November 16, 2010

MEMORANDUM TO: Mark Tonacci, Chief
BWR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

FROM: Tekia Govan, Project Manager **/RA/**
BWR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

SUBJECT: REGULATORY AUDIT SUMMARY OF SOUTH TEXAS PROJECT, UNITS 3 AND 4 COMBINED LICENSE APPLICATION – HYDROLOGY

By letter dated September 16, 2009, STP Nuclear Operating Company (STPNOC, applicant) submitted Revision 3 of the South Texas Project (STP) Units 3 and 4 Combined License Application (COLA). To support the staff's evaluation of Tier 2 Chapter 2.4 – Hydrology, the U. S. Nuclear Regulatory Commission staff participated in an on-site audit at the STPNOC offices in Bay City, Texas on August 31 – September 1, 2010. The audit supported the review of Sections 02.04.04, 02.02.05 and 02.04.10 of the STP Units 3 and 4 COLA. The detailed results of the audit are provided in the attached Enclosure.

Docket Nos.: 52-012
52-013

Enclosure:
As stated

CONTACT: Tekia Govan, NRO/DNRL
301-415-6197

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LPLI-1 R/F
HAhn, NRO
TGovan, NRO
MTonacci, NRO
RRaione, NRO
GWunder, NRO

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OFFICE	DNRL/BWR/PM	DNRL/BWR/LA	DSER/RHEB/TR	DSER/RHEB/BC	DNRL/BWR/PM
NAME	TGovan	BAbeywickrama	HAhn	RRaione	GWunder
DATE	9/28/10	9/28/10	9/30/10	9/30/10	11/16/10

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SOUTH TEXAS PROJECT (STP) UNITS 3 AND 4
COMBINED LICENSE APPLICATION,
2.4 Hydrology
AUDIT SUMMARY

1. Background

As a part of the South Texas Project (STP) Units 3 and 4 Combined Operating License Application, STP submitted to the U. S. Nuclear Regulatory Commission (NRC) the response of Request for Additional Information (RAI) 2.4.5-10 in relation to estimating the design based flooding level caused by hurricane storm surge and embankment breach. NRC staff reviewed the RAI response and found deficiencies on the modeling, mainly on the establishing the probable maximum hurricane scenarios and the set up of storm surge and dam breach models. Because the RAI response omits details of the modeling, it is needed for the staff to have a site audit to resolve the outstanding modeling issues in an efficient and timely manner. The purpose of the audit is for the staff to review the STP's storm surge and dam breach models, supporting modeling documentations, and calculation packages. The audit is needed for the staff to better understand the modeling result in order to make accurate safety conclusions in relation to writing the safety evaluation report for FSAR Sections 2.4.4 "Potential Dam Failure", 2.4.5 "Probable Maximum Surge and Seiche Flooding", and 2.4.10 "Flood Protection Requirements".

2. Regulatory Basis

The regulatory guidance for estimating the design based flood level is available from the following NRC documents:

- Standard Review Plan Sections 2.4.4, 2.4.5, and 2.4.10
- Regulatory Guide (RG) 1.59
- RG 1.206

3. Audit Activities and Results

A. FSAR 2.4.5, "Probable Maximum Surge and Seiche Flooding" : (**Morning Session**)

1) (Question): Provide a detailed description of the Advanced Circulation (ADCIRC) model including details of the Holland B model (or SWAN model) to generate offshore hurricane wind distributions in the model domain. Provide a comparison of the wind models used in ADCIRC and SLOSH ("Sea, Lake, and Overland Surges from Hurricanes") models. Provide a comparison of the wind field (or stress) distributions produced by the wind models employed by ADCIRC and SLOSH.

   (Applicant's Response): Dr. Bob Bailey presented a description of ADCIRC and SLOSH and their application to simulate the STP Probable Maximum Storm Surge (PMSS). He stated that ADCIRC is a hydrodynamic circulation model that can be applied in 2-dimensional or 3-dimensional configurations however the STP PMSS was simulated on the ADCIRC 2D configuration. He mentioned that the wind model by Holland (1980)

was used to generate the PMH wind fields in ADCIRC. Dr. Bailey stated that the Holland B parameter in the Holland wind model is estimated as a function of central pressure, pressure differential, and Coriolis parameters (which is a function of latitude). However, the description of the detailed procedure for computing the Holland B parameter was not provided to the NRC staff during the site audit. He explained that ADCIRC can be simulated with different wind field input externally. He mentioned that sustained wind speeds in the ADCIRC model are defined as 1-minute averages at 33 ft height.

Dr. Bailey said that SLOSH uses the Newtonian equation of motion with the Jelesnianski and Taylor (1973) wind model, and that ,SLOSH uses a symmetric wind profile around the eye of a storm while ADCIRC's Holland wind model uses an asymmetric profile. He mentioned that, in both the ADCIRC and SLOSH simulations, wind speeds were not allowed to decay until landfall.

(Resolution): NRC staff concluded that applicant's response to the question is satisfactory. However the staff noted that the applicant needs a sensitivity analysis to ensure the certainty of the storm surge estimates. The NRC staff determined that this issue will be addressed through an additional RAI.

2) (Question): Discuss the Probable Maximum Hurricane (PMH) scenarios and parameters used in both ADCIRC and SLOSH models. Provide ADCIRC and SLOSH input and discuss the set up of the models (e.g., model grids, surface structures, etc.) for all simulated PMH scenarios. Provide graphical comparison of model inputs, computational grids, PMH storm tracks, topographic features, simulated water surface elevations, and others modeling components of ADCIRC and SLOSH to facilitate staff's review.

   (Applicant's Response): Dr. Bailey responded that the PMH parameters were obtained from the National Weather Service Report 23 (NWS 23) as: p_w = 1020 mb, p_0 = 887 mb, R = 6-24 mi, and T = 7-23 mph. The applicant's consultant, Bechtel staff, indicated that they simulated 25 PMH scenarios with SLOSH, however the details of their simulation scenarios were not provided to the NRC staff as the applicant choose to use the Bailey's simulation result which is less conservative but more accurate.

   Dr. Bailey indicated that only two hurricane tracks were used in his simulation. He said that the SWAN model was coupled with the ADCIRC model internally to simulate wind waves, and that the initial condition in the model was set up using a 10 percent exceedance tide and a long-term sea-level rise.

   (Resolution): This issue is resolved.

3) (Question): Discuss topographic data used in the ADCIRC model grids and how the data differ from those used in the SLOSH grids. Discuss the difference of topographic features represented by the ADCIRC and SLOSH grids.

   (Applicant's Response): The applicant stated that the ADCIRC model uses the Federal Emergency Management Agency's (FEMA) Texas Grid version 13 which is the latest revision of the computational mesh in the south Texas region, uses high-resolution Gulf bathymetry data and near-shore topography data. They said that the mesh uses high-resolution irregularly-spaced triangular computational elements. Therefore, they said that the Texas Grid version 13 represents more accurate near-shore topography

features (e.g., barriers, islands, levees, rivers, dredge piles, and canals) than those in the SLOSH grid. In particular, the Texas Grid version 13 incorporates both the protective levee around the City of Matagorda and the dredge file across the levee accurately, while the SLOSH grid does not have these features. Therefore, the applicant mentioned that the result of ADCIRC simulation is more accurate than that of the SLOSH model.

(Resolution): Staff determined that the applicant's explanation is sufficient, thus this issue is resolved.

4) (Question): Discuss the result and interpretation of the ADCIRC and SLOSH simulations; Provide graphical comparison of the output from the two models to facilitate staff's review.

   (Applicant's Response): Dr. Bailey presented the model results graphically and discussed the interpretations of two simulations. His presentation included the animations the ADCIRC simulated storm surge towards the STP site to show the effects of the levee system and dredge pile on surge run-up. The animations clearly demonstrate the effects of two topographic features (levee and dredge file) located southeast of the STP site on the surge run-up. By showing the a shadowing effect on the storm surge advancing from the Gulf towards the STP site, he noted that the shadowing effect may be major factor that results in low ADCIRC-simulated PMSS levels compared to those by SLOSH.

   (Resolution): The applicant's response and explanation to the question is adequate, thus this issue is resolved. However, the staff found that no sensitivity analysis was performed to clarify the effects of these topographic features and that only two hurricane tracks were used in the ADCIRC simulation. NRC staff pointed that it is not clear how the ADCIRC simulation represents the most severe of the possible combinations of the PMH parameters specified in NWS 23. Therefore, the staff determined that the issues related to the PMH scenario and the sensitivity analysis will be addressed together with the question #1 as an additional RAI.

B. <u>FSAR 2.4.4 "Potential Dam Failure" : (**Afternoon Session**)</u>

5) (Question): Provide the values of the velocities of hurricane surge currents near the northern Main Cooling Reservoir (MCR) levee. Provide geotechnical details that were used in the RAI response to access the potential MCR embankment erosion.

   (Applicant's Response): PBS&J contractors discussed three methods for estimating velocities of the surge currents: First, they obtained current velocities at the northern MCR embankment from the SLOSH simulation instead of the ADCIRC simulation which show no inundate at the northern MCR embankment. The second method is based on the Manning's equation with the hydraulic slope between the west and east ends of the area of inundation, and the roughness coefficient of the flooding area. The third method is similar to the second one but is based on a volumetric calculation over time to estimate the flow velocity at which water would have to flow to achieve the computed level of inundation. This last method is based on the observation from the SLOSH simulation where the east end of the northern embankment is inundated earlier than the west end, thus the surge propagate from the east to the west.

The applicant said that, for all methods, inundation levels and times were obtained from the SLOSH simulation. They assumed that the surge water inundating the site comes from the east side, while the third method uses broke down of the level of inundation over time and analyzes the expected currents over time intervals. Their estimated current velocities from these three methods ranged from 6 to 13 ft/s.

STP staff and their contractors stated that the MCR embankment was constructed with an engineering compaction and protected by cement blocks on the interior side and grass on the top and exterior side. Therefore, they concluded based on U.S. Army Corps of Engineers (USACE) studies on grass-lined embankment safety studies that the potential of erosion on the northern side of the MCR embankment due to the PMSS event would be highly unlikely.

(Resolution) This issue is resolved.

6) (Question): Discuss the conservatism in estimating MCR breach parameters (i.e., breach time and width) in FSAR Table 2.4S.4-5 (Rev. 3). Explain why storage-based equations (e.g., the Macdonald and Langridge-Monopolis equation: USBR, 1990 report) are not considered in estimating MCR breach width? Discuss the adequacy of determining the breach time of 1.7 hours in the RAI response.

   (Applicant's Response): STP contractors stated that, of the several dams used for establishing the U.S. Bureau of Reclamation's breach-width equation, only the Teton Dam is comparable in storage size to the MCR but has a high hydraulic head behind the dam at the time of failure. They said that the estimated MCR breach width in the FSAR is conservative because the MCR has a low hydraulic head and the estimated breach width is about 60 percent longer than that of the Teton Dam.

   (Resolution): The NRC staff requested a sensitivity analysis to assure the conservatism in estimating the breach width and the resulting MCR breach flood level estimation. The NRC staff will issue an RAI to address this concern.

7) (Question): Discuss the validity of the extent of the model area and setting up of boundary condition for the RMA2 model to simulate MCR breach floods.

   (Applicant's Response): Dr. Yu-Chun Su of PBS&J discussed the RMA2 simulation. He explained that a fixed-head boundary condition was used at the downstream boundary of the simulation domain, and that he performed a sensitivity analysis of the downstream boundary condition using two different hydraulic heads from which he obtained a conclusion that the flood elevation near the safety-related SSCs for Units 3 and 4 will not changed significantly by changing hydraulic head specified at the downstream boundary. The applicant noted that the FSAR contains a brief description of this sensitivity analysis to justify the adequacy of the boundary setting.

   (Resolution): This issue is resolved.

8) (Question): Elaborate the discussion of excluding the potential of the MCR breach caused by a probable maximum storm surge event. Explain why this combined scenario is infeasible in terms of the dam safety aspect. Provide sufficient background information that justifies the reasons why a combined event of MCR breach and hurricane surge is excluded in consideration.

(Applicant's Response): The applicant mentioned that, based on the SLOSH and ADCIRC simulations, STP has determined that wind waves would not be a significant factor on the northern MCR embankment breach. The applicant said the expected current velocities are estimated during the PMSS event as described above. Based on USACE studies of grass-lined embankments, STP has determined that the MCR embankment would not fail during the PMSS event.

(Resolution): This issue is resolved.

9) (Question): The applicant set the value of a SED2D input variable, DEPLIMIT, to 50,000,000 even though the SED2D recommended DEPLIMIT default value is 0.25. The staff tried the simulation with the default value resulting in ending the simulation prematurely. Therefore, the SED2D model seems sensitive to this parameter. Provide a discussion of the effects of this parameter on the simulated water surface elevations and sediment depositions at the vicinity of safety-related SSCs.

(Applicant's Response): Dr. Yu-Chun Su of PBS&J discussed the SED2D simulations. Based on the recommendation from the SED2D, he used an artificial sump around the Units 3 and 4 facilities to ensure the convergence of the numerical hydrodynamic solution. He said that flow velocities reduce within this artificial sump and therefore sediment begins to settle within this sump. He said that the parameter DEPLIMIT is a limiting ratio of sediment accumulation or erosion to the water depth at any location in the simulation domain. That is, DEPLIMIT of 0.25 means that the SED2D simulation should be stopped if the deposition or scouring at a point in the simulation domain exceeded 25 percent of the RMA2-simulated water depth at that point.

Dr. Su explained that, because of the artificial reduction of flow velocities within the sump, the SED2D-simulated deposition of sediments within the sump is also artificial and results in unnecessary premature termination of the SED2D simulations. He, therefore, set the DEPLIMIT parameter to a very high value (e.g., 50,000,000) to effectively disable the check and complete the simulation.

(Resolution): The NRC staff asked to PBS&J the effect of using real terrain values instead of the artificial sump on the result of the SED2D simulation. PBS&J responded that using the real terrain elevations resulted in instability of the RMA2. Staff determined that the applicant needs to investigate further the effects of the DEPLIMIT on the SED2D simulation, thus this issue is unresolved. The NRC staff will issue a new RAI to obtain more information from the applicant on this issue.

C. <u>FSAR 2.4.10 "Flood Protection Requirements": (**Afternoon Session**)</u>

10) (Question): Briefly describe how safety-related facilities (buildings and foundations) are designed to withstand the static and dynamic forces of MCR breach flood, hurricane storm surge, or a combination of the two events.

11) (Question): Provide the design specific information on the proposed watertight doors and openings that should resist the static and dynamic forces of the design basis flood

without water penetrations into them, or provide design specifications and/or industry standard that are applicable to design and maintenance of watertight doors and openings.

12) (Question): The proposed flood protection is solely relied on the watertight doors and emergency operation procedures. Discuss the possibility of the failure of the watertight doors. Applicant's flood protection is relied only on the closure of watertight doors which could fail during severe flood events. Therefore, explain why additional flood protection in a defense-in-depth concept was not considered.

    (Applicant's Response): The applicant stated that the above three issues (10 through 12) are related to the structural and operational integrity of the watertight doors and hatches. STP staff stated that previously submitted responses to RAIs 3.8.1-4, 3.8.1-7, and 3.8.4-22 and currently being prepared response to RAI 3.8.1-10 provide additional details regarding issue #10. STP staff indicated that FSAR Section 2.4.10 will be updated to refer the design information related to the flood protections in FSAR Sections 3.4 and 3.8.

    STP staff stated that previously submitted responses to RAIs 3.4.2-2 Rev. 1, 3.4.2-6, 3.8.1-3 Rev. 1, 3.8.1-6 Rev. 1, and 14.3.2-9 Rev. 1 and currently being prepared responses to RAIs 3.8.1-9 and 3.4.2-6 Rev. 1 provide additional details regarding issue #11. STP staff indicated that FSAR Section 2.4.10 must be updated to refer to information in other FSAR sections.

    STP staff stated, regarding issue #12, that there are three doors below the site grade that need flood protection. These doors are designed as Seismic Category I structures and have associated technical specifications to maintain the integrity of the doors.

    (Resolution): The NRC staff expects **confirmatory action** from STP for the above three issues.

13) (Question): Provide the expected duration of the flooding caused by the postulated MCR breach. Discuss alternative accesses to the buildings during prolonged MCR breach flood events. Discuss the potential impacts of the prolonged inundation from a MCR breach on the maximum groundwater level established in FSAR Section 2.4.12.

    (Applicant's Response): STP staff and contractors described that the peak flow during the MCR breach occurs at 1.7 hours following the breach, that flow reduces to 50 percent of the peak value by 9 hours after the breach, and that the flood elevation near Units 3 and 4 would be the site grade of 34 ft MSL at 10 hours following the breach. They said that, after 30 hours following the breach, the MCR water level would be at 34 ft MSL and the flood elevation near Units 3 and 4 would be below the site grade.

    Mr. Stewart Taylor of Bechtel stated that no quantitative analysis on the groundwater elevation rising due to the ponding from MCR breach flooding was conducted. He said that, because the soil near STP Units 3 and 4 is fine-grained with low hydraulic conductivity, significant infiltration is not expected to occur.

    STP staff stated that FSAR Section 2.4.10 would be updated to refer to FSAR Section 3.4 and others on the flood protection measures.

(Resolution) Applicant's response to the inundation times are adequate, however, the NRC staff determined after the site audit that the applicant needs to consider the potential erosion of top soils from MCR breach flooding and the resulting infiltration effects on the maximum groundwater level. The staff will issue an RAI on this issue.

D. Additional PMSS Analyses Proposed by STP (**9/1/2010, Morning Session**)

1) Dr. Bob Bailey led the discussion on how additional PMSS analyses could be performed to address the staff's concerns regarding consistency of the PMSS analyses with GDC2 requirements. The following approach was presented to the NRC staff **(confirmatory action)**:

   a) STP would use the wind profile used by the SLOSH model as input to ADCIRC.

   b) STP would simulate the ADCIRC model using the same pressure difference between the peripheral and central pressures, ΔP, of 133 mb which is provided in NWS 23 and used in SLOSH.

   c) STP would perform additional ADCIRC runs that would cover the range of PMH parameters (radius to maximum winds, track direction, and track speed) provided by NWS 23 for the STP site. These additional runs would also include alternative landfall points.

2) Dr. Bob Bailey provided contact information for FEMA Texas Grid version 13 for the NRC staff to obtain the grid file, however he indicated that FEMA will not release the grid file to the third parties until the grid is validated and finalized.

3) Input files for all ADCIRC runs will be provided for staff's review. (**Confirmatory action.)**