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January 25, 2016 **VIA E-MAIL**

Mr. Eric Greene
Independent Peer Review Panel
California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA

Re: Pacific Gas and Electric Company's Response to Independent Peer Review Panel Report Number 10

Dear Mr. Greene:

I. Introduction

This letter is to respond to the California Public Utility Commission's (CPUC) Independent Peer Review Panel (IPRP) Report No. 10, "*Preliminary Comments on PG&E's May 2015 Update of the Three-Dimensional Velocity Model for the Diablo Canyon Power Plant Foundation Area and Site Amplification Using Analytical Approach",* herein referred to as "IPRP Report No. 10." This letter also summarizes the additional work performed by Pacific Gas and Electric Company (PG&E) with regard to the site three-dimensional (3-D) velocity model, site amplification, and associated uncertainties that were the subject of IPRP Report Nos. 6 and 9. PG&E herein is providing additional documents and clarifications to the IPRP's specific comments on Ground Motion analysis to support the IPRP's in-depth review.

As part of PG&E's December 21, 2015 Response to the Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI), the following supporting documentation was uploaded onto PG&E's Seismic Hazard Update website www.pge.com/dcpp-ltsp to assist in the completion of the IPRP review. PG&E provided a copy of the RAI response to the NRC, DCL-15-154, to the IPRP on December 22, 2015.

1. Fugro Consultants, Inc., *Update of the Three-Dimensional Velocity Model for the Diablo Canyon Power Plant (DCPP) Foundation Area, November 15, 2015.*

2. Fugro Consultants, Inc., *Update of the Three-Dimensional Velocity Model for the Diablo Canyon Power Plant (DCPP) Foundation Area Supplemental Report, November 15, 2015.*

3. Fugro Consultants, Inc., *Project Memorandum: 1-D Profile below the DCPP Area, December 14, 2015.*

4. Fugro Consultants, Inc., Electronic files of the 3-D velocity model described in Appendix H of the *Update of the Three-Dimensional Velocity Model for the Diablo Canyon Power Plant (DCPP) Foundation Area, November 15, 2015.*

5. Pacific Engineering and Analysis, *Development of Amplification Factors for the Diablo Canyon Nuclear Power Plant: Site Wide Profiles, November 24, 2015.*

II. Response to IPRP Report No. 10

IPRP Report No. 10 addresses the Diablo Canyon 3-D velocity model and the site amplification using the analytical approach, following the NRC guidance document "*The Screening Prioritization and Implementation Details (SPID) by the Electric Power Research Institute, 2013.*

A. 3-D Velocity Model

IPRP Report No. 10 notes that PG&E developed a revised 3-D velocity (Vs) model from the Fugro May 2015 report.[1] The intended application of the 3-D velocity model is for the dynamic analyses of the critical structures at DCPP to develop updated fragility curves for use in the probabilistic risk assessment. The current 3-D model covers these key structures (Containments for Units 1 and 2, Turbine Building, Aux Building). There are no plans to develop a 3-D velocity model for a larger region.

The 3-D model included sufficient surface dispersion data that allowed development of uncertainty ranges in the Vs profiles that satisfied previous tomographic data as well as new surface dispersion data. The revised 3-D Vs model was further adjusted by waveform analyses based on the tomographic data and verified via numerical analyses using the finite difference approach of the commercial software package, FLAC-3D. The 3-D Vs model was later adjusted using the data from the November 2015 Fugro report. This iterative process incorporated the latest new data and permitted optimization of the model.

IPRP Comment: As a verification of the revised 3-D Vs model, seismic waves were propagated through the velocity model and synthetic shear wave travel times were compared with arrival time picks from the 1978 shear wave velocity measurements for each of the three boreholes, DDH-A2, DDH-C, and DDH-D.

The IPRP review comments suggested that measured Vs profiles from the updated 3-D Vs model do not provide a better consistency with the 1978 downhole measurements.

PG&E Response: Borehole DDH-D is near the containment structures and DDH-A is southwest of the turbine building. As shown in the November 2015 Fugro report, the 3-D velocity model agrees with the picked arrival times for these locations. The main discrepancy between the borehole estimates and the 3-D model is for borehole DDH-C, located south of the turbine building. The velocities estimated from the borehole picks have a zone (elevation 20 ft to -70 ft) with much lower velocity than seen in the 3-D model. As shown in the November 2015 Fugro

[1] This report, and other referenced reports, can be found at:
http://www.pge.com/en/safety/systemworks/dcpp/sshac/index.page

supplemental report, this discrepancy for DDH-C is likely due to late picks when the borehole data was originally processed. Picking arrival times can be difficult in certain conditions, particularly when the picks imply significant low velocity zone and if the first arrival is weak. Given that the tomography data and surface wave dispersion data provide a much larger sample of data, PG&E considers the 3-D velocity model to be more representative than the 1-D velocity profiles developed from the borehole picks.

B. Site Amplification Using the Analytical Approach

IPRP Comment: IPRP Report No. 10 notes that PG&E used an empirical approach to evaluate local site conditions to either amplify or de-amplify earthquake ground motions to develop the ground motion response spectrum (GMRS) for the PG&E March 2015 submittal to the NRC.

PG&E Response: In response to the NRC RAI, PG&E derived updated amplification factors.[2] At the request of the NRC, ground motion levels were derived for site conditions that reflect the range of 1-D profiles, extracted from the 3-D velocity model under the Turbine Building and containment structures. These reference site profiles with uncertainty reflect the plant-wide velocities rather than the specific location (ESTA28) as was originally submitted in March 2015. In addition, the site response was computed using both the empirical and analytical methods using a logic tree approach. Uncertainty in the analytical site terms was evaluated using multiple shear-wave velocity profiles, kappa values, and non-linear material models. In the logic tree, the empirical approach was given 2/3 weighting and the analytical approach 1/3 weighting. The higher weighting given to the empirical approach reflects the preference to use empirical data when available over analytical modelling because the empirical approach better captures 3-D velocity structure and representation of the plant region wave propagation effects, whereas the analytical approach reflects the more localized effects of a range of 1-D velocity profiles.

An advantage of the analytical approach is that it allows non-linear site effects to be evaluated. The analytical site response is computed for a range of input ground motion levels. The full range of site amplifications is combined with the reference rock site hazard curves to compute site-specific hazard curves on the surface at DCPP following the methodology in the SPID document. Examples of the analytical amplification factors for two levels of ground motion (peak ground acceleration of 0.2g and 1.07g for the reference rock site with VS30=760 m/s) are shown in Figures 1 and 2. The factors for a peak acceleration of 0.2g represent the linear range applicable to the empirical data. The factors for 1.07g represent the non-linear site effects for a level of shaking corresponding to the 1.0E-4 hazard level. The empirical model and the site amplification data are shown in Figure 3.

The empirical and analytical site factors are compared in Figure 4. Overall, the results from the empirical and analytical approaches are similar, although there are some differences. The empirical factors show a stronger amplification in the 1 to 3 Hz range which may reflect either deep site amplification or path effects that were not fully removed. The analytical factors show a stronger amplification near 10 Hz which may reflect site resonances due to the use of 1-D velocity models that is not seen in the empirical data.

[2] See PG&E's DCL-15-154, provided to the IPRP on December 22, 2015.

The IPRP had two concerns with the analytical approach: 1) using a broad range of kappa values (0.024s to 0.07s); and 2) using deep 1-D velocity profiles to characterize a site that is spatially complex geologically.

1. Kappa values

The initial wide range of kappa values was based on the typical uncertainty range used for kappa to be consistent with the approach used in standard site response studies; however, this wide range of kappa values does not account for the available ground motion data at DCPP. In the December 2015 response to the NRC, the range of kappa values used in the analytical approach was reduced to 0.03s to 0.05s, which reflects that range from the DCPP data. This reduced range is also consistent with the NRC staff evaluation of the site-specific kappa values at DCPP.

2. Use of 1-D Velocity Profiles

The 3-D velocity model was tested using the observed ground motions at ESTA27 and ESTA28 during the 2004 Parkfield earthquake, as described in the Fugro reports. The observed ground motions at ESTA27 were larger than the ground motions at ESTA28. Ideally, the difference in the site factors computed at these two sites using the 3-D velocity model would match the differences in the observed ground motions; however, the 3-D modeling of the site response did not lead to the observed trend of larger ground motions at ESTA27. Based on this comparison, PG&E concluded that the 3-D site response methodology with the 3-D velocity model for DCPP is not ready for application. Additional work is needed to develop a 3-D site response methodology and model before applying the results. Therefore, the current analysis is based on a 1-D site response, consistent with industry and NRC-accepted methodology.

The general consistency of the empirical factors and the analytical factors shown in Figure 4 indicate that the analytical results based on the 1-D velocity profiles are reasonable and reflect the site amplification in the DCPP turbine building and containment structure region.

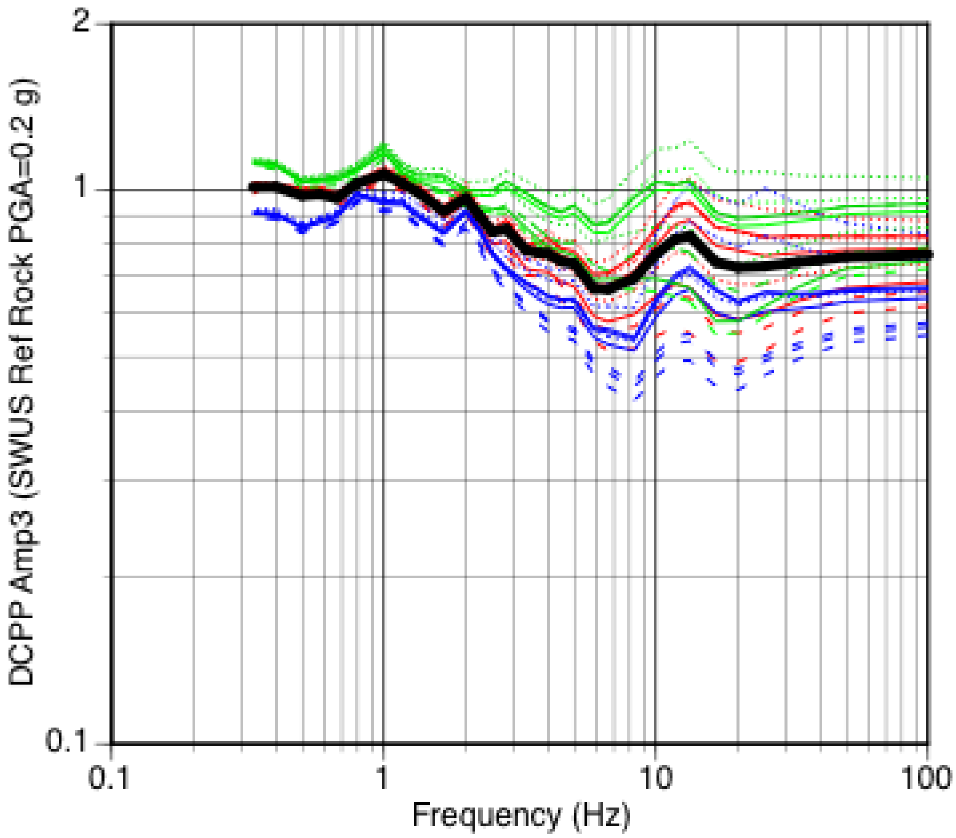

Figure 1 - Analytical Site Terms for a SWUS Reference Rock (760 m/s) PGA of 0.2 g

(The green curves are for the lower VS profile; red curves are for the central VS profile; and the blue curves are for the upper VS profile. The short dashed lines are for the target kappa of 0.03 sec, the long dashed lines are for the target kappa of 0.05 sec, and the solid lines are for the target kappa of 0.04 sec. The black line is the mean.)

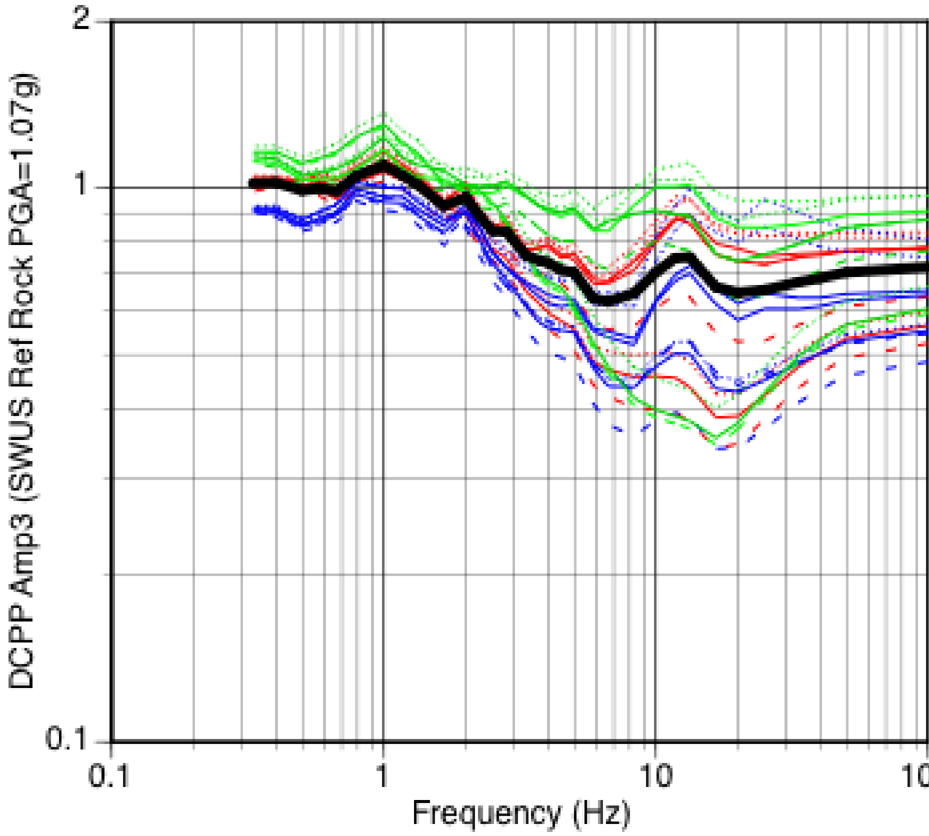

Figure 2 - Analytical site terms for a SWUS reference rock (760 m/s) PGA of 1.07 g

(The green curves are for the lower VS profile; red curves are for the central VS profile; and the blue curves are for the upper VS profile. The short dashed lines are for the target kappa of 0.03 sec, the long dashed lines are for the target kappa of 0.05 sec, and the solid lines are for the target kappa of 0.04 sec. The black line is the mean.)

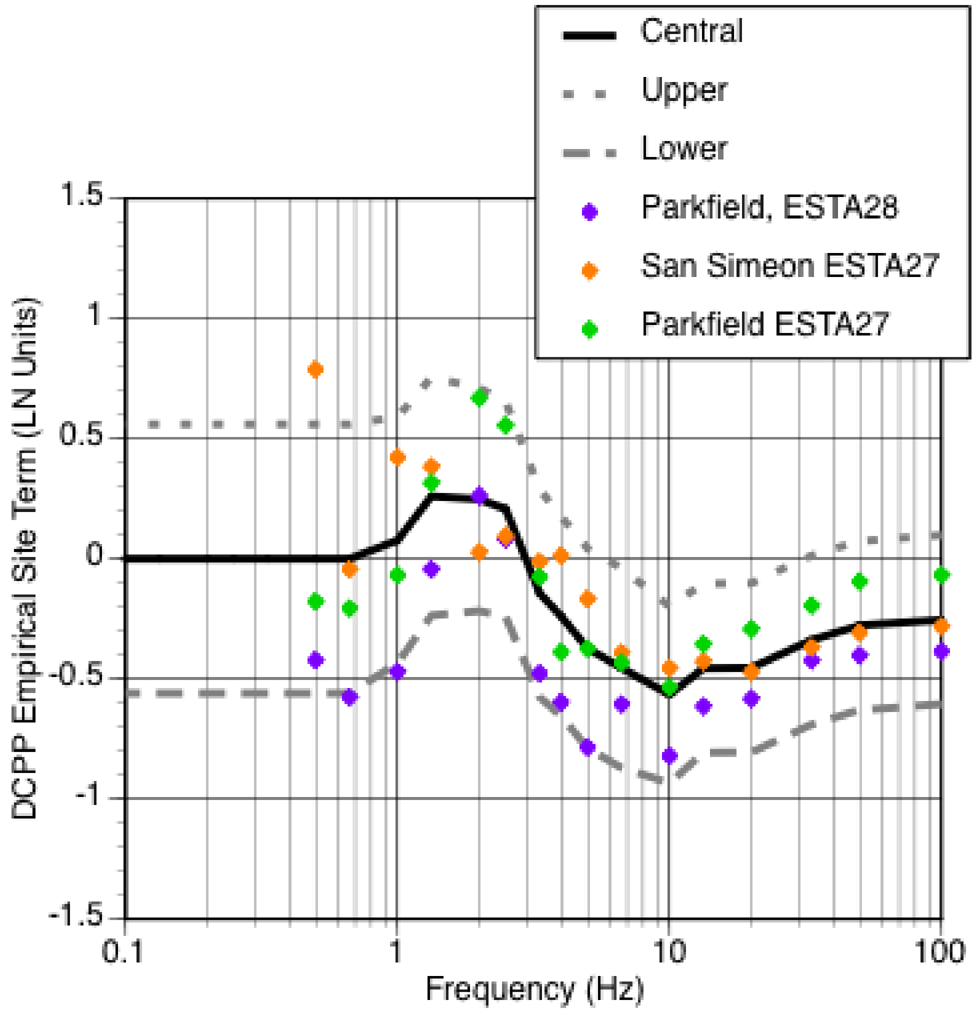

Figure 3 - Empirical Site Term for DCPP Relative to SWUS Reference Rock

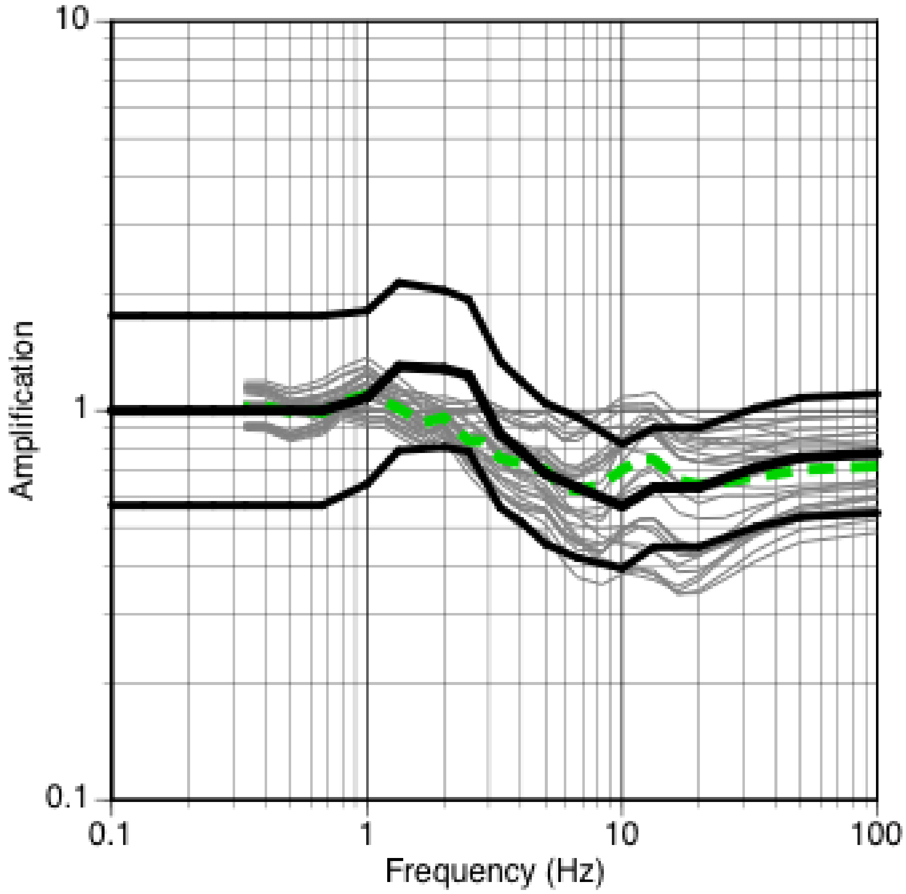

Figure 4 - Comparison of the amplification from the empirical and analytical methods. (Heavy Black lines are the empirical results, light grey lines are the analytical results for PGA=1.07g, Heavy green bashed line is the mean for the analytical results for PGA=1.07g.)

III. Closure

Again, PG&E would like to thank the members of the IPRP for their valuable insight and guidance, and their diligent review and feedback on the study results. PG&E proposes a future meeting with members of the IPRP to discuss their final comments on the 3-D velocity model for Diablo Canyon Power Plant and on calculation of site amplification factors.

Sincerely,

/s/

Valerie Winn

cc: Chris Wills