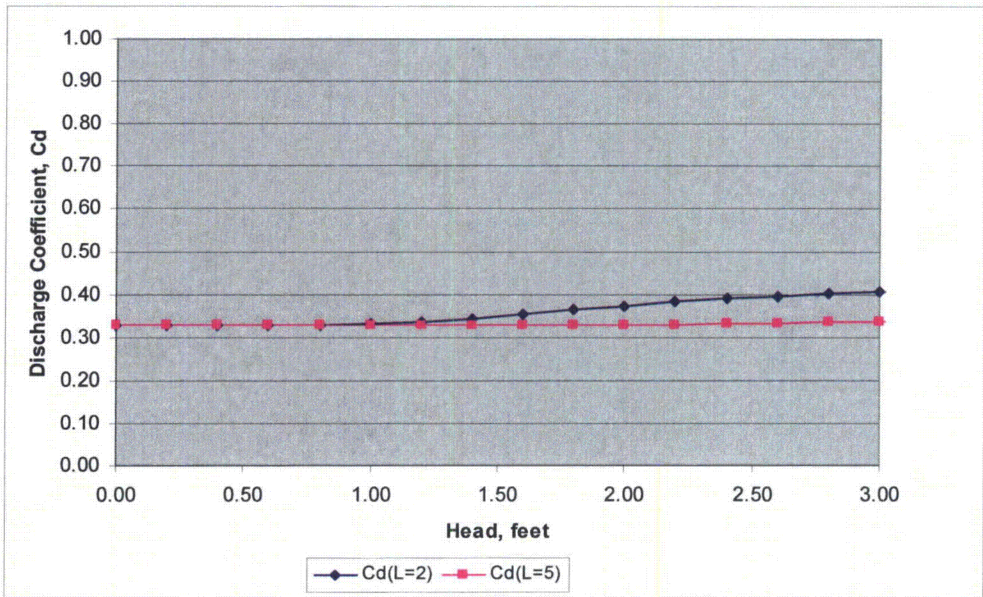

Figure 2 – Variation in broad-crested weir discharge coefficient with head and weir crest flow length

Based on this lack of variation, a constant discharge coefficient for the broad-crested weir is utilized in the calculation with a negligible loss of accuracy on the conservative side. The minimum value of the discharge coefficient of 0.3267 is used, based on the fact that for a long broad-crested weir, H/L to the power of four tends to zero. For this discharge coefficient value, the corresponding weir coefficient value (C_w) is 2.6215.

The use of a second row of VBS (weirs) means that the head on the outside VBS will in some cases create a tailwater elevation causing submergence of the inside VBS weir, reducing the discharge for a given head, as shown schematically in Figure 3.

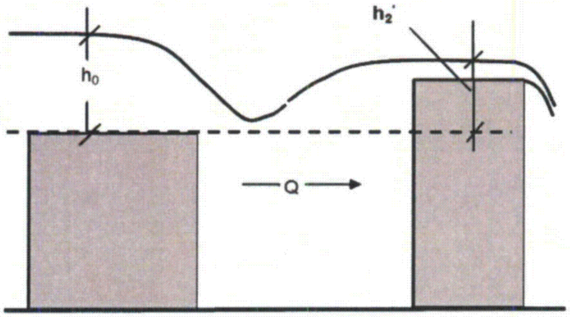

Figure 3 – Schematic diagram of weir submergence

For weirs, submergence, S, is defined as the ratio of the h_0 and h'_2, as shown in Figure 3 (i.e. $S = h'_2/h_0$). When the tail water falls below the elevation of the upstream weir crest (i.e. $h'_2 \leq 0$), submergence is zero.

The impact of submergence is accounted for with a discharge reduction coefficient, C_s, which is determined from the following empirically-determined function of submergence (Reference 2), as shown in Figure 4:

$$C_s = \begin{cases} 1, & S < \frac{2}{3} \\ \frac{3}{2} S\sqrt{3(1-S)}, & \frac{2}{3} < S < 1 \end{cases}$$

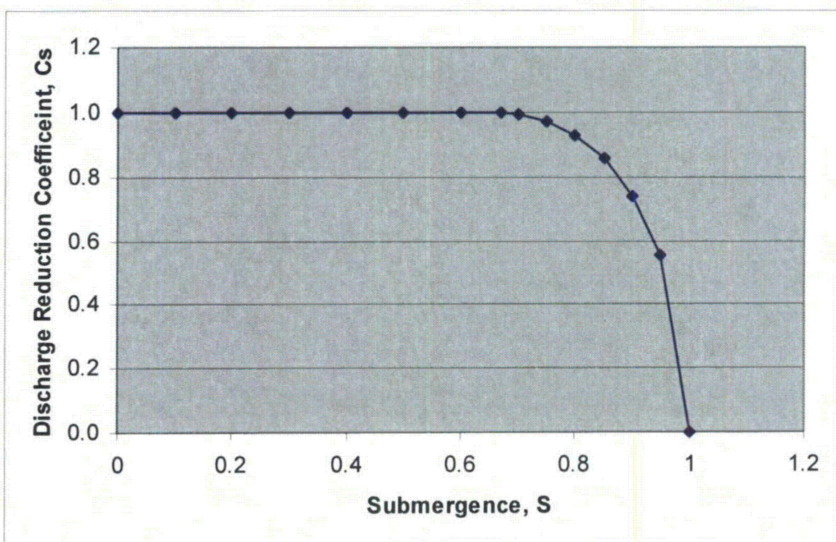

Figure 4 – Discharge reduction as a function of Submergence

Given the discharge reduction coefficient, the drowned-weir discharge, Q, is obtained from the modular flow discharge (i.e. the free discharge condition), Q_0, as $Q = Q_0*Cs$.

c. Because of the need to check for down-stream control resulting from submergence for each segment of the VBS (see Figure 5), the following calculation procedure was adopted:

   i. For each double weir segment i of length L_i and for a selected range of specific discharges, q (0, 0.25, 0.50, 0.75, and 1.00 cfs/ft):

      - Calculate the head on the downstream weir
      - Calculate head on the upstream weir accounting for submergence
      - For q = 0, HW_i is the weir crest elevation. For other q values, calculate HW_i from downstream or upstream control, as appropriate (in general, the HW for a given q will be different for each weir segment)
      - Calculate $Q = q_i \times L_i$

   ii. Develop rating curve $(HW, Q)_i$ for each segment from calculated points and fit to a quadratic equation to develop curves at regular HW-intervals.

   iii. Develop an aggregate rating curve with regular HW-intervals by summing up the segment curves.

Following the above steps the double row VBS rating curve is developed and is shown in Attachment RAI 4-1 included as the file named "Attachment RAI 4-1.pdf" on the electronic storage media. Sheet 1 of the attachment represents the above Item c(i) and Sheets 2 and 3 (in continuation) represent the discharge over the VBS segments at the indicated elevations. The information on sheets 2 and 3 demonstrates that the barriers are not at the same elevation and that overflow occurs at several locations with no distinct flow path leaving the power block area. Note that flow from VEGP Units 3 and 4 actually enters the Unit 1 and 2 power block area over the VBS along the western edge of the power block area during the temporary construction phase period.

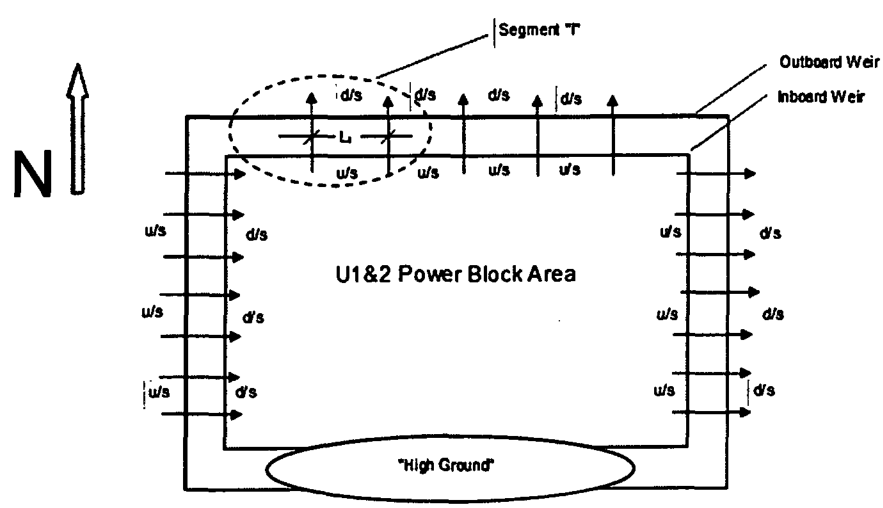

Figure 5 – Weir flow calculation schematic

(3) Based on the process of above Items 2 (b) and 2 (c), the VBS rating curve surrounding the site is developed through the use of the Excel spreadsheet program. A PDF copy of the spreadsheet is provided in Attachment 4-1. As shown in this attachment (Sheet 3 of 3, Segments 157 and 163), the overflow from VBS starts at Elevation 217.8 ft. As flood level increases the overflow from other VBS segments also occur as shown in this attachment.

References:

1. Hager, Willi H., "Discharge Measurement Structures," Chapter 2 of Hydraulic Structures Design Manual #8, Discharge Characteristics, D.S. Miller, Editor, International Association of Hydraulic Research (IAHR), 1994
2. Kolkman, P.A., "Discharge Relationships and Component Head Losses for Hydraulic Structures," Chapter 3 of Hydraulic Structures Design Manual #8, Discharge Characteristics, D.S. Miller, Editor, International Association of Hydraulic Research (IAHR), 1994

NRC RAI 5 **Local Intense Precipitation Flooding - PMP**

The licensee stated in Section 2.1 of the FHRR that the local intense precipitation (LIP) flood analysis is based on a 6-hr onsite probable maximum precipitation (PMP) scenario. Since a longer duration PMP may induce higher flood levels and/or longer inundation durations, the licensee is requested to justify, based on a sensitivity analysis, whether the 6-hr probable maximum precipitation scenario used in the LIP analyses bounds the flood effects of LIP in comparison with alternative-duration PMP scenarios, such as 12 hr, 48-hr, and 72-hr probable maximum precipitation values.

SNC Response to NRC RAI 5

The requested information will be provided by May 30, 2014 as described in the transmittal letter.

NRC RAI 6 **Local Intense Precipitation Flooding - Power block**

The licensee stated in the FHRR (page 15) that the LIP flooding within the Units 1 and 2 power block area is simulated by HEC-HMS with an assumption that the entire power block area is represented by a single hypothetical reservoir encompassed by the Vehicle Barrier System. The licensee also assumed that the LIP flood level is instantaneously leveled over the power block area, and that the flood level within power block area is determined by weir flow over the top of the Vehicle Barrier System. This simulation scheme may result in an underestimation of the LIP flood level if the level-pool assumption is not consistent with conditions at the time of the peak precipitation. In general, terrain and flood levels within the power block area varies and overland flow can be interrupted by buildings; both potentially causing water to accumulate to a greater depth. Based on these considerations, the licensee is requested to: (a) clarify the assumed flow path of water between the various structures in the power block area, and (b) determine the maximum water heights near safety-related structures based on flood routing using measured elevation data within the power block area.

SNC Response to RAI 6

The requested information will be provided by May 30, 2014 as described in the transmittal letter.

NRC RAI 7 Hazard Input for the Integrated Assessment

By letter dated May 24, 2013, the licensee clarified text contained in the FHRR and confirmed that the licensee will perform an integrated assessment. The licensee is further requested to clarify which flood hazard mechanisms will be included in the Integrated Assessment.

SNC Response to RAI 7

The VEGP Units 1, 2, 3, and 4 site is located on an elevated plateau above the Savannah River floodplain. The only flood hazard affecting the site is the Local Intense Precipitation (LIP) flood. No other flood hazards pose any flooding threat to the VEGP Units 1 and 2 site. Only the LIP flood hazard will be included in the Integrated Assessment.

NRC RAI 8 Hazard Input for the Integrated Assessment - Duration parameters

The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. Flood scenario parameters from the flood hazard reevaluation serve as the input to the integrated assessment. To support efficient and effective evaluations under the integrated assessment, the NRC staff will review flood scenario parameters as part of the flood hazard reevaluation and document results of the review as part of the staff assessment of the flood hazard reevaluation.

The licensee is requested to provide the applicable flood event duration parameters (see definition and Figure 6 of the Guidance for Performing an Integrated Assessment, JLD-ISG-2012-05) associated with mechanisms that trigger an integrated assessment using the results of the flood hazard reevaluation. This includes (as applicable) the warning time the site will have to prepare for the event (e.g., the time between notification of an impending flood event and arrival of floodwaters on site) and the period of time the site is inundated for the mechanisms that are not bounded by the current design basis. The licensee is also requested to provide the basis or source of information for the flood event duration, which may include a description of relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and/or timing information derived from the hazard analysis.

SNC Response to RAI 8

The requested information will be provided by May 30, 2014 as described in the transmittal letter.

NRC RAI 9 Hazard Input for the Integrated Assessment - Flood height

The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. Flood scenario parameters from the flood hazard reevaluation serve as the input to the integrated assessment. To support efficient and effective evaluations under the integrated assessment, staff will review flood scenario parameters as part of the flood hazard reevaluation and document results of the review as part of the staff assessment of the flood hazard reevaluation.

The licensee is requested to provide a summary of the flood height and associated effects (as defined in Section 9 of JLD-ISG-2012-05) for mechanisms that trigger an Integrated Assessment. This includes the following quantified information for each mechanism (as applicable):

- Flood Height
- Wind waves and run-up,
- Hydrodynamic loading, including debris,
- Effects caused by sediment deposition and erosion (e.g., flow velocities, scour),
- Concurrent site conditions, including adverse weather,
- Groundwater ingress, and
- Other pertinent factors.

SNC Response to RAI 9

The requested information will be provided by May 30, 2014 as described in the transmittal letter.